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Wildlife Habitats in Managed Forests

the Blue Mountains of Oregon and Washington

U.S. Department of Agriculture • Forest Service
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Preface

Until just a few years ago, forest managers were not especially concerned with wildlife. The law did not require it. The public did not demand it. Politics did not compel it. Public forest lands in the West were still largely an untapped source of wood products and recreational space for the growing nation. Many resource management professionals were secure in the assurance given them in their basic forestry and wildlife management classes that "good timber management is good wildlife management."

Times have changed. Laws have changed. Public demands and politics have changed. The public forests have been thrust into the forefront as a prime supplier of wood products and recreation. It seems likely that these forests will become ever more intensively managed to meet the Nation's burgeoning demands for wood, water, recreation, grazing, and wildlife. As for good timber management being good wildlife management, wildlife biologists and foresters alike have found that it is not necessarily so!

Forest managers are now under increasing pressure to account for wildlife in their management activities, particularly land use planning. That means all wildlife—not just species that are hunted or are esthetically pleasing or classified as threatened or endangered.

In reacting to these pressures, forest managers are asking more and tougher questions about how forest management practices will affect the myriad of wildlife species. Too often the wildlife biologists' responses have been inadequate, ranging from "Don't do it" to "We don't know enough to give you an answer." Neither response will help the forest manager make the decisions and evaluations that must be made. To do nothing is seldom a realistic alternative—economically or politically.

The knowledge necessary to make a perfect analysis of the impacts of potential courses of forest management action on wildlife habitat does not exist. It probably never will. But more knowledge is available than has yet been brought to bear on the problem. To be useful, that knowledge must be organized so it makes sense both biologically and silviculturally.

In the past, wildlife management in forests has been considered from a rather limited viewpoint. The standard practice has been to study one species at a time or develop management plans for one species or a limited number of species. As a result, wildlife biologists and foresters have been unable to effectively evaluate the impacts of forest management on all wildlife.

So we began with a different approach and a simple question. What do forest managers do that affects wildlife? They certainly do not manage wildlife directly. They manage habitat. The forest manager alters wildlife habitat with every decision. Habitat is something the manager can relate to, understand, and control. Most important, it is an entity for which a manager can be held accountable. The maintenance of appropriate habitat is the foundation of all wildlife management. Habitat, therefore, is the key to organizing knowledge about wildlife so it can be used in forest management.

In this book, wildlife habitats are described in such a way that they can be considered simultaneously with timber management. By accounting for the habitats, the maager can account for the wildlife.

Perhaps the greatest challenge that faces professionals engaged in forest research and management is the organization of knowledge and insights into forms that can be readily applied. To say we don't know enough is to take refuge behind a half-truth and ignore the fact that decisions will be made regardless of the amount of information available. In my opinion it is far better to examine available knowledge, combine it with expert opinion on how the system operates, and make predictions about the consequences of alternative management actions.

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Foreword

Man's activities have had an impact on North American forests for centuries. In the 500-year "instant" of geologic time following European settlement, forested landscapes have undergone dramatic and accelerated change. More people, advanced technology, and increased material wealth have combined to generate greater demands and capabilities to modify the continent's forests.

These alterations continue to have profound effects on wildlife. Road construction, timber harvest, and changes in species composition of forests all affect wildlife habitats and populations. Certain kinds of wildlife benefit from some changes; other wildlife may be adversely affected. In the past, our understanding of forest-wildlife relationships was inadequate to minimize adverse impacts and to assure required conditions for individual wildlife species or groups of species with similar habitat needs. Data are available but scattered, making it difficult for foresters, biologists, and resource managers to obtain and consolidate vital information into practical guidelines useful in resource management.

This book is a response to that need. It is the first major attempt to use an integrated system to examine the impacts of forest management on terrestrial vertebrate fauna. This pioneering perspective is both theoretically sound and of immediate practical value. It skillfully blends theories, facts, and management practices to provide essential information and predictions about how wildlife respond to changes in forest habitats.

The authors demonstrate that the habitat needs of wildlife can be accommodated readily in carefully integrated plans for intensive forest management. Application of this system has led to substantial improvements in the effectiveness of forest-wildlife planning in the Pacific Northwest's Blue Mountains. Similar systems are being designed for other types of forest ecosystems in the Western United States. As they are completed and applied, additional improvement in yields of multiple benefits from forested lands can be expected.

The full potential of this new planning system can be realized only through its broad application in forest management. The challenge is ours—foresters, biologists, managers, and citizens alike.

Laurence R. Jahn
Vice President
Wildlife Management Institute

That is what this book is about. It is a framework for planning, in which habitat is the key to managing wildlife and making forest managers accountable for their actions. This book is based on the collective knowledge of one group of resource professionals and their understanding about how wildlife relate to forest habitats. And it provides a long-overdue system for considering the impacts of changes in forest structure on all resident wildlife.

This book presents a reasonable facsimile of the way managed forests and wildlife interrelate. In this sense, the entire book may be termed a working hypothesis. It is a place to start and a way to derive tentative responses to questions for which there are no certain answers. As Walter P. Taylor (1956, p. 11) said, "no book dealing with living creatures is in any sense final. The subject matter is so fascinatingly complicated that no contribution can be more than a progress report."

The many people who contributed to this book are acknowledged elsewhere. But there are several who deserve particular mention here. John L. Rogers, Herbert B. Rudolph, Al Oard, Glen E. Hetzel, and Dan E. Williams, who served as Forest Supervisors of the four National Forests in the Blue Mountains while this effort was underway, are due special recognition. They saw the utility of and need for such a tool and gave the direction and encouragement to carry out the task. Leon W. Murphy of the USDA Forest Service and Ira D. (Dave) Luman of the Bureau of Land Management obtained additional financial resources for completing this effort. Robert F. Tarrant and Robert A. Hann, of the USDA Forest Service's Pacific Northwest Forest and Range Experiment Station, encouraged us to compile and publish this material so others could use the fully developed wildlife evaluation system.

Jack Ward Thomas
Technical Editor

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the Blue Mountains of Oregon and Washington

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Jack Ward Thomas
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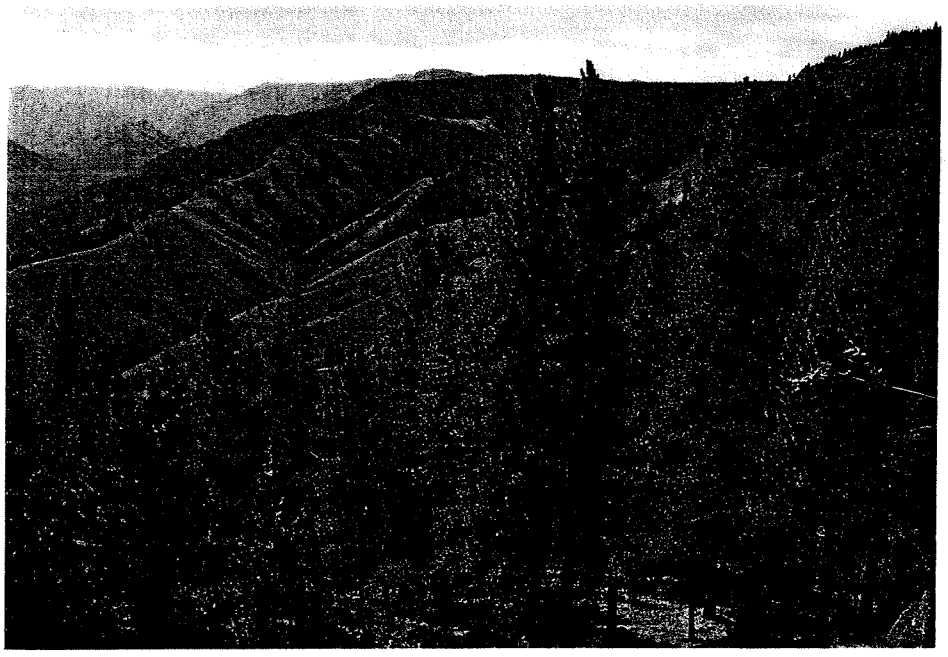
1
Introduction

by
Jack Ward Thomas



Topography in the Blue Mountains is typically rugged with timber stands interspersed with openings.

The Nation's forests are one of the last remaining natural habitats for terrestrial wildlife. Much of this vast forest resource has changed dramatically in the last 200 years and can no longer be considered wild. It is now managed for multiple use benefits, including timber production. Timber harvesting and roadbuilding now alter wildlife habitat more than any other forest management activity.

In recent years public forest managers have had to account more completely for the impacts of their activities on wildlife. Federal laws and other legislation have set forth specific responsibilities for protection and enhancement of wildlife habitats in managed forests. This publication is designed to help forest managers deal more effectively with these new responsibilities.

The setting is the Blue Mountains of Oregon and Washington (Dicken 1973). But it could be anywhere in North America where coniferous forests are a dominant part of the landscape and where public ownership of forest land is extensive. Although the setting is geographically narrow, the general concepts, principles, and practices are applicable to forest management throughout the country.

The book has three purposes: (1) to develop a common understanding among resource specialists about wildlife habitats in managed forests,

(2) to provide a system to predict the impact of forest management practices on wildlife, and (3) to show how the system can be applied to a specific area—in this case, the Blue Mountains. With the information provided, forest managers, wildlife biologists, and other specialists will be able to work together to assure the existence of most, if not all, important wildlife habitats in managed forests.

Timber management and wildlife habitat management are seen as generally compatible, but only if the needs of wildlife are recognized and considered along with requirements for timber management. This compatibility can be realized through a better understanding of plant and animal communities, how they change over time, and how they respond to silvicultural practices.

Management of wildlife on public lands is a joint responsibility of State and Federal governments. By longstanding agreement, the manipulation of wildlife populations or regulation of the harvest of wildlife on federally owned land is the prerogative of the States. Habitat management is the prerogative of the Federal land management agencies. Therefore, close cooperation is required between State and Federal agencies in setting and achieving wildlife management goals. This book deals only with the relationship of wildlife to their habitats. The forest manager should work with appropriate State officials to develop suitable wildlife production goals.

Wildlife as a Product of Forest Management

Forest management is the process of manipulating the forest environment to produce a mix of products desired by the owners. These products change with time, economic conditions, public demand, legislation, and capability of the land. Managers of federally administered lands have guidance, in the form of laws passed by Congress, as to what these products shall be. Other regulations result from agency and court interpretations of these laws. A number of laws specify that wildlife shall be a product of Federal lands and that wildlife shall be considered in every management decision (fig. 1). Managers of State-owned lands and private landowners are influenced by similar State laws. For example, the Oregon Forest Practices Act (Oregon Laws, Statutes, etc. 1971, p. 455) says:

> . . . Recognizing that the forest makes a vital contribution to Oregon by providing jobs, products, tax base and other social and economic benefits, by helping to maintain forest tree species, soil, air and water resources and by providing a habitat for wildlife and aquatic life, it is . . . public policy . . . to encourage forest practices that maintain and enhance such benefits and such resources, and that recognize varying forest conditions.

In most managed forests, wildlife habitat is a byproduct of timber management. As demands have grown for increased production of wood fiber, recreation, and livestock, as well as for increased allocation for wilderness, it has become increasingly obvious that such cliches as "good timber management is good wildlife management" will no longer suffice (Bunnell 1976a). Passage of the National Environmental Policy Act of 1969 (U.S. Laws, Statutes, etc., Public Law 91-190) brought matters to a critical stage. It required that the environmental effects of any federally financed project must be fully evaluated. Bunnell (1976b, p. 151-152) put it this way:

> . . . foresters have changed little, but the social and natural environment in which forestry is practiced has changed greatly. Not only are more demands being placed on the same base of forested-land, but the demands come from more diverse groups. One result of the increasing diversity in demands is that wildlife habitat is no longer synonymous with game habitat but encompasses the requirements of a multitude of non-game species as well. Prognosis suggests an enormous increase in the number of decisions arbitrating use of forested land including the exploration of very different kinds of forestry. . . . the average forester will frequently encounter a dilemma in such decisions: on

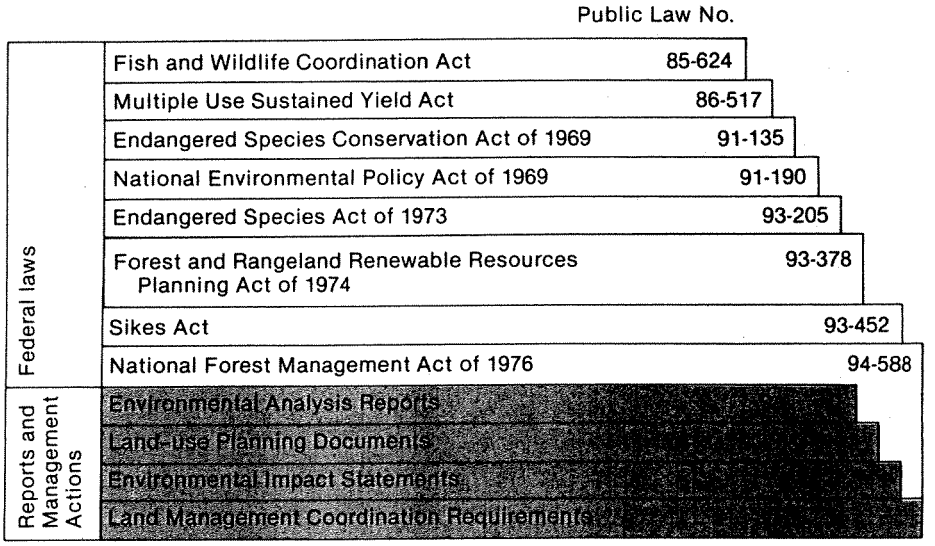


Figure 1. Some major Federal laws and planning requirements that influence wildlife habitat management on public lands.

Forests are being altered rapidly by road construction and timber harvest.

one hand, a professional charge to pursue what is good for the land in terms of sustained wood fibre production; on the other hand, a professional charge to facilitate societal ends which locally may be in complete opposition to fibre production ... Imperfect knowledge and doubt is manifest at all the trade-offs between resource uses, and particularly with forestry-wildlife. ... It is equally his charge to indicate how he weighed the uncertainties and now accepts responsibility.

The Need

How is the public forest manager to balance the demands for forest resources, including wildlife, and still maintain a sustained yield of wood products? How can the needs of all wildlife be considered? As these problems are pondered, the forest manager is likely to discover the wisdom of two of Commoner's (1971) "laws" of ecology—"everything is connected to everything else" and "there is no such thing as a free lunch." Forest managers must not be solely timber managers. They must take a more holistic view.

The National Forest Management Act of 1976 (U.S. Laws, Statutes, etc., Public Law 94-588) requires that detailed and holistic plans be prepared for the management of National Forest System lands. Further, the National Environmental Policy Act of 1969 (U.S. Laws, Statutes, etc., Public Law 91-190) requires that the environmental impacts and consequences of planned actions involving any Federal Government funds be examined and revealed. One of the weakest aspects of such planning and examination has been the inability of forest managers to predict the effects of management alternatives on wildlife populations. This has frequently resulted in criticism of land-use plans and environmental impact statements by the public, other agencies, and the courts.

Continued generalized criticism of timber management and land-use planning by conservationists and wildlife biologists will do little to help wildlife. Instead, better techniques are needed to help predict the consequences, whether good or bad, of timber management on wildlife. Managers need a conceptual framework that will enable them: (1) to consider the habitat needs of all vertebrate wildlife, (2) to emphasize management of particular wildlife species when desired, and (3) to identify habitats that require special attention. Perhaps the greatest challenge will be to bring together existing information so it can be readily used in resource planning. Giles (1962, p. 404-405) described the problem as follows:

> A great hindrance to the advancement of a coordinated use program is failure to imaginatively use existing knowledge of forest wildlife needs and to develop these into management directives. ... Certainly, research is needed, but while waiting, we need to work with what we have. Work to be done is not for the research staff, but the management team who sees the needs, recognizes limitations, and can make modifications to fit existing conditions. The "applied ecologist" needs to start applying. . . . Managers must then share information on the results of their efforts with their colleagues.

The development of a process to consider the impact of timber management on wildlife should no longer be delayed. The land-use planning process continues at full speed; loaded log trucks roll into the mills by the hundreds every day, and the demand for wood fiber from public lands is increasing. In the Blue Mountains, for example, about 45 344 hectares (112,045 acres) or 3 percent of the commercial forest land is affected each year by timber harvest activities.

Some will say it is too soon to undertake such a task, but there are really only two choices—too soon or too late. Of these, the first is far preferable. With intensified forest management, impacts on wildlife will be magnified. The need is critical. The time is now.

The Blue Mountains Guidelines

This book grew out of a need for guidelines to help forest managers in the Blue Mountains with a specific problem—how to salvage large quantities of timber damaged by an outbreak of the Douglas-fir tussock moth and at the same time protect wildlife habitat.

As the salvage program was being planned, the supervisors of the Wallowa-Whitman and Umatilla National Forests requested their staffs to develop guidelines to protect wildlife habitat. The guidelines were produced by a team of forestry and wildlife professionals from the USDA Forest Service, the Oregon Department of Fish and Wildlife, and the Washington State Department of Game. The guidelines so impressed the supervisors of all four National Forests in the Blue Mountains that they asked for expanded guidelines for use in all types of forest management and land-use planning.

As managers began to use the guidelines, they also prepared critiques. And they were adamant on one point—that the guidelines were too rigid. The managers needed more flexibility to apply them to local situations. As a result, the information has been drawn into a system that can be used to predict the consequences of contemplated management alternatives on wildlife, rather than specific guidelines for all situations. This gives the manager the ability to respond to individual management situations while still being fully accountable for the impacts of such decisions on wildlife habitat. The manager can survey alternatives, make trade-offs, and account for those decisions.

The data in this book are applicable only in the Blue Mountains and should not be used elsewhere without modification. The concepts and principles are adaptable, however, and can be used as guides for preparing similar analyses of forest-wildlife relationships in other areas.

A Basic Assumption

The basic assumption about wildlife habitat management in forests that are managed under the policy of multiple-use is that it must be carried out in coordination with timber management. On public forest lands in the Blue Mountains, as in many other parts of North America, timber management is the dominant land management activity. Large-scale wildlife management usually results from the manipulation of forest vegetation primarily for wood production. Timber management *is* wildlife management. The degree to which it is *good* wildlife management depends on how well the wildlife biologist can explain the relationship of wildlife to habitat and how well the forester can manipulate habitat to achieve wildlife goals. These interrelationships are shown in figure 2.

Wildlife habitat management in forests requires manipulation of tree cover (Trippensee 1948), but this is usually too expensive solely for wildlife purposes. Forest management practices undertaken to enhance wood production, however, cause dramatic changes in wildlife habitat. If correctly planned and executed, timber management practices are potentially the most practical way to achieve wildlife habitat goals.

In most situations, the wildlife biologist is responsible for making the forest manager aware of the ramifications of proposed forest management activities on wildlife habitats. The forest manager considers advice from many staff specialists and selects a course of action. But it is the field forester who actually manipulates the vegetation and alters habitat. It is essential, therefore, that the forest manager, field forester, and wildlife biologist work closely together. Giles (1962, p. 406) said:

> The time has come to face up to the fact that the harvest of wood, a forester's function, has greater influence on game [wildlife] than any active technique available to the wildlifer. In one sale a forester can . . . influence more cover over a longer time than a game [wildlife] manager . . . can create . . . in a decade. The wildlifer, realizing the potentials of the wood harvest, must not only increase the effectiveness of his present practices, but must provide guidance for foresters so their efforts will not so strongly negate his efforts and can be made to complement them.

Large-scale wildlife goals must be accomplished through timber management

because

timber management:

- affects many acres
- is well financed
- dramatically affects wildlife habitat
- has great impact on wildlife

while

wildlife habitat management:

- affects few acres
- has little financing
- has little influence on wildlife habitat
- has little present impact on wildlife

Figure 2. Large-scale wildlife habitat management must be accomplished through timber management.

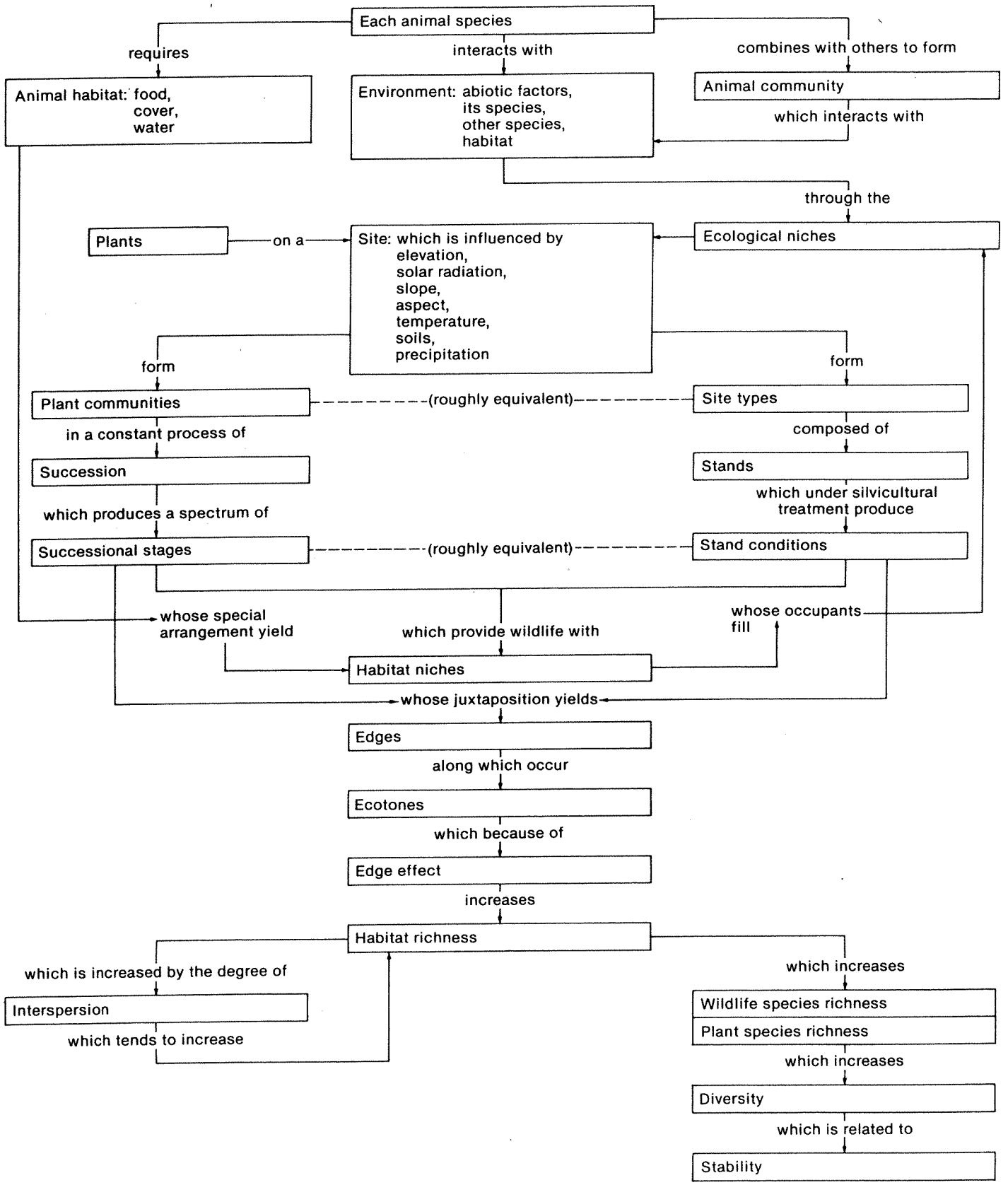


Figure 3. Relationship between terms used in forest and wildlife habitat management.

Principles of Forest-Wildlife Management

Resource management professionals come from varied backgrounds: forestry, ecology, wildlife biology, forest engineering, and landscape architecture, to name a few. For these professionals to work together, they need a common vocabulary and an understanding of the principles of forestry, ecology, and wildlife management. The relationship between terms used in forest and wildlife habitat management is shown in figure 3. These have been touched upon by such authors as Odum (1963), Leopold (1933), and Hylander (1966). The discussion that follows draws heavily on summaries by Thomas et al. (1975, 1976) and Gill et al. (1976).

Animal habitat is the arrangement of food, cover, and water required to meet the biological needs of one or more individuals of a species. Each species is adapted to a *habitat niche* or specific arrangement and amount of food, cover, and water. The role a particular wildlife species plays in the environment is referred to as its *ecological niche.*

A *plant community type* is a unique combination of plants that occurs in particular locations under certain environmental influences. The plant community type reflects the environmental influences on the site, such as soil, temperature, elevation, solar radiation, slope, aspect, and rainfall as they influence vegetation (Daubenmire 1976).

Plant communities, as described in chapter 2, are defined in terms of the dominant single species of climax vegetation. As many as five kinds of plant community types may be included. The plant community evolves through a general series of conditions as it progresses from bare ground to final *climax* stage. This process is called *succession* and the various stages are known as *successional stages.*

Each combination of plant community and successional stage has its own unique set of habitat niches. The wildlife supported by these habitat niches make up the attendant *animal community.* The animals fill various ecological niches and, in turn, influence the plant community. Habitat niches are valuable to wildlife for feeding, reproduction, or security. Individual species may use a particular habitat on a seasonal or yearlong basis. See also reviews by Meslow and Wight (1975) and Thomas et al. (1975).

Some of the terms already discussed have counterpart terms that are used primarily in forestry. It is important to understand their relationship to the language of ecology and wildlife biology.

A *site* is an area considered in terms of its environment, particularly as this determines the type and quality of the vegetation the area can support. Sites are classified either qualitatively by their climate, soil, and vegetation into *site types* or quantitatively by their potential for producing wood into *site classes* (Ford-Robertson 1971, p. 242). Site type is roughly analogous to the plant community.

Each site is occupied by one or more *stands.* They are plant communities, particularly trees, that have sufficient uniformity of composition, size, density, age, spatial arrangement, and condition to distinguish them from adjacent plant communities. Stands are the common basis on which silvicultural prescriptions are considered (USDA Forest Service 1974). The *stand condition* can be described by measuring these factors. Timber harvest or other silvicultural treatment alters stand condition. Stand condition is roughly analogous to successional stage, when wildlife habitat is considered, because both measure the composition and structure of the stand.

The juxtaposition of plant communities, successional stages, or stand conditions within communities produces *edge.* The area where the two communities or successional stages overlap or produce a distinct combination of plants or structure is called the *ecotone.* Edges and their ecotones are rich habitat for wildlife because they have attributes of the edge itself plus those of the adjoining communities or successional stages (Leopold 1933). The influence of this phenomenon on animal populations is called *edge effect.*

Increasing the amount of edge increases *habitat richness* which is a measure of the number of wildlife species resident within an area. The mixing of plant communities or successional stages is measured by the degree of *interspersion.* An increase in interspersion increases the amount of edge. In turn, this may increase *diversity* or the variety that exists in plant and animal communities (Patton 1975). Increased diversity in plant communities provides an increasing number of habitat niches which, in turn, support more animal species. A forest with a high degree of diversity of communities and successional stages provides habitat for a wide variety of wildlife (Odum 1971).

Increased diversity is thought by some ecologists to be related to community *stability.* Stability is the ability of a community to withstand catastrophe (Margalef 1969) or to return to its original state after severe alteration. Such a cause-and-effect is suspected but has not been proved (Odum 1971, p. 256):

> . . . If it can be shown that biotic diversity does indeed enhance physical stability in the ecosystem, or is the result of it, then we would have an important guide for conservation practice. . . . is variety only the spice of life or is it a necessity for the long life of the total ecosystem comprising man and nature?

A *forest ecosystem* is a complex of plant and animal communities along with the abiotic environment that comprises one functioning whole. Forest ecosystems are dynamic. Any change in forest structure or composition will favor some wildlife species while adversely affecting others. Such changes can affect the number and type of wildlife species and their use of habitat.

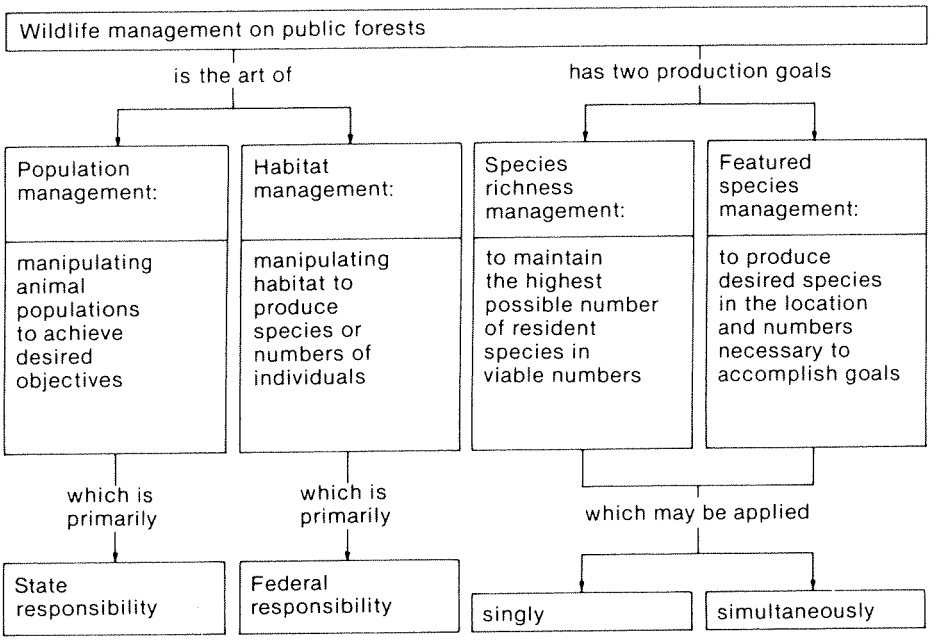


Figure 4. The art and goals of wildlife management on public forests.

Production goal	Management for species richness	Featured species management
Objective	Insure that all resident species exist in viable numbers. All species are important.	Produce selected species in desired numbers in designated locations. Production of selected species is of prime importance.
Process	Manipulate vegetation so that characteristic stages of each plant community are represented in the vegetative mosaic.	Manipulate vegetation so that limiting factors are made less limiting.

Figure 5. Production goals in wildlife management.

Forest-Wildlife Management Systems

Wildlife management is the scientifically based art of manipulating habitat to enhance conditions for a selected species or manipulating animal populations to achieve other desired ends (fig. 4). The term "wildlife management" implies the ability and managerial flexibility to manipulate vegetation (habitat) or animal populations or both (Leopold 1933, Trippensee 1948, Giles 1971).

There are two general production goals in wildlife management—management for species richness (Evans 1974; USDA Forest Service 1973a, 1975) and featured-species management (Zeedyk and Hazel 1974, USDA Forest Service 1971b) (fig. 5).

The goal of management for species richness is to insure that most wildlife species are maintained as residents of the managed forest in viable numbers (King 1966). Hence, all species are important. Management for species richness can be achieved by providing a broad spectrum of habitat conditions; characteristic stages of adequate size of each plant community should be represented in the vegetative mosaic. To do this, it is necessary to have information on the habitat needs of each species. This must then be incorporated into guides to protect the integrity, stability, and diversity of the forest ecosystem. The result should be a relatively stable and varied wildlife population.

Under featured-species management, the goal is to produce selected species in desired numbers in specific locations. This can be achieved by manipulating vegetation so the limiting factors of food, cover, and water are made less limiting for the species featured. These may be game species, threatened or endangered species, or species that have particular esthetic value.

Featured-species management has also been called key-species management or indicator-species management if the species selected represent the habitat needs of several species. If the species to be featured are carefully selected and their habitat needs vary widely, then featured-species management will also insure habitat diversity. The result can be similar to management for species richness.

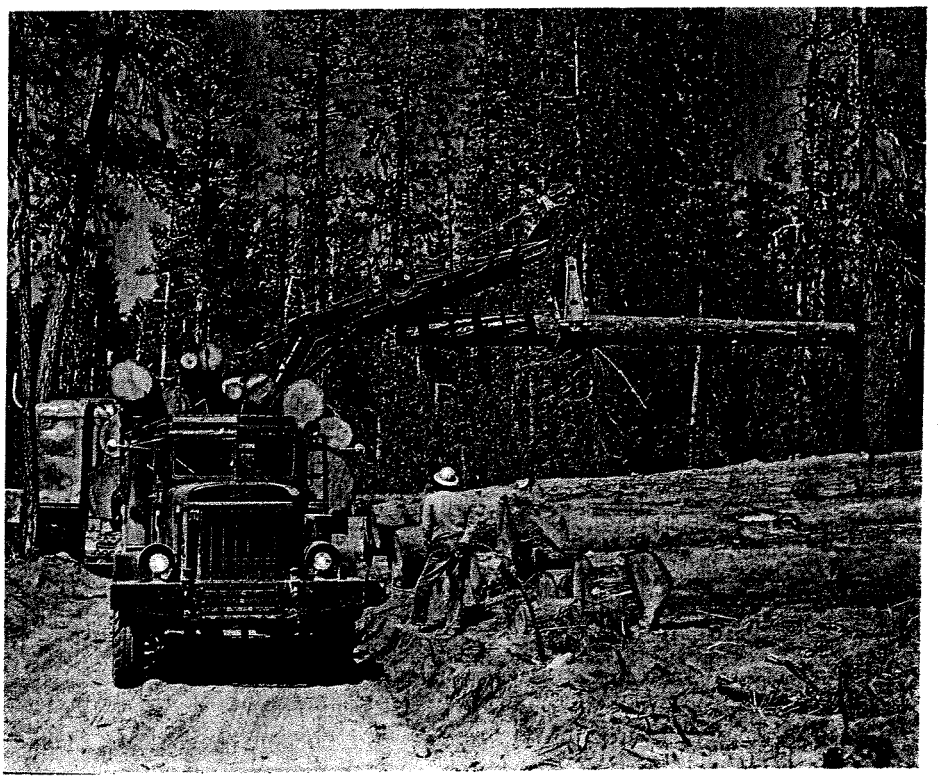
The two management systems can also be used together to insure species richness while favoring selected species in specific locations for particular purposes. For example, management for species richness can be accomplished by providing an appropriate mix of successional stages or stand conditions within each plant community. Featured-species management can be accomplished by arranging stand size and successional stages to provide both cover and forage for selected species.

Timber Management Systems

Different timber management systems have different potential to affect diversity and stability of the forest ecosystem because of their tendency to either magnify or reduce the dynamic aspects of plant community development. Two timber management systems are used by forest managers in the Blue Mountains—uneven-aged management and even-aged management (Twombly 1977, Work 1977).

Uneven-aged management maintains stands of trees that differ markedly in age (Ford-Robertson 1971). Such stands are "continuously or periodically regenerated, tended, and harvested with no real beginning or end" (Alexander and Edminster 1977, p. 5). This management system tends, over time, to reduce the diversity of plants and animals in the forest. The resulting stands often have high structural diversity because of the intermingling of different ages and sizes of trees. But there is a gradual reduction of shade-intolerant trees and understory plants (Franklin 1976). Uneven-aged management tends to produce large blocks of continuous forest cover dominated by relatively mature trees. Such forests lack the variety of distinct successional stages that insure diversity and a myriad of habitat niches.

Uneven-aged management, however, can be a useful wildlife management technique. It benefits wildlife species adapted to more mature forest conditions, and it can be used to preserve the integrity of delicate and disproportionately important wildlife habitats, such as riparian zones.

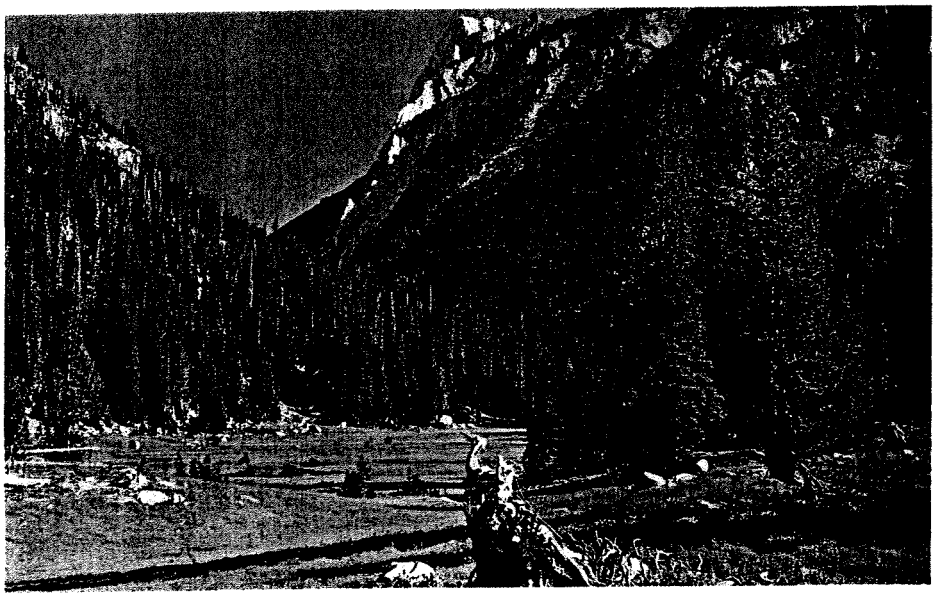


Timber harvest activities are the dominant management activity affecting wildlife habitat in the Blue Mountains.

Uneven-aged management involves harvest of timber by either single tree selection or group selection. Uneven-aged stands have a high degree of vertical diversity. They "are distinctly irregular in height with great variation in size of trees. Competition between age classes is unequal; the smaller, younger trees tend to grow slowly because they are suppressed by the larger, older trees which grow quite rapidly." (Smith 1962, p. 357). Conversely, the horizontal diversity between stands will be low in an ideal uneven-aged situation. When forests under uneven-aged management are examined carefully, it is obvious that the forest is composed of small groups of even-aged trees. The characteristics of horizontal diversity "are most pronounced along the margins of the small even-aged groups that must inevitably make up most of an uneven-aged stand. . . ." (Smith 1962, p. 357).

In the group selection form of uneven-aged management, trees are cut in small groups rather than individually. If the openings created exceed 0.4 hectare (1 acre), this will tend to produce conditions similar to even-aged management (USDA Forest Service 1973b). Group selection tends to increase diversity of plants and animals because of temporary increases in shade-intolerant plants and forage plants in the small openings created. But such small openings do not satisfy the territorial requirements of many species adapted to early successional stages. Such species may not be present in such a forest even though a variety of successional stages are present.

The objective of even-aged timber management is to maintain forest stands and produce crop stands with little or no difference in tree age. By convention, the age of trees in such stands can vary from 10 to 20 years for rotations of less than 100 years and as much as 30 percent of the rotation period for longer rotations (Ford-Robertson 1971). In conifer forests of the Blue Mountains, unit area control (Davis 1959) is the primary criterion by which silvicultural treatments are determined (Twombly 1977).



High elevation forests and meadows are important for recreational use and as summer habitat for elk.

Even-aged management implies that even-aged stands of various ages and sizes are distributed throughout the managed forest. This is necessary to insure a continuous flow of wood products to the market. As a result, the potential for a mix of successional stages or stand conditions is present at all times. This should insure a comparatively high degree of diversity of habitat niches and wildlife.

A forest under even-aged management usually has individual stands of relatively low vertical diversity because of the comparative simplicity of the stand structure. Smith (1962, p. 357) said that even-aged stands tend to be of uniform height with a high degree of competition between trees of approximately the same size. The lower branches die and the trees have short, narrow crowns.

Most even-aged stands have a single-tiered canopy. This is not always true, however. Stands resulting from shelterwood and seed-tree regeneration techniques may be multi-tiered for many years after final harvest in a rotation because some trees are left to provide shade or seed. This adds vertical diversity and enables birds that would otherwise be eliminated during the early years of the rotation to use the stands. The effect is temporary, however, because overstory trees are usually removed after the new stand is established. If left, they often succumb to windthrow, sun-scald, insects, or disease.

The major difference between uneven-aged and even-aged management systems, in terms of habitat, is the long-lasting effect of the regeneration harvest. Even-aged systems—such as clearcutting, seed-tree, or shelterwood harvest—produce distinct successional stages and a high degree of horizontal diversity because there are numerous stands of various age classes scattered through the forest. These stands provide a variety of habitats. For example, the vegetation associated with early successional stages provides forage for deer and elk and a myriad of habitat niches for other wildlife. These conditions are not available in the more mature forest. The mature stages provide hiding and thermal cover for deer and elk and for other wildlife species, such as the pileated woodpecker, that are adapted to mature forest habitats. The edges between stands form ecotones that provide additional habitat niches. The impact of regeneration cuts on wildlife have been reviewed by Hooven (1973), Pengelly (1972), and Resler (1972).

No single system of forest management can be a panacea for wildlife management. The decision about which system to use must be based on specific wildlife management goals. The forest structure must be considered, along with size and shape of the stand, its juxtaposition to other stands, the road systems, and special habitat needs. Flexibility in the use of silvicultural systems can be a key to meeting a range of wildlife goals. The appropriate uses of various silvicultural systems for the two largest forest types in the Blue Mountains—ponderosa pine and mixed conifer—are summarized by Seidel (1973) and Barrett (1973).

Every silvicultural decision has consequences for wildlife. The chapters that follow discuss the relationships between forest conditions and wildlife habitats. The forest manager should consider, in each case, that the habitat described results from some kind of silvicultural activity. Each chapter should be read with an eye to how these conditions can be produced in the managed forest.

The Setting

The Blue Mountains of northeastern Oregon and southeastern Washington contain a number of ranges including the Strawberry, Greenhorn, Elkhorn, Aldrich, and Maury Ranges, and the Ochoco, Blue, and Wallowa Mountains. (Franklin and Dyrness 1973). These mountains extend throughout the Oregon counties of Baker, Crook, Grant, Harney, Malheur, Morrow, Umatilla, Union, Wallowa, and Wheeler; and the Washington counties of Asotin, Columbia, Garfield, and Walla Walla.

Franklin and Dyrness (1973) and Hall (1973) have described the environments of the Blue Mountains in detail. The great diversity of the region is reflected by the occurrence of 10 (9 percent) of the 116 forest and range ecosystems identified by Küchler (1964) for the United States (fig. 7). This broad spectrum of ecosystems made the Blue Mountains an ideal place to develop and test the timber-wildlife management systems discussed in this book.

In 1973, about 1 602 590 hectares (3,960,000 acres), or 72 percent of the 2 239 579 hectares (5,534,000 acres) of total commercial forest land in the Blue Mountains, were in the Malheur, Ochoco, Umatilla, and Wallowa-Whitman National Forests (fig. 8). These National Forests contained 87 percent (40,578 million board feet, Scribner Rule) of the total standing timber volume of 46,683 million board feet. Other public lands covered 46 540 hectares (115,000 acres) and included 2 percent of the commercial forest land and 2 percent (829 million board feet) of the standing timber. Farmers, ranchers, and other private citizens owned 379 199 hectares (937,000 acres) or 17 percent of the commercial forest land and 7 percent (3,173 million board feet) of the standing timber. Timber companies owned 211 251 hectares (522,000 acres) or 9 percent of the commercial forest land and 4 percent (2,103 million board feet) of the standing timber (Bassett and Choate 1974a, 1974b). A comparison of the land area, standing timber volume, and potential timber production in each ownership class is shown in figure 8.

Extensive public landownership increases pressure from local governments for more intensive forest management which, in turn, increases employment and Federal payments to local governments in lieu of property taxes (Hall 1977). This is typical of the national situation (USDA Forest Service 1973c).

Timber harvest in the Blue Mountains has been relatively constant since 1955, averaging 882 million board feet per year through 1976. The cut on private land declined from an average of 516 million board feet per year in the late 1950's to 212 million in the early 1970's. Harvest on National Forest land in the same period increased from an average of 357 million to 706 million (Berger 1964; Beuter 1962, 1963; Gedney 1962; Lloyd 1973-78a, 1973-78b; Metcalf 1963, 1964; Nielsen 1963; Pacific Northwest Forest and Range Experiment Station 1962; Pacific Northwest Forest and Range Experiment Station, Division of Forest Economics 1955-59a, 1955-59b; Wall 1965, 1965-72, 1966-72). Inventories on National Forests declined about 10 percent from the mid-1950's to the early 1970's while inventories on other ownerships declined about 40 percent (Bassett and Choate 1974a, 1974b; Bolsinger and Berger 1975; Bones and Simonson 1960; Moravets 1954, 1955). Obviously, the timber industries of the area are becoming more dependent on the public forests. It seems likely that there will be increasing pressure on the National Forests of the Blue Mountains to provide wood to sustain a local economy heavily dependent on the timber industry.

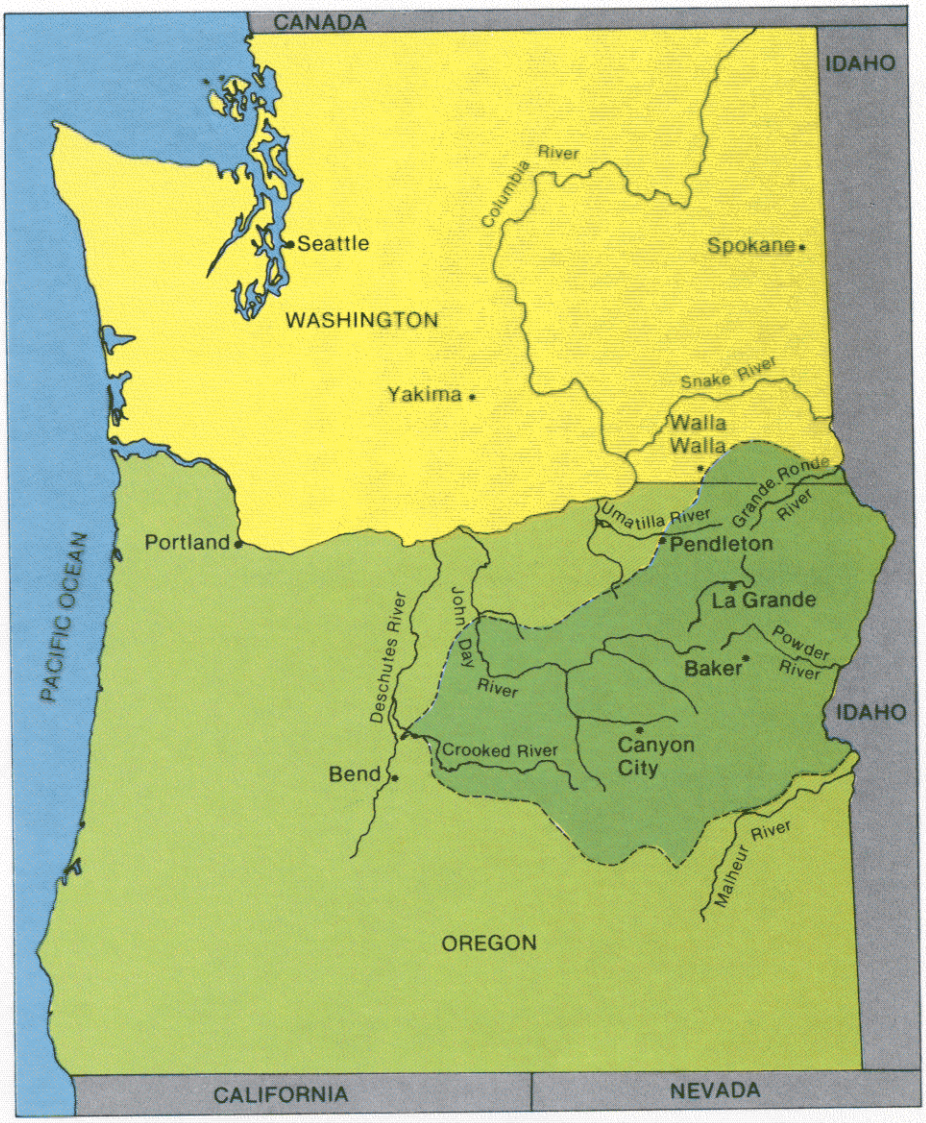
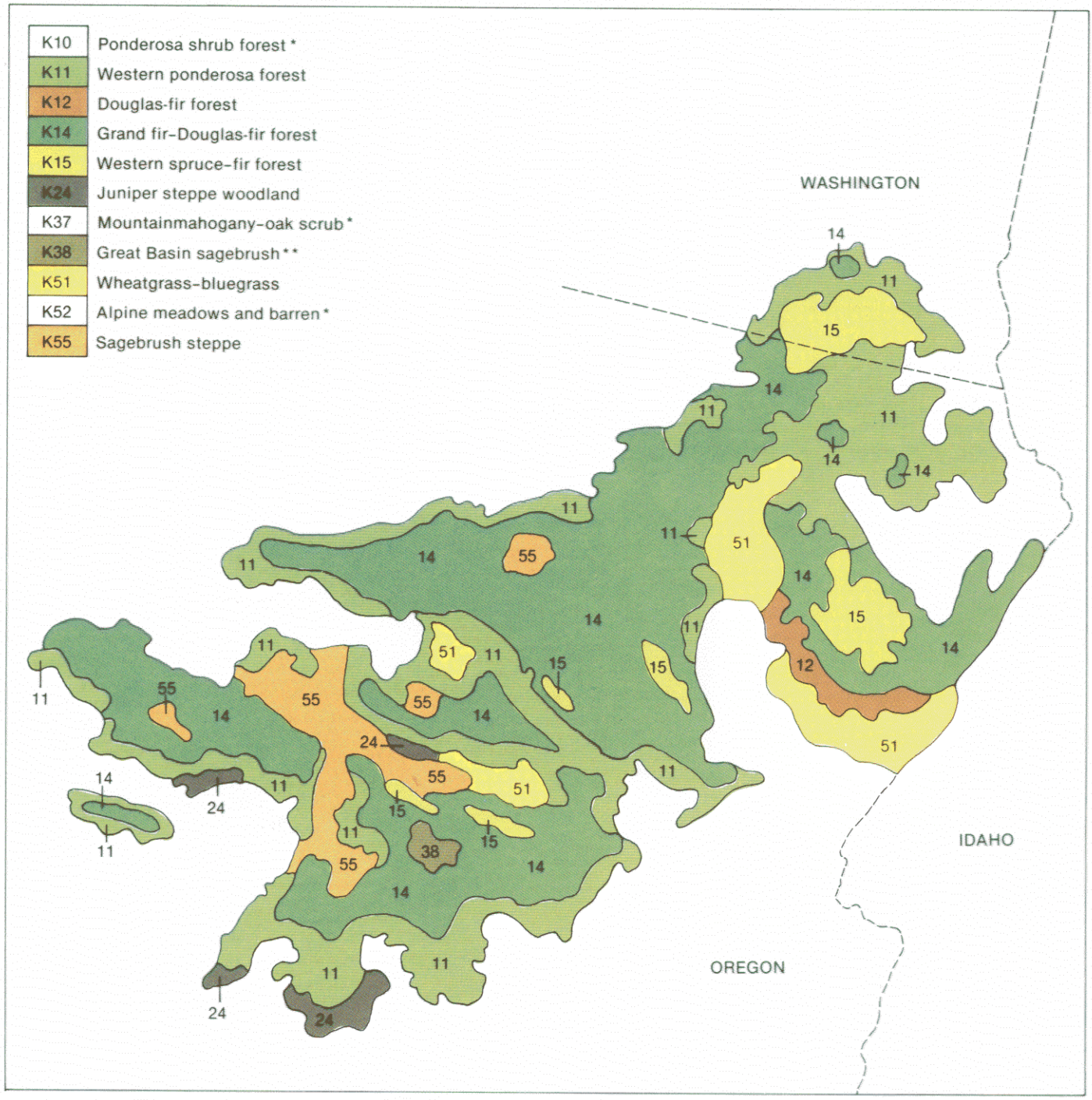


Figure 6. The Blue Mountains province (after Franklin and Dyrness 1973, p. 3).



*These classifications are too small to appear on a map of this scale.
**According to Hall (1973) K38 should be mapped as K55 sagebrush steppe.

Figure 7. Forest and range ecosystems of the Blue Mountains (after Küchler 1964).

At the same time, there is a burgeoning use of these same lands for recreation. The number of hunters, particularly elk hunters, has continued to increase. This results in increased pressure to produce and sustain large numbers of deer and elk. Extensive areas are classified as Wilderness, and other areas are being considered for addition to the Wilderness System. Such special use allocation, no matter how well justified, will increase industry and public pressure on managers of the public forests to produce more timber from fewer acres.

Increasing demands for more timber, wildlife, recreation, and grazing lead inevitably to conflicts. Careful management will be necessary to obtain the desired wildlife and wildlife-related recreational experiences from such heavily managed forests.

The Following Chapters

The following chapters are presented in a sequence designed to logically develop certain principles and ideas. Chapter 2 relates all terrestrial vertebrates to wildlife habitats that are described by plant community and their successional stage or condition. The idea is that each species is adapted to a particular habitat and the welfare of each species can be predicted by the quantity and quality of available habitat. The purpose is to show the manager how to deal simultaneously with all species in forest land-use planning.

Chapters 3 through 7 discuss special and unique habitats. Special habitats are biological in nature, can be manipulated by the forest manager, and play a critical role in the lives of at least some species. These habitats include riparian zones, edges, snags, logs, and other dead woody material on the forest floor. Unique habitats are geomorphic in nature, usually cannot be manipulated to the advantage of wildlife, and are critical to certain species. In the Blue Mountains such habitats include cliffs, talus, and caves.

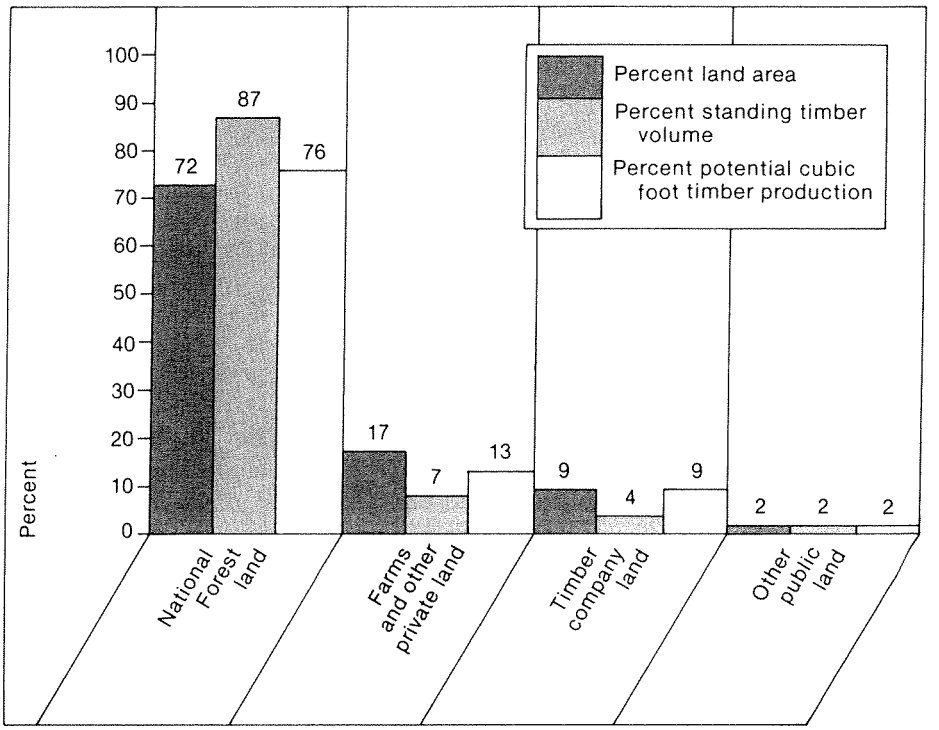


Figure 8. Percent of standing timber volume in the Blue Mountains by ownership class (Bolsinger and Berger 1975; Bassett and Choate 1974a, 1974b; Lloyd, unpublished, see "References Cited").

Chapter 8 points out that some animals receive more attention in forest planning and management than others. As Orwell (1946, p. 112) put it: "ALL ANIMALS ARE EQUAL BUT SOME ANIMALS ARE MORE EQUAL THAN OTHERS." Federal agencies, for example, are required by law to pay special attention to species designated as threatened or endangered. More attention is also paid to economically important animals, such as game species or other animals that provide recreational opportunities. Mule deer and elk are used as examples of how forests can be managed to provide habitat for such featured species.

Chapter 9 demonstrates that there are often several silvicultural approaches that will meet diverse wildlife goals and at the same time produce the desired wood products. The message is that both wildlife and timber management objectives can be met, given flexibility and careful planning.

Chapter 10 turns the tables. Up to this point the emphasis has been on predicting the consequences to wildlife of various timber management decisions. But to make well-informed decisions, the forest manager needs to know all the trade-offs. This final chapter provides a system for predicting the consequences to timber production of decisions made to enhance wildlife habitat.

2
Plant Communities and Successional Stages

by
Jack Ward Thomas
Rodney J. Miller
Chris Maser
Ralph G. Anderson
Bernie E. Carter

The Federal forest land manager must account for the impacts—whether good or bad—of management activities on all species of wildlife. The legal challenges, reviews, and court opinions that have emerged from conflicts over management of Federal forest land have raised questions for which the land manager has had inadequate answers.

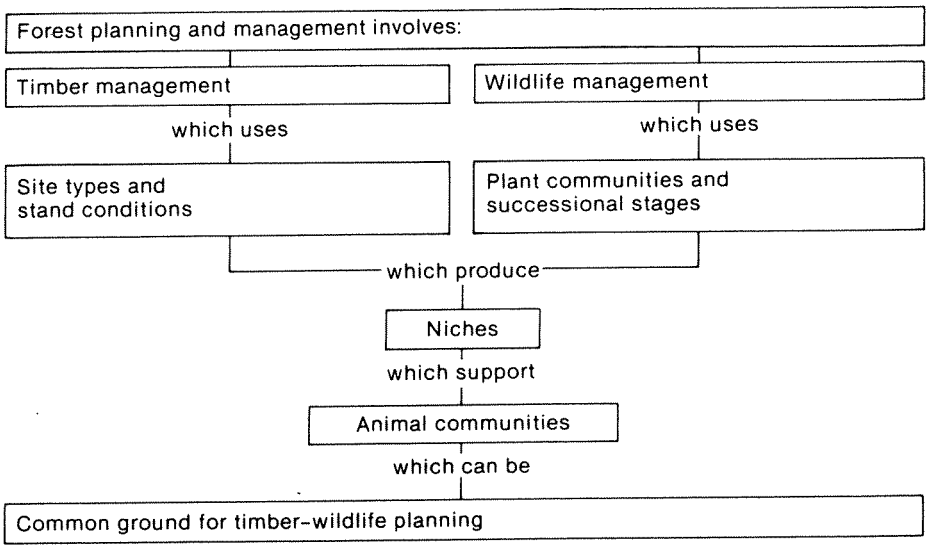
For example, which species of wildlife will be adversely influenced, which benefited, and which unaffected by forest management activites? What is the degree of impact on those species? How will these influences vary over time? Which negative impacts are irreversible and which can be reduced by appropriate management activity? Which species are especially sensitive to habitat change and how will they respond to habitat alterations? Which species are threatened or endangered and how will they be influenced?

This chapter shows how the forest manager can deal with these problems in forest management planning. The system described is designed to handle a large volume of technical information about wildlife and their habitats in a way that makes sense to the forest manager.

The first task was to assemble all pertinent data for the 378 species of vertebrates in the Blue Mountains. The amount of data varied from extensive for some species to almost nothing for others. This presented two problems—how to "fill in the blanks" when information was inadequate and how to present information on a large number of species without overwhelming the manager with detail.

Another problem was to weigh the impact of timber management activities on wildlife. There are basically two ways to consider wildlife in forest planning and management. The more traditional way is to develop management plans for one or several species of prime interest. But this does not take into account the habitat needs of all species. The approach used here was to consider habitat as the prime determinant of wildlife welfare and to associate wildlife with habitat condition.

Wildlife habitats also had to be identified in such a way that they could be considered simultaneously with timber management activities. This was accomplished by equating plant communities and their successional stages with habitats for wildlife. Successional stages are the result of the natural growth and development of plant communities. These stages are sometimes altered by management activities, such as controlling brush, planting or seeding trees or grass, and thinning forest stands. The conditions produced by these activities differ somewhat from natural conditions, but they are roughly equivalent because the structure of the altered forest is similar to natural conditions at various stages of succession. By associating individual wildlife species and groups of species with plant communities and their successional stages (fig. 9), the forest manager can translate standard forest inventories into information on wildlife habitats.



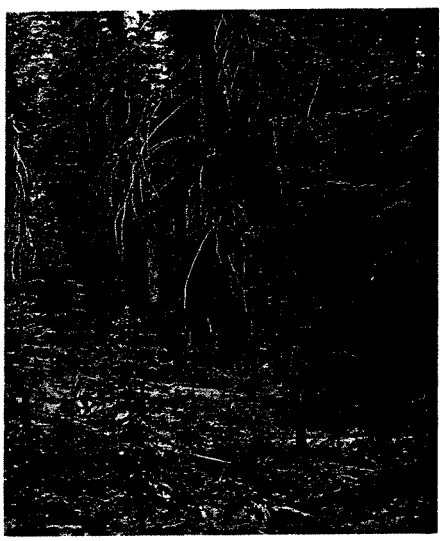
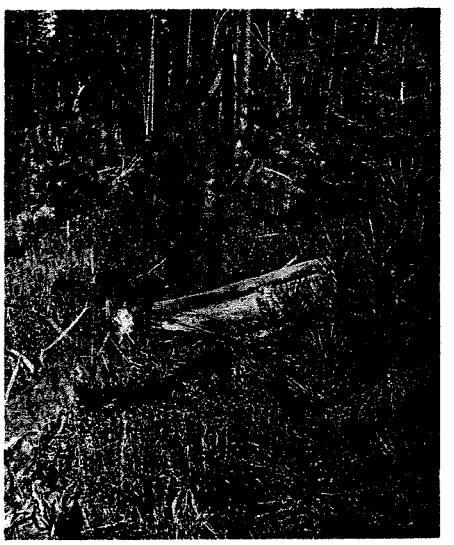


Figure 9. Plant communities and their successional stages can be a common ground for timber-wildlife planning.

Timber harvest activities produce conditions that mimic natural stages of succession. Clearcutting, for example, changes a mature or old-growth forest (left) to the grass-forb stage and then to the shrub-seedling stage (below).



Plant Community Descriptions

The starting point for describing the plant communities was the classification of the forest and range ecosystems of the Blue Mountains as adapted from Garrison et al.'s (1977) descriptions of forest and range ecosystems. This classification required some modification to bring it in line with other systems already in use by forest land managers. Since wildlife usually respond to vegetative structure rather than plant species composition, structurally similar ecosystems were grouped and others were divided or identified as structurally distinct and important habitats.

Forest and range ecosystems as described by Garrison et al. (1977)	Plant community designations used in this publication	Plant community types of the Blue Mountains as described by Hall (1973)	Potential natural vegetation as described by Küchler (1964)
Sagebrush	Sagebrush-bitterbrush	Stiff sage scabland Low sagebrush/bunchgrass Big sagebrush/bunchgrass Bitterbrush/bunchgrass	K55 Sagebrush steppe
Pinyon-juniper	Western juniper	Juniper/bunchgrass Juniper/stiff sage scabland Juniper/low sagebrush Juniper/big sagebrush	K24 Juniper steppe woodland
Ponderosa pine	Ponderosa pine	Ponderosa pine/wheatgrass Ponderosa pine/fescue Ponderosa pine/bitterbrush/Ross sedge Ponderosa pine/blue wildrye	K10 Ponderosa shrub forest K11 Western ponderosa forest
Douglas-fir	Mixed conifer	Ponderosa pine-Douglas-fir/elk sedge Ponderosa pine-Douglas-fir/ snowberry-oceanspray Ponderosa pine-Douglas-fir/ninebark	K12 Douglas-fir forest [interior]
Larch		Mixed conifer/pinegrass-ash soil Mixed conifer/pinegrass-residual soil	K14 Grand fir-Douglas-fir forest
Spruce-fir	White fir (grand fir)	White fir/twinflower White fir/big huckleberry White fir/grouse huckleberry	
	Subalpine fir	Subalpine fir/big huckleberry Subalpine fir/grouse huckleberry Subalpine fir-whitebark pine/sedge	K15 Western spruce-fir forest
Lodgepole pine	Lodgepole pine	Lodgepole/pinegrass-grouse huckleberry Lodgepole/big huckleberry Lodgepole/grouse huckleberry	[No provision in Küchler (1964)]
Chaparral-mountain shrub	Other shrubs	Snowberry shrubland Ninebark shrubland Thinleaf alder snowslides	[No provision in Küchler (1964)]
	Curlleaf mountainmahogany	Curlleaf mountainmahogany/grass	K37 Mountainmahogany-oak scrub
Mountain meadows	Dry meadow	Dry meadow	[No provision in Küchler (1964)]
	Moist meadow	Moist meadow Wet meadow	
	Quaking aspen	Quaking aspen meadow	
Mountain grasslands	Other grasses	Bunchgrass on shallow soil, gentle slopes Bunchgrass on deep soil, gentle slopes Bunchgrass on shallow soil, steep slopes Bunchgrass on deep soil, steep slopes Bluegrass scabland Biscuit scabland	K51 Wheatgrass-bluegrass
Alpine	Alpine meadow	Subalpine fir-whitebark pine/sedge Alpine sagebrush Alpine fescue Alpine sedge Alpine fleeceflower	K52 Alpine meadows and barren
[No provision in Garrison et al. (1977)]	Riparian (deciduous)	[No provision in Hall (1973)]	[No provision in Küchler (1964)]

Figure 10. Relationships between plant communities as described in this publication and three other plant classification systems used in the Blue Mountains (sources: appendix 25 and table 40).

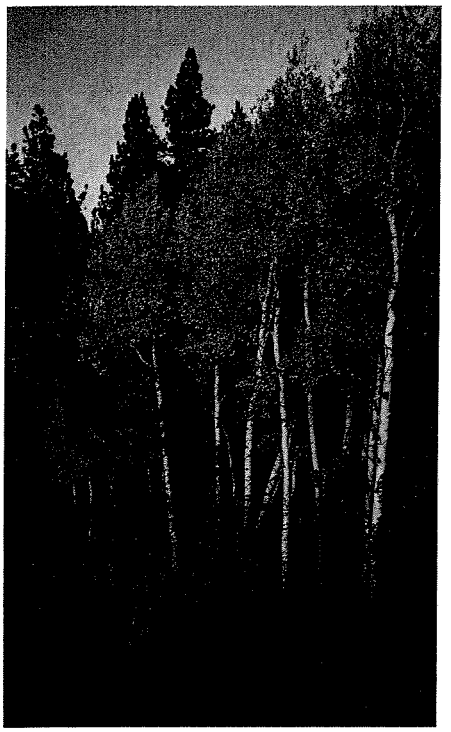
The modifications are described in figure 10 which shows the relationship between the ecosystems described by Garrison et al. (1977) and Küchler (1964) and the plant community types in the Blue Mountains described by Hall (1973). Hall's classification system is much more detailed and is widely used in Forest Service planning and management in the Blue Mountains. It could not be used in this book, however, because information on the relationships of wildlife to their habitats was not detailed enough.

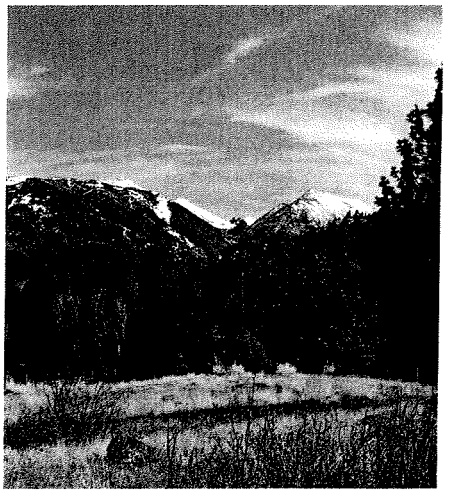
The following discussion shows why and how these descriptions of ecosystems and plant communities were modified to fit the wildlife habitat conditions in the Blue Mountains. Similar modifications would probably be required of any standard vegetative classification scheme.

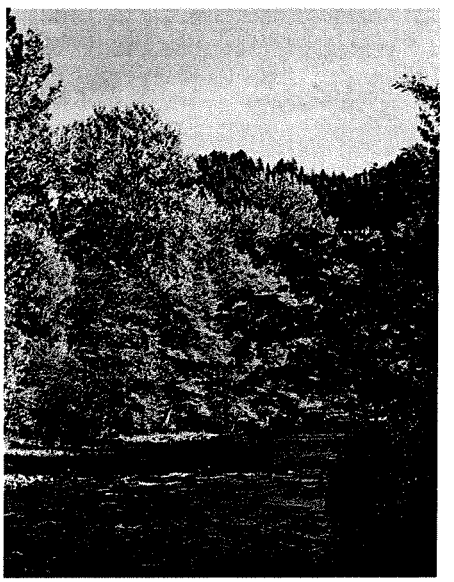
The Douglas-fir and larch ecosystems were combined to make up the mixed conifer community. In the Blue Mountains, these ecosystems are most frequently found as a mix of conifers commonly involving two or more of these species: Douglas-fir, larch, ponderosa pine, lodgepole pine, and white fir. Mixed conifer stands have a structure that is reasonably consistent and usually quite diverse compared with relatively pure stands. In addition, the mixed conifer designation was already used for timber management and land-use planning.

The spruce-fir ecosystem was divided into white fir and subalpine fir. These subdivisions are well developed, and each has a distinct structure which results in different wildlife communities.

The chaparral-mountain shrub ecosystem was broadly defined. The two expressions of this ecosystem frequently encountered are curlleaf mountainmahogany-dominated communities and other shrub-dominated communities, such as those dominated by ninebark, ceanothus, and oceanspray. Curlleaf mountainmahogany is associated with rocky outcrops where the shrubs are protected from fire (Dealy 1975). The other shrub-dominated communities usually occur on forest sites after a disturbance, such as fire, logging, snowslides, avalanches, or overgrazing. Shrub communities that result from such disturbances can last a long time but are eventually replaced by other vegetation.







Each plant community supports a distinct animal community. Three plant communities common in the Blue Mountains are quaking aspen (above left), mixed conifer (above right), and riparian.

Three other communities—aspen, riparian, and other grasslands—are contained within two or more of the ecosystems. They are separately identified here because they are distinct and important communities for wildlife. For example, aspen does not occur over large enough areas to be identified as an ecosystem, but numerous stands are scattered throughout higher elevations. Deciduous stands within the predominantly coniferous forest and grassland landscape add a different kind of wildlife habitat.

Riparian communities are well developed along stream courses in forest, grassland, and shrub areas. These communities are characterized by deciduous shrubs and trees, primarily cottonwood and willow, that have distinct structure and lots of edge with special value to wildlife.

Other grasslands include all grasslands cultivated and maintained in selected grasses and forbs.

Environmental variable	Successional stages: Grass-forb	Shrub-seedling	Pole-sapling	Young	Mature	Old growth
Plant diversity	●●	●●●●●	●●●	●	●●	●●●
Vegetation height		●	●●	●●●	●●●●	●●●●●
Canopy volume		●	●●	●●●	●●●●●	●●●●
Canopy closure	●	●●	●●●●	●●●●	●●●●	●●●
Structural diversity	●	●●●●	●	●	●●	●●●●●
Forage production	●●●●●	●●●	●	●	●●	●●●
Browse production	●	●●●●●	●	●	●●	●●●
Animal diversity	●●●	●●●●	●	●●	●●●●●	●●●●

Figure 11. Forest successional stages and related environmental conditions.

Wildlife Habitat Relationships

Plant communities and their successional stages have unique environmental conditions that are ecologically important as niches for wildlife species (fig. 11). The niches are a product of the plant community, its successional stages, and other environmental factors—including soil type, moisture regime, microclimate, slope, aspect, elevation, and temperature. The complex interactions of site and plant community structure could be dissected and the more precise influence of each on the animal community determined. If such information existed, it would probably be too complex to use readily. The plant community type, however, can be considered an integrator of the many factors interacting on the site.

Wildlife species are individually adapted to combinations of plant community and successional stage for feeding or reproduction or both. These wildlife-habitat relationships provide the basic information from which the following informational displays (tables, figures, and appendices) were developed. Depending on their requirements, forest managers and planners can extract information at four levels of detail. The amount of detail increases with each level:

Level 1: The relationship of animal life forms to plant communities and their successional stages for feeding and reproduction. Life forms are groups of wildlife species that exhibit similar habitat requirements for both feeding and reproduction.

Level 2: The relationship of individual species to plant communities and their successional stages for feeding and reproduction.

Level 3: A summary of the available biological data for each species.

Level 4: Selected references on habitat relationships for each species. Examination of these references and their bibliographies can provide the user with more detailed data and additional sources of information.

The information on each species in level 2 has been used to develop a relative measure of vulnerability of each species to habitat manipulation. This is another source of information for the manager's use.

The informational displays were constructed from: (1) the literature, (2) interpretation and extrapolation of information in that literature, and (3) a consensus of wildlife biologists. In all cases, the best available information was used. If the literature was specific to the Blue Mountains and contained the required information, it was used. If the literature was not specific to the area or habitat condition, it was adapted as appropriate. In the absence of published information, the relationship of the species to habitat was determined by consensus of the consulting biologists.

Naturally, data for the most intensively studied species were more voluminous and detailed than for relatively obscure species. As new information becomes available, it can be added to the system.

Level 1: Life Form Association with Plant Communities and Successional Stages

The large number of wildlife species present in most areas makes it difficult for the land manager to account for them in the land-use planning process. In the Blue Mountains, this number was reduced from 378 species (appendix 1) to 16 life forms (table 1). This life form concept was adapted from Haapanen's (1965) division of birds of the Finnish forests into groups based on specific combinations of habitat requirements for reproduction and feeding. The concept was expanded to include all terrestial vertebrates. The relationship of the species to their habitats is the basis for grouping them into life forms.

This grouping is distinctly different from the usual grouping of species by morphological characteristics. It enables the forest manager to evaluate the response of wildlife to habitat much more readily than if each species were considered individually. If this concept is applicable in land use planning, new and different life forms will most likely be developed. They can be changed as needed to fit the circumstances.

The relationship of vertebrate life forms to plant communities and successional stages is shown in appendix 10 (table 2). Fifty-two of the 378 species that occur in the Blue Mountains do not appear in this listing or subsequent discussion. Fifty-one bird species migrate through or are accidental in the Blue Mountains. The bullfrog, the only species in life form 1, has also been omitted as it is semiterrestrial. The 51 bird species excluded are listed in appendix 3.

Life form 13 is shown here as an example. The species in life form 13 feed in trees, in bushes, on the ground, or in the air and excavate their own holes in trees for nesting. In the Blue Mountains, the life form contains 13 species.

Life form	Reproduces	Feeds	No. of species[1]	Examples
1	in water	in water	1	bullfrog
2	in water	on the ground, in bushes, and/or in trees	9	long-toed salamander, western toad, Pacific treefrog
3	on the ground around water	on the ground, and in bushes, trees, and water	45	common garter snake, killdeer, western jumping mouse
4	in cliffs, caves, rimrock, and/or talus	on the ground or in the air	32	side-blotched lizard, common raven, pika
5	on the ground without specific water, cliff, rimrock, or talus association	on the ground	48	western fence lizard, dark-eyed junco, elk
6	on the ground	in bushes, trees, or the air	7	common nighthawk, Lincoln's sparrow, porcupine
7	in bushes	on the ground, in water, or the air	30	American robin, Swainson's thrush, chipping sparrow
8	in bushes	in trees, bushes, or the air	6	dusky flycatcher, yellow-breasted chat, American goldfinch
9	primarily in deciduous trees	in trees, bushes, or the air	4	cedar waxwing, northern oriole, house finch
10	primarily in conifers	in trees, bushes, or the air	14	golden-crowned kinglet, yellow-rumped warbler, red squirrel
11	in conifers or deciduous trees	in trees, in bushes, on the ground, or in the air	24	goshawk, evening grosbeak, hoary bat
12	on very thick branches	on the ground or in water	7	great blue heron, red-tailed hawk, great horned owl
13	in own hole excavated in tree	in trees, in bushes, on the ground, or in the air	13	common flicker, pileated woodpecker, red-breasted nuthatch
14	in a hole made by another species or in a natural hole	on the ground, in water, or the air	37	wood duck, American kestrel, northern flying squirrel
15	in a burrow underground	on the ground or under it	40	rubber boa, burrowing owl, Columbian ground squirrel
16	in a burrow underground	in the air or in the water	10	bank swallow, muskrat, river otter
		Total:	327	

[1]Species assignment to life form is based on predominant habitat-use patterns.

Table 1. Life form descriptions (source: appendix 7)

The Columbian ground squirrel belongs to life form 15. It characteristically feeds above ground and reproduces in a burrow underground.

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 0 F 2	Shrub-seedling (0-10 years) R 0 F 2	Pole-sapling (11-39 years) R 0 F 1	Young (40-79 years) R 8 F 8	Mature (80-159 years) R 13 F 13	Old growth (160 + years) R 12 F 12
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 0	F	0					
Moist meadow	R 0	R	0					
	F 0	F	0					
Other grasses	R 0	R	0					
	F 0	F	0					
Sagebrush-bitterbrush	R. 0	R	0	0				
	F 0	F	0	0				
Other shrubs	R 0	R	0	0				
	F 0	F	0	0				
Curlleaf mountain-mahogany	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Western juniper	R 1	R	0	0	0	1	1	1
	F 1	F	1	1	1	1	1	1
Quaking aspen	R 3	R	0	0	0	3	3	*as above
	F 4	F	1	1	1	3	4	
Riparian (deciduous)	R 4	R	0	0	0	4	4	
	F 4	F	2	2	1	4	4	
Ponderosa pine	R 8	R	0	0	0	3	8	8
	F 8	F	2	2	1	3	8	8
Mixed conifer	R 9	R	0	0	0	5	10	10
	F 10	F	2	2	1	5	10	10
White fir (grand fir)	R 6	R	0	0	0	4	6	6
	F 6	F	1	1	1	4	6	6
Lodgepole pine	R 4	R	0	0	0	4	*as above	
	F 4	F	0	0	0	4		
Subalpine fir	R 4	R	0	0	0	3	4	4
	F 4	F	0	0	0	3	4	4
Alpine meadow	R 0	R	0	*as above				
	F 0	F	0					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 13 is equivalent to 10 units.

Table 2. Relative degree of use of plant communities and successional stages by wildlife species in life form 13 (source: appendix 10)

Much useful information can be derived from such displays. From table 2 it can be seen that: (1) life form 13 is strongly associated with forest communities, (2) some forest communities, such as ponderosa pine and mixed conifer, are disproportionately important, and (3) the older forest successional stages are critical. Reproductive and feeding orientation to plant community types and their successional stages can be determined for the entire life form.

By examining the relationship of the life form to plant communities and their successional stages, the forest manager can judge the impact of forest management practices on the life form. This is done by determining the importance (expressed by the number of species) of a particular successional stage of a community. The impact of a contemplated management action is determined by comparing the two numbers for the stages involved.

For example, consider the importance of the mature (150-year-old) stage of a mixed conifer forest to life form 13. Of the 13 species in the life form, 11 feed there and 10 species reproduce there. The manager is contemplating two courses of action: (1) harvest the stand by clearcutting, thereby altering the vegetative condition to the grass-forb stage or (2) forgo timber harvest and allow the area to progress to the old-growth successional stage and harvest at stand age 180. What are the consequences of each alternative to life form 13?

Reduction to the grass-forb successional stage would eliminate reproduction for all 10 species and eliminate feeding for 9 species. This extremely adverse impact would continue for about 40 years after regeneration. At that time, the stand would enter the young forest successional stage where six species both feed and reproduce. Full recovery of the habitat for life form 13 would not occur until the stand was about 80 years old and had returned to the mature forest successional stage.

A decision to allow the stand to progress from the mature stage to the old-growth stage would have little effect on the life form because 11 species feed and 10 species reproduce in both stages. The area would continue as good habitat for 30 years until the stand is clearcut. Then it would revert to the grass-forb stage with the results already discussed.

Management action	Grass-forb	Shrub-seedling	Pole-sapling	Young	Mature	Old growth
Shrub control:						
• Herbicides	▶	▶	▶	◀	◀	◀
• Mechanical control	◀	◀	NA	◀	◀	◀
Controlled burn:						
• Cold burn	◀	◀	▶	▶	◀	◀
• Hot burn	◀	◀	◀	◀	◀	◀
Fertilization	◀	▶	▶	▶	▶	O
Grazing and browsing (moderate rates):						
• Cattle and sheep	◀	▶	O	O	◀	◀
• Goats	O	◀	O	O	◀	◀
• Deer and elk	◀	▶	O	O	◀	◀
Planting:						
• Trees	▶	▶	NA	NA	▶	▶
• Shrubs	▶	◀	NA	NA	NA	NA
• Grasses-forbs	▶	◀	NA	▶	▶	O
Regeneration cut:						
• Clearcut	NA	NA	NA	◀	◀	◀
• Shelterwood	NA	NA	NA	▶	◀	◀
• Seed tree	NA	NA	NA	◀	◀	◀
Salvage	NA	NA	◀	◀	◀	◀
Thinning (including single tree selection harvest)	NA	▶	▶	▶	▶	O
Successional stage condition						

▶ advances succession
◀ retards succession
O no effect on succession
NA not applicable

Table 3. Anticipated changes in successional stage or condition because of management activities

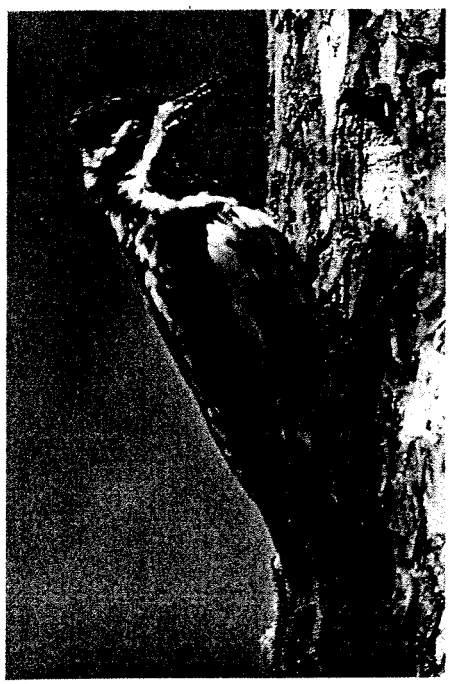
Obviously, if the manager considered factors such as the percentage of the area affected, the distribution of plant communities and successional stages, and anticipated changes over time, a more sophisticated analysis could be made. But the same basic comparisons would be used.

The displays in appendix 10 can be used to predict the response of animal life to all alterations in the plant community, whether manmade or natural. Such alterations could result from natural phenomena, such as fire, insect infestation, or windstorm, or from management activites like seeding, planting, herbicide treatment, thinning, or fertilization.

Any of these actions would either advance or retard succession (table 3) (Thomas et al. 1975). For example, planting trees advances succession, thinning and fertilization make stands appear older, and wildfire sets succession back. Since wildlife is mainly a product of the vegetative structure of a community and not the age of the vegetation, it is possible to predict the effect of various manipulations of vegetation on wildlife.

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	• Reproduction and feeding R Reproduction only F Feeding only																		
	BIRDS																		
COAU	common flicker								•	•	•	•	•	•				6	6
DRPI	pileated woodpecker											•	•	•				3	3
ASLE	Lewis' woodpecker										•	•	•					3	3
SPVA	yellow-bellied sapsucker									•	•							2	2
SPTH	Williamson's sapsucker											•	•	•		•		4	4
DEVI	hairy woodpecker											•	•	•	•	•		5	5
DEPU	downy woodpecker									•	•							2	2
DEAL	white-headed woodpecker											•	•					2	2
PIAR	black-backed three-toed woodpecker												•	•	•	•		4	4
PITR	northern three-toed woodpecker														•	•		2	2
SICA	white-breasted nuthatch											•	•					2	2
SICAN	red-breasted nuthatch												•	•	•			3	3
SIPY	pygmy nuthatch									F		•	F					1	3
	No. of species using each community:	Reproduction	0	0	0	0	0	0	1	3	4	8	9	6	4	4	0		
		Feeding	0	0	0	0	0	0	1	4	4	8	10	6	4	4	0		

Table 4. Orientation of wildlife species in life form 13 to plant communities (source: appendix 8)



The yellow-bellied sapsucker shows primary orientation to the quaking aspen and riparian communities.

Level 2: Relationship of Species to Plant Communities and Successional Stages

The responses of vertebrate life forms to plant communities and successional stages can be generalized. But the response of each species within a life form varies because of its specific habitat requirements. Level 2 shows orientation to plant community and successional stage for each species. Species are grouped by life form to facilitate comparison with information in level 1. The primary orientation of species within life forms to plant communities is illustrated for life form 13 in table 4. Similar information for all life forms is in appendix 8. Information on species orientation to successional stages is illustrated in table 5; complete information for all life forms is in appendix 9.

The use of plant communities and successional stages by a particular species can be determined from appendices 8 and 9. Table 4 contains information on the orientation of species to plant communities for feeding and reproduction. Table 5 shows the use of successional stages by each species. The two sets of information must be considered in tandem—one before the other.

For example, the pygmy nuthatch shows orientation to the aspen community for feeding only. This means that information on reproduction in table 5 should be disregarded for the pygmy nuthatch in the aspen community.

Wildlife obviously have habitat requirements other than plant community and successional stage. Orientations to special and unique habitat components are shown for all life forms in appendix 14 and illustrated for life form 13 in table 6. The importance of these special and unique habitat components, as reflected by the number of wildlife species using them, is shown in figure 12.

Additional information may be derived from appendices 8 and 9. The total number of species oriented to each plant community and successional stage for feeding and reproduction was used to produce appendix 10 and table 2 which demonstrate the orientation of the life form. In other words, to develop the information on life form (level 1) the information for individual species in level 2 must first be completed.

The information in level 2 has a variety of uses. For example, the importance of each community and successional stage can be evaluated in terms of its ability to provide habitat for different species. In each planning scenario, the forest manager can examine the impact of proposed management actions on wildlife—individual species or all wildlife. The information can also be used to determine the role of plant communities as habitat for featured species or for rare and endangered species.

Species			• Reproduction and feeding R Reproduction only F Feeding only							
BIRDS										
COAU	common flicker		F	F	F	•	•	•	3	6
DRPI	pileated woodpecker						•	•	2	2
ASLE	Lewis' woodpecker		F	F		•	•	•	3	5
SPVA	yellow-bellied sapsucker					•	•		2	2
SPTH	Williamson's sapsucker						•	•	2	2
DEVI	hairy woodpecker					•	•	•	3	3
DEPU	downy woodpecker					•	•	•	3	3
DEAL	white-headed woodpecker						•	•	2	2
PIAR	black-backed three-toed woodpecker					•	•	•	3	3
PITR	northern three-toed woodpecker					•	•	•	3	3
SICA	white-breasted nuthatch						•	•	2	2
SICAN	red-breasted nuthatch					•	•	•	3	3
SIPY	pygmy nuthatch						•	•	2	2
Letter code	No. of species using successional stage	Reproduction	0	0	0	8	13	12	Reproduction	Feeding
		Feeding	2	2	1	8	13	12		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Table 5. Orientation of wildlife species in life form 13 to successional stages (source: appendix 9)

SPECIES		• Reproduction and feeding R Reproduction only F Feeding only																								
BIRDS																										
COAU	common flicker	•	•	•	•	•	•		•	•			•				F	F	•	F					10	13
DRPI	pileated woodpecker	•	•		•	•													•	F					5	6
ASLE	Lewis' woodpecker[1]	•	•	•	•	•			•	•			•				•	•	•	F					11	12
SPVA	yellow-bellied sapsucker	•	•	•	•	•	•		•	•			•				•		•						11	11
SPTH	Williamson's sapsucker	•	•				•		F	F			F				F	F	•						4	9
DEVI	hairy woodpecker[1]	F	F		F	F	F		F	F			F				F	F	•	F					1	12
DEPU	downy woodpecker	•	•	•	•	•	•		•	•			•				F	F	•	F					10	13
DEAL	white-headed woodpecker																		•						1	1
PIAR	black-backed three-toed woodpecker																F	F	•	F					1	4
PITR	northern three-toed woodpecker[1]																		•	F					1	2
SICA	white-breasted nuthatch																F	F	•	F					1	4
SICAN	red-breasted nuthatch[1]	F	F			F	F										F	F	•	F					1	8
SIPY	pygmy nuthatch	F	F			F	F										F	F	•						1	7
Letter code	Reproduction	6	6	4	5	5	4	0	4	4	0	0	4	0	0	0	2	1	13	0	0	0	0	0	Reproduction	Feeding
	Feeding	9	9	4	6	8	7	0	6	6	0	0	6	0	0	0	10	9	13	9	0	0	0	0		
		Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
									Marshes								Edges (ecotones)				Unique habitats					
			Special habitats (components)																							

[1]Species of special interest; see appendix 4.

Table 6. Orientation of wildlife species in life form 13 to special and unique habitats (source: appendix 14)

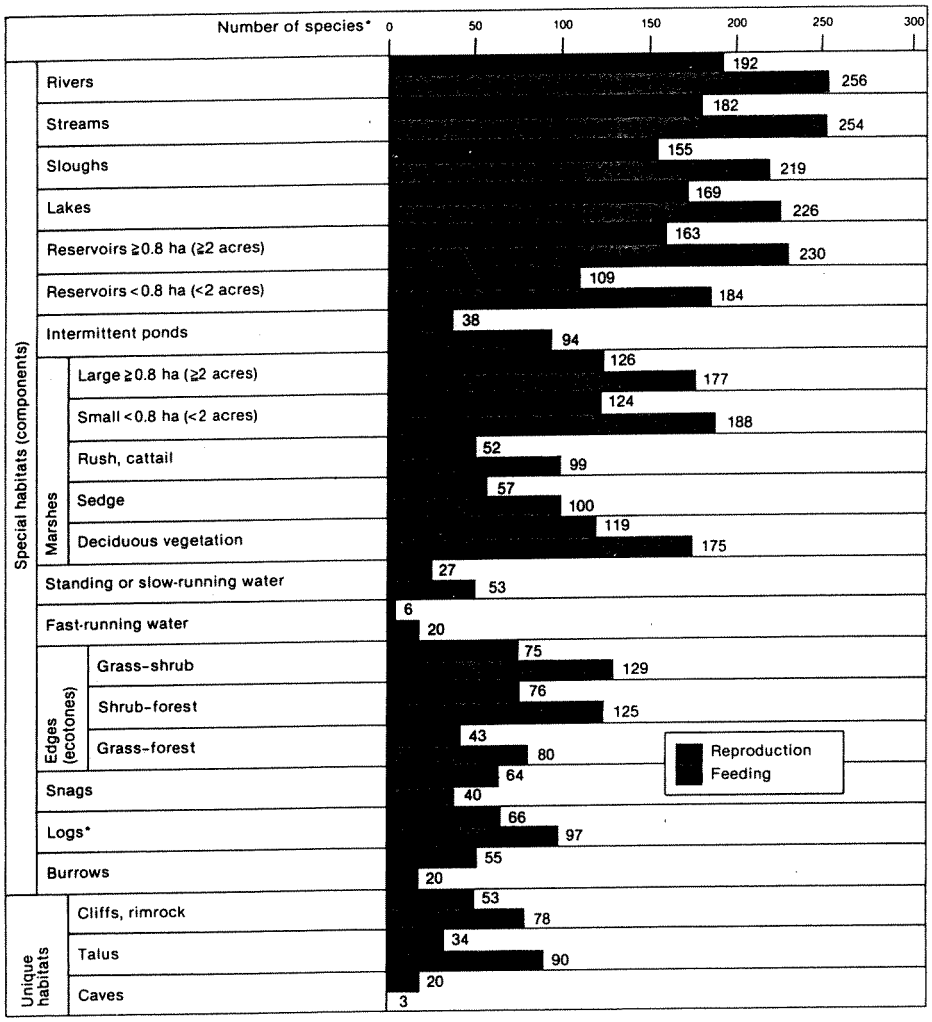


Figure 12. Number of terrestrial vertebrate wildlife species using special and unique habitats (source: appendix 15).

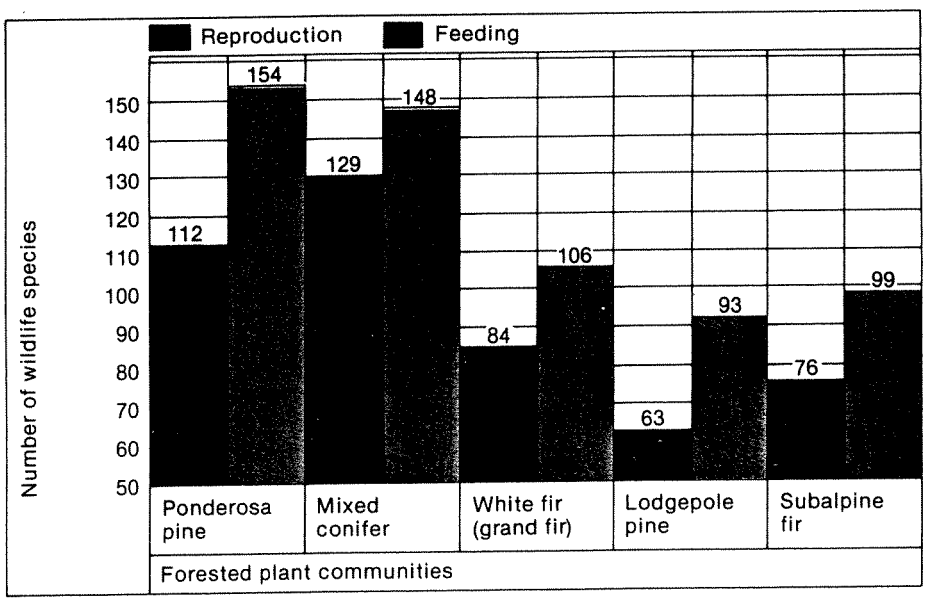


Figure 13. Number of wildlife species oriented to forested plant communities for feeding and reproduction (source: appendix 8).

Some forest communities obviously produce more species of wildlife than others (fig. 13). It should be interesting to the manager to note that the ponderosa pine and mixed conifer communities in the Blue Mountains—those most affected by timber management activites—are also the most productive in terms of wildlife.

Figure 14 shows that the later stages of succession in the mixed conifer community are important to more species than are earlier stages. Habitat for reproduction is also more restrictive than habitat for feeding. A similar display for all plant communities is shown in appendix 11.

Using the same data, the forest manager can predict the response of individual species to alterations in a successional stage. For example, a series of timber sales might be planned in an extensive area covered by 80-year-old lodgepole pine stands. The stands have a dense canopy and little understory. What species are likely to be affected? In an actual analysis, the information on each species in each life form would be examined (appendices 8 and 9). As an example, consider the data for life form 13 (table 4). Of the 13 species in life form 13, 4 (hairy woodpecker, black-backed three-toed woodpecker, northern three-toed woodpecker, and the red-breasted nuthatch) have a strong association with lodgepole pine for both feeding and reproduction.

In this situation, what effect would clearcutting 35 percent of the area have on these species? Clearcutting would put those areas into the grass-forb successional stage. Table 5 shows that these four species are oriented to the mature successional stage for both feeding and reproduction. None show orientation to the grass-forb stage. It can be concluded that such action will reduce habitat for those species by approximately 35 percent for at least 40-50 years—the time required for the stand to regenerate and reach a successional stage suitable for reoccupancy.

At the same time, a number of species would benefit from the early successional stages that follow clearcutting. Appendix 9 shows that most of the species in life forms 5 and 6 would benefit for the period of time (10 to 20 years) that the grass-forb and shrub-seedling successional stages were present. As the vegetation on the site moves into the pole-sapling stage the suitability of the site for these species declines.

As another example, consider the generalized relationship of wildlife in the Blue Mountains to successional stages of forested communities (fig. 15). This shows why many people are concerned about the effects of intensive timber management on wildlife diversity and on the welfare of species that are narrowly adapted to certain successional stages, particularly grass-forb, shrub-seedling, and old growth (Wight 1974, Meslow and Wight 1975, Thomas et al. 1975).

Only a few uses of such data have been illustrated. There are as many others as there are specific management questions, and new applications are being found as managers begin to use this system.

Level 3: Summary of Biological Data by Species

Level 3 is a one-line summary of key information on each species. Some of the information was derived from the appendices and some from literature reviews. Other information was drawn from the experience of wildlife biologists.

Details for each species are presented in appendix 6. Life form 13 is shown here as an example (table 7). Additional information on distribution, habits, and other biological attributes are shown in appendix 16 and illustrated here by table 8.

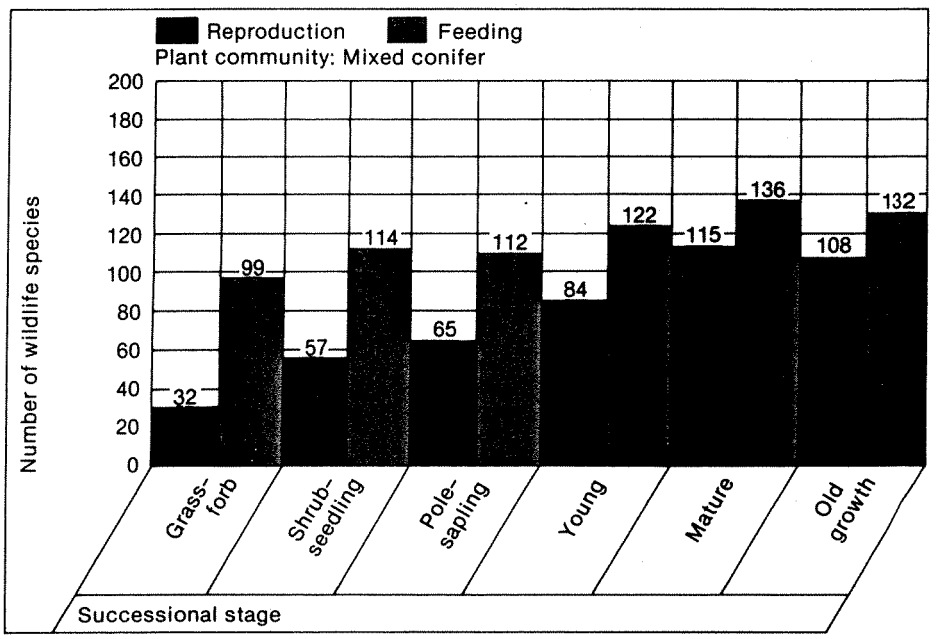


Figure 14. Number of wildlife species associated with successional stages in the mixed conifer community (source: appendix 11).

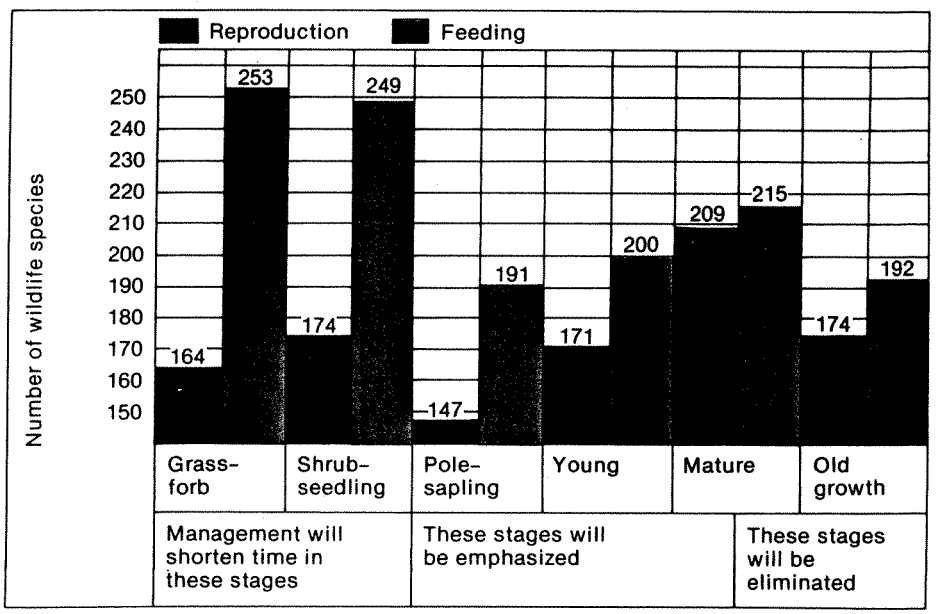


Figure 15. Number of wildlife species oriented to forest successional stages and the potential effect of intensive timber management (source: appendix 9).

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
BIRDS																	
COAU	13	common flicker	M													5-10	terr. 16.2 ha (40 acres)/pair
DRPI	13	pileated woodpecker	L													3-5	terr. 121 ha (300 acres)/pair
ASLE	13	Lewis' woodpecker[10]	L													6-8	terr. 6.1 ha (15 acres)/pair
SPVA	13	yellow-bellied sapsucker	L													4-6	terr. 4 ha (10 acres)/pair
SPTH	13	Williamson's sapsucker	L													3-7	terr. 4 ha (10 acres)/pair
DEVI	13	hairy woodpecker[10]	L													3-6	terr. 10.1 ha (25 acres)/pair
DEPU	13	downy woodpecker	L													4-7	terr. 4 ha (10 acres)/pair
DEAL	13	white-headed woodpecker	L													3-5	terr. 8.1 ha (20 acres)/pair
PIAR	13	black-backed three-toed woodpecker	L													4-5	terr. 30.4 ha (75 acres)/pair
PITR	13	northern three-toed woodpecker[10]	L													4-5	terr. 30.4 ha (75 acres)/pair
SICA	13	white-breasted nuthatch	L													5-9	
SICAN	13	red-breasted nuthatch[10]	L													4-7	
SIPY	13	pygmy nuthatch	L													6-9	

L Low; M Medium; H High ▒ Reproductive activity ■ Feeding activity

See footnotes at end of appendix 6.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
common flicker		☐	☐	☐	☐	☐	☐	● ■	● ■	● ■	● ■	● ■	○ ☐	○ ☐	☐	● ■	● ■	● ■			■	● ■	■				
pileated woodpecker										● ■	● ■	● ■	☐	☐		○ ☐	○ ☐					● ■	■				
Lewis' woodpecker[10]			☐	☐		☐			☐	● ■	● ■					● ■	● ■	● ■			● ■	● ■	■				
yellow-bellied sapsucker						☐		☐	● ■	○ ☐	○ ☐	☐	☐	☐		● ■	● ■	● ■			● ■	● ☐					
Williamson's sapsucker								☐	☐	● ■	● ■	● ■	☐	● ■		○ ☐	○ ☐	☐			■	● ☐					
hairy woodpecker[10]									☐	● ■	● ■	● ■	● ■	● ■		☐	☐	☐			☐	● ■	■				
downy woodpecker						☐			● ■	☐	☐					● ■	● ■	● ■			☐	● ■	■				
white-headed woodpecker										● ■	● ■	○ ☐	☐	○ ☐								● ■					
black-backed three-toed woodpecker										☐	● ■	● ■	● ■	● ■							☐	● ■	■				
northern three-toed woodpecker[10]											☐	○ ☐	● ■	● ■								● ■	■				
white-breasted nuthatch									☐	● ■	● ■	☐									■	● ■	☐				
red-breasted nuthatch[10]									☐	☐	● ■	● ■	● ■	☐		☐	☐				■	● ■	☐				
pygmy nuthatch									■	● ■	○ ■	☐	☐			☐	☐				■	● ■					

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); ☐ Secondary (<40%)

Table 7. Key information on species in life form 13 (source: appendix 6)

Letter code	Life form	Common name	Comments
SPTH	13	Williamson's sapsucker	Feeds by gleaning and sapsucking; locally abundant.
DEVI	13	hairy woodpecker	Feeds in both live and dead wood; widely distributed in conifer zones.
DEPU	13	downy woodpecker	Feeds and nests largely in deciduous trees; feeds primarily on surface insects on trees and bushes.
DEAL	13	white-headed woodpecker	Primarily associated with ponderosa pine; feeds by gleaning; eats pine seeds in winter; locally distributed and abundant.
PIAR	13	black-backed three-toed woodpecker	Feeds on bark and subsurface insects in both live and dead wood.
PITR	13	northern three-toed woodpecker	Feeds on bark and subsurface insects in both live and dead wood; species suggested as threatened in Oregon due to restricted habitat and local distribution (see appendix 4).
COAU	13	common flicker	Feeds extensively on ground; uses open areas; occurs in all habitat types.
DRPI	13	pileated woodpecker	Feeds largely in dead wood; requires large snags for nesting.
ASLE	13	Lewis' woodpecker	Feeds largely in air—hawking; locally abundant in deciduous timber situations; semicolonial nester.
SPVA	13	yellow-bellied sapsucker	Feeds by gleaning, sapsucking, hawking, and pecking; nesting largely restricted to open water sources.
SICA	13	white-breasted nuthatch	Primarily associated with ponderosa pine; feeds extensively on insects in trunk bark of live trees.
SICAN	13	red-breasted nuthatch	Associated with mixed conifer stands; feeds extensively on insects in bark of live trees.
SIPY	13	pygmy nuthatch	Primarily associated with ponderosa pine; forages in flocks; feeds on insects in bark and on surface of trees; locally distributed in ponderosa pine zone; loosely colonial.

Table 8. Information of management significance for wildlife species in life form 13 (source: appendix 16)

Level 4: Selected References

If the information displayed so far is not sufficient, additional sources may be consulted. The most appropriate references for each species are listed in appendix 29, illustrated here by table 9 for life form 13. If the user, after consulting the sources suggested, still does not have sufficient information, the literature cited sections of these sources may provide useful leads.

Versatility Index

Each wildlife species exhibits a different degree of versatility (adaptability) in the number of plant communities and successional stages it can use for feeding and reproduction. The sensitivity of each species to habitat change is directly related to that versatility. The most versatile species are the least sensitive to habitat manipulation; the least versatile are most sensitive.

Data in appendices 8 and 9 (illustrated by tables 4 and 5) were used to develop a versatility score (V score) for each species. The V scores can be used to rate the versatility of individual species. Collectively, the scores also provide an index to the relative versatility of all resident wildlife species.

The V score for each species is derived by determining the total number of plant communities and the total number of successional stages to which the species show primary orientation for feeding and reproduction:

$$V = (C_r + S_r) + (C_f + S_f);$$

where V is the versatility score, C_r is the number of communities used by the species for reproduction, S_r is the number of successional stages used for reproduction, C_f is the number of communities used for feeding, and S_f is the number of stages used for feeding.

Letter code	Life form	Species	Selected references
		BIRDS	
COAU	13	common flicker	Anderson 1972, Burns 1900, Conner 1973, Jackman 1974b, Jackman and Scott 1975, Kelleher 1963, Lawrence 1967, Neff 1926
DRPI	13	pileated woodpecker	Anderson 1972, Bull 1975, Conner 1973, Hoyt 1957, Jackman 1974b, Jackman and Scott 1975, Meslow and Wight 1975, Tanner 1942
ASLE	13	Lewis' woodpecker	Bent 1964c, Bock 1970, Bock et al. 1971, Jackman 1974b, Jackman and Scott 1975
SPVA	13	yellow-bellied sapsucker	Bent 1964c, Erskine and McLaren 1972, Jackman 1974b, Kilham 1971b, Rushmore 1973
SPTH	13	Williamson's sapsucker	Bent 1964c, Jackman 1974b, Michael 1935
DEVI	13	hairy woodpecker	Anderson 1972, Conner 1973, Jackman 1974b, Kilham 1968a, Lawrence 1967, Staebler 1949
DEPU	13	downy woodpecker	Anderson 1972, Conner 1973, Jackman 1974b, Jackson 1970, Lawrence 1967, Staebler 1949
DEAL	13	white-headed woodpecker	Bent 1964c; Gabrielson and Jewett 1940, 1970; Jackman 1974b; Jackman and Scott 1975; Ligon 1973
PIAR	13	black-backed three-toed woodpecker	Bock and Bock 1974, Jackman 1974b, Short 1974
PITR	13	northern three-toed woodpecker	Jackman 1974b, Jackman and Scott 1975, Short 1974
SICA	13	white-breasted nuthatch	Anderson 1972; Balda 1975; Bent 1964f; Jackman 1974a; Kilham 1968b, 1971a, 1972; Tyler 1916
SICAN	13	red-breasted nuthatch	Anderson 1970, 1976; Bent 1964f; Jackman 1974a; Kilham 1973; Stallcup 1968
SIPY	13	pygmy nuthatch	Balda 1975, Barefield 1943, Bent 1964f, Bock 1969, Jackman 1974a, Knorr 1957, Norris 1958

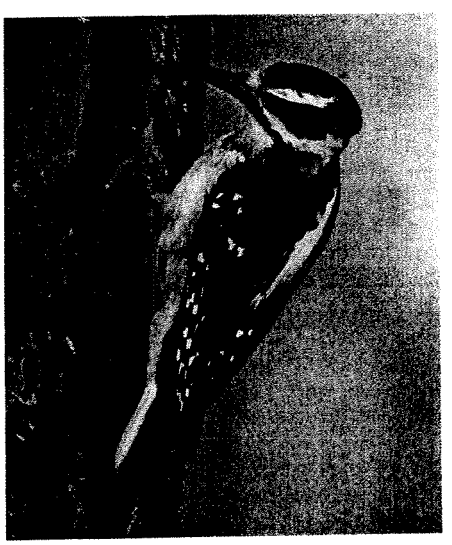
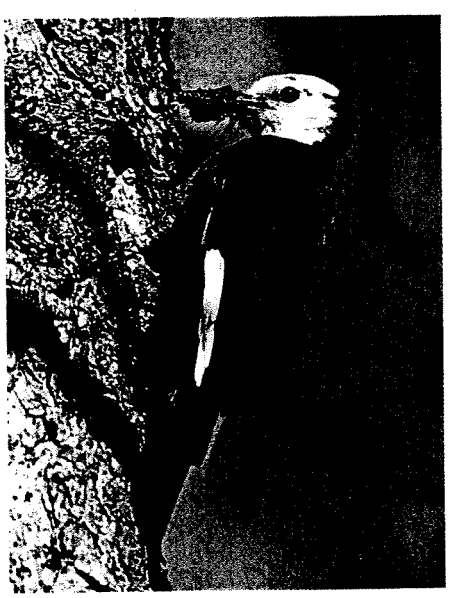
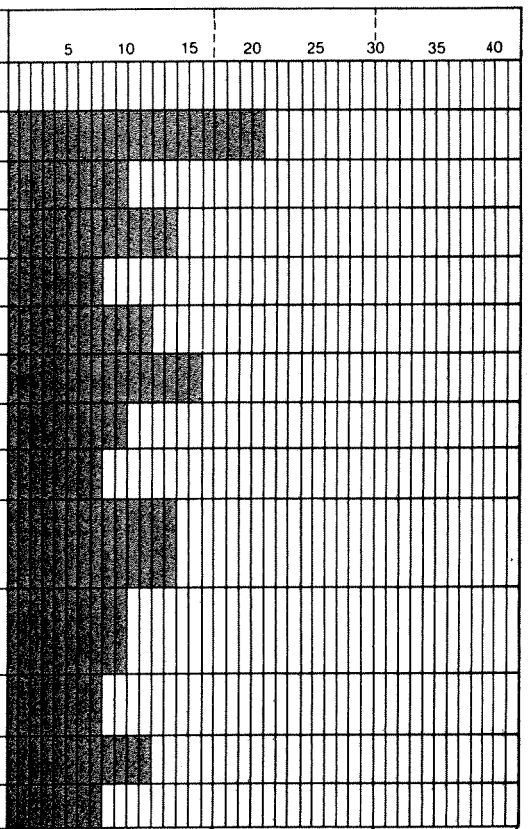


Table 9. Selected references for species in life form 13 (source: appendix 29)

Species that are similar in appearance may have very different versatility ratings. The hairy woodpecker (left) has a medium versatility rating and is found in many forest communities. The white-headed woodpecker (below) has a low versatility rating and much narrower habitat requirements.



Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
COAU	common flicker	6	3	9	6	6	12	21
DRPI	pileated woodpecker	3	2	5	3	2	5	10
ASLE	Lewis' woodpecker[1]	3	3	6	3	5	8	14
SPVA	yellow-bellied sapsucker	2	2	4	2	2	4	8
SPTH	Williamson's sapsucker	4	2	6	4	2	6	12
DEVI	hairy woodpecker[1]	5	3	8	5	3	8	16
DEPU	downy woodpecker	2	3	5	2	3	5	10
DEAL	white-headed woodpecker	2	2	4	2	2	4	8
PIAR	black-backed three-toed woodpecker	4	3	7	4	3	7	14
PITR	northern three-toed woodpecker[1]	2	3	5	2	3	5	10
SICA	white-breasted nuthatch	2	2	4	2	2	4	8
SICAN	red-breasted nuthatch[1]	3	3	6	3	3	6	12
SIPY	pygmy nuthatch	1	2	3	3	2	5	8



Letter code: 1 No. of plant communities used; 2 No. of successional stages used; 3 Columns 1 + 2 (Reproductive orientation); 4 No. of plant communities used; 5 No. of successional stages used; 6 Columns 4 + 5 (Feeding orientation); 7 Versatility score: columns 3 + 6 (Versatility rating (mean scale))

Low 1-16 | Medium 17-29 | High 30-42

[1]Species of special interest; see appendix 4.

Table 10. Versatility ratings for wildlife species in life form 13 (source: appendix 12)

Table 11. Life form versatility rating for life form 13 (source: appendix 13)

Life form[1]	Number species[2]	Range of versatility scores[3]	Mean versatility score	Life form versatility rating[4] (median scale)
13	13	8 to 21 (13)	11.62	Low

See appendix 13 for footnotes.

V scores for all wildlife species in the Blue Mountains are shown in appendix 12 and illustrated here by table 10. The V score for each species can be used to derive a V score for the life form as a whole as illustrated in table 11 and shown for all life forms in appendix 13. These scores reflect the versatility of species only in the Blue Mountains. It is possible for a nationally common and very versatile species, such as the house sparrow, to have a low V score in a particular area because suitable habitat is limited.

Potentially rare or threatened species are identified in appendix 4 (illustrated by table 12). These species were identified by Dyrness et al. (1975), Arbib (1975), and the U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife (1973) among others. More complete data on rare, threatened, and endangered species are given in appendix 4.

A Data Base For Planners

The informational displays presented here are a data base from which the forest manager may draw information at various levels. The system has been tested in preparation of land-use plans, environmental impact statements, and environmental analysis reports. It has enabled the users to produce better, more comprehensive, and more accurate results in less time.

The information system presented in this chapter is best suited for use in broad-scale land-use planning. The smaller the area and the greater the detail of the plan, the less likely these data are to predict results accurately. The general predictive ability should hold, but the inherent biological variability is more apt to become noticeable as size of the area diminishes.

This information base is not intended to replace the trained and experienced wildlife biologist; rather, it is a tool for use by the wildlife biologist. If applied without proper interpretation, qualification, and sensitivity to individual conditions, the results will be less accurate.

Species			1	2	3	4	5	6	7	8
PAHA	12	osprey			SU	SI	R	X	U	SU
FAME	4	prairie falcon			T	SI	R	X	R	T
FAPE	4	peregrine	E	E	T	SI	E		E	T
FACO	11	merlin				SI	E	X		
FASP	14	American kestrel				SI		X		
ORAM	4	mountain goat				U				

Letter code — Life form

E - Endangered
P - Peripheral
R - Rare
SI - Species of special interest
SU - Status undetermined
T - Threatened
U - Unique
X - Occurs on list

1 Federal Register (endangered)
2 Oregon State (endangered or threatened)
3 U.S. Dep. Inter. Fish & Wildl. Serv. "Red Book"
4 USDA FS RNA "Yellow Book"
5 OSU endangered plants & animals of Oregon
6 Audubon—Blue list for 1976
7 USDA FS R-6
8 Threatened wildlife of Idaho

See page 191 for sources referenced.

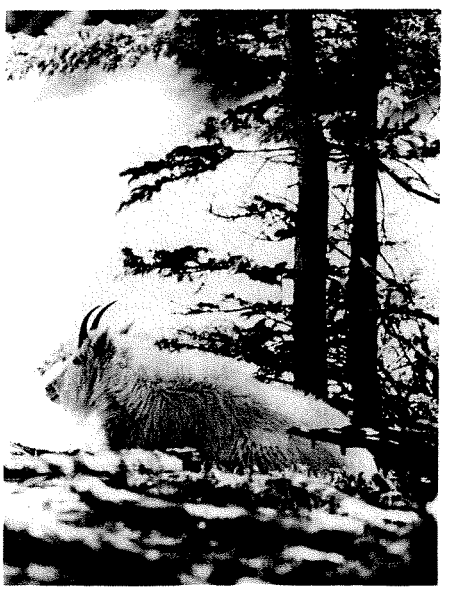


Table 12. Some species in the Blue Mountains are of special interest because of their potentially threatened or endangered status (source: appendix 4)

The mountain goat is worthy of special management consideration because of its "unique" status.

3
Riparian Zones

by
Jack Ward Thomas
Chris Maser
Jon E. Rodiek

Riparian zones can be identified by the presence of vegetation that requires free or unbound water or conditions that are more moist than normal (fig. 16) (Franklin and Dyrness 1973, Minore and Smith 1971). Riparian zones can vary considerably in size and vegetative complex because of the many combinations that can be created between water sources (fig. 17) and physical characteristics of a site. Such characteristics include gradient, aspect, topography, soil, type of stream bottom, water quality, elevation, and plant community (Odum 1971).

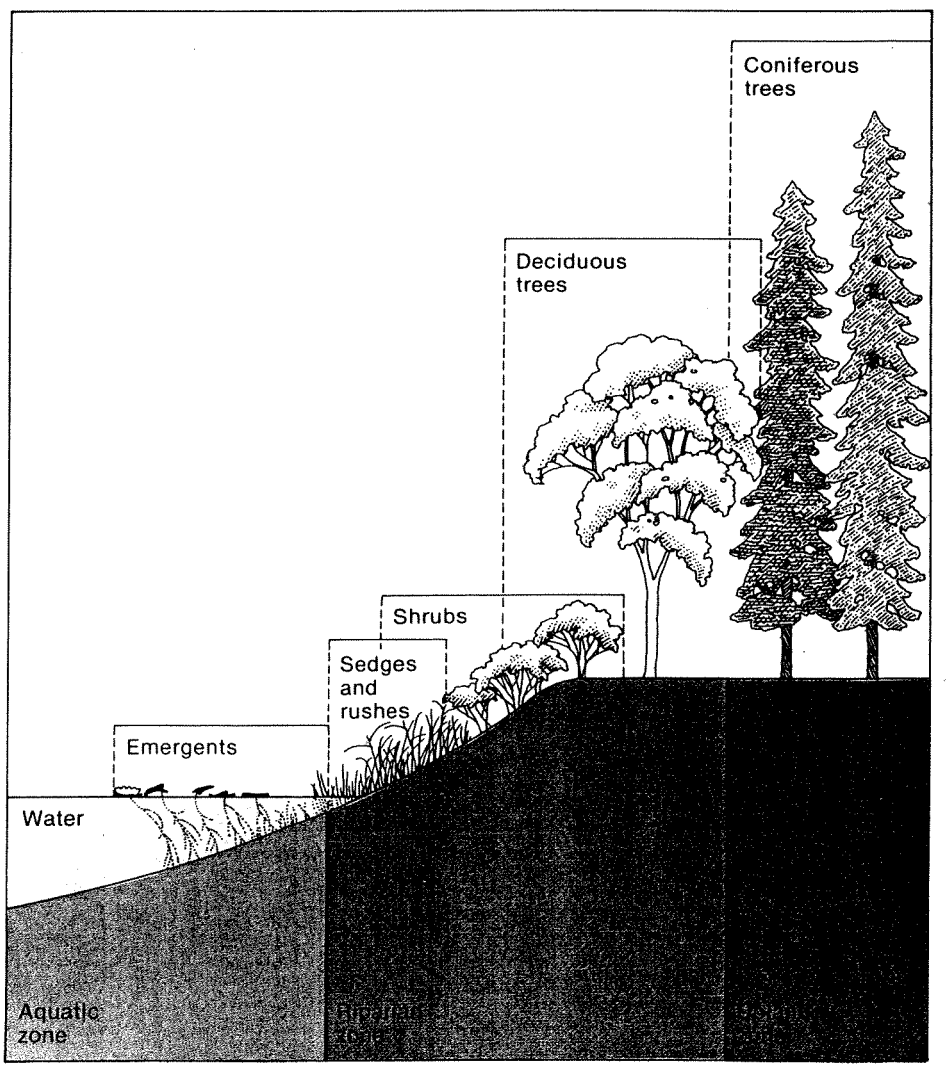


Figure 16. Riparian zones are identified by the presence of vegetation requiring large amounts of free or unbound water.

All riparian zones within forested areas of the Blue Mountains have these things in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor proportion of the overall area; (3) they are generally more productive in terms of biomass —plant and animal—than the remainder of the area; and (4) they are a critical source of diversity within the forest ecosystem. Carothers and Johnson (1975) and Curtis and Ripley (1975) have prepared summary papers on the subject of riparian habitats as associated, respectively, with range and forest areas.

Importance of Riparian Zones

Wildlife use riparian zones disproportionately more than any other type of habitat (Kelly et al. 1975; Bottorff 1974; Wooding 1973; Beidleman 1948, 1954). Of the 378 terrestrial species known to occur in the Blue Mountains, 285 are either directly dependent on riparian zones or utilize them more than other habitats. Vertebrates that either reproduce in water or feed in water are totally dependent on riparian and adjacent aquatic zones. In short, riparian zones are the most critical wildlife habitats in the Blue Mountains.

Riparian zones are also disproportionately important for other forest and range uses. Stream margins frequently contain highly productive timber sites. Cattle utilize the vegetation in riparian meadows more heavily than in other areas. The relatively gentle topography, particularly in mountainous areas, makes riparian zones attractive for road locations. Streams and rivers and their banks are also handy sources of rock for building roads. Recreationists concentrate their use in such areas. In addition, scenic values are often high. As a result, riparian zones are the most critical zones for multiple use planning in the Blue Mountains.

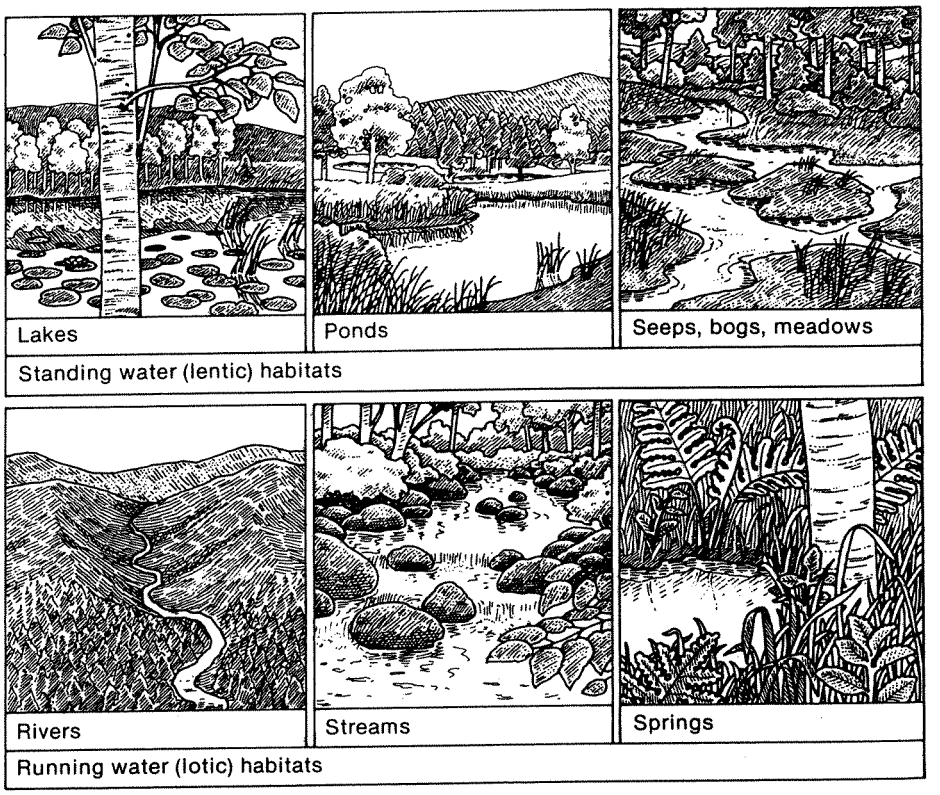


Figure 17. The type of water source influences riparian vegetation.

The Pacific treefrog is highly dependent on riparian zones as habitat for both feeding and reproduction.

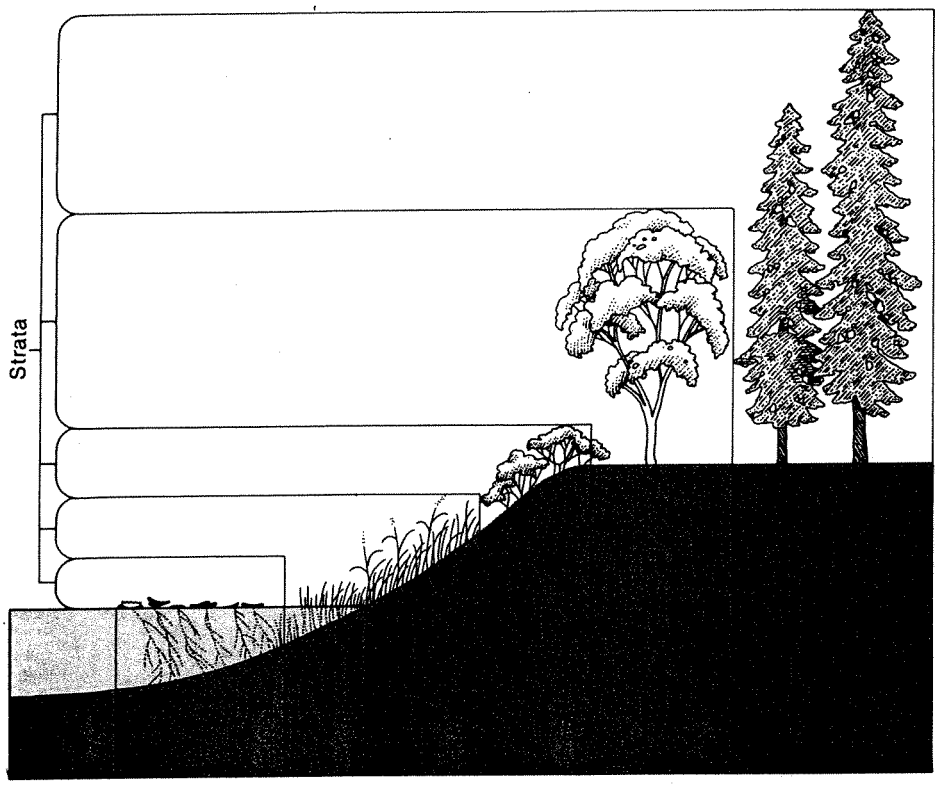


Figure 18. Riparian zones frequently have a high number of edges and strata in a comparatively small area. These produce habitat for a greater number of species, reflecting the diversity of plant species and community structure.

The western grebe, a minor species in the Blue Mountains, is important because its population may be declining.

There are many reasons why riparian zones are so important to wildlife. Not all can be attributed to every riparian zone. Each combination of water source and site attributes must be considered separately. Some of these reasons are discussed below:

1. The presence of water lends importance to the zone. Wildlife habitat is composed of food, cover, and water. Riparian zones offer one of these critical habitat components and often all three.

2. The greater availability of water to plants, frequently in combination with deeper soils, increases plant biomass production and provides a suitable site for plants that are limited elsewhere by inadequate water (Minore and Smith 1971, Minore 1970). These factors, in combination, lead to increased diversity of plant species and structural diversity in the community.

3. The dramatic contrasts of the plant complex of the riparian zone with the general surrounding upland forest vegetation add to the structural diversity of the area. For example, open wet meadows and groves of deciduous trees around seeps provide edges with stark contrast when they are surrounded by coniferous forest. Moreover, those riparian zones dominated by deciduous vegetation provide one type of habitat during the summer when in full leaf and another type of habitat during the winter following leaf fall.

4. The shape of many riparian zones, particularly the linear nature of streams, maximizes the development of edge which is so productive of wildlife (Bottorff 1974, Patton 1975).

5. Riparian zones in coniferous forests frequently produce more edges within a small area than would be expected (fig. 18). In addition, there are many vegetative strata exposed in stairstep fashion. This stairstepping of vegetation of contrasting form (deciduous vs. coniferous; shrubs vs. trees) provides diverse nesting and feeding opportunities for wildlife—especially birds and bats. The association of particular birds with distinct layers of vegetation has been repeatedly demonstrated (Lack 1933, MacArthur et al. 1962, Dambach 1944, Preston and Norris 1947, Thomas et al. 1977, DeGraaf et al. 1975). In addition, birds have been shown to select between coniferous and deciduous vegetative volumes in distinct strata (Thomas 1973, DeGraaf 1976).

6. The microclimate of riparian zones is different from that of the surrounding coniferous forest because of increased humidity, a higher rate of transpiration, more shade, and increased air movement. Some wildlife species are attracted to this microclimate. For example, elk on a Blue Mountain summer range spent 40 percent of their time in riparian zones which made up only 7 percent of the area (Pedersen, unpublished, see "References Cited"). The attraction of elk to these areas was caused by the abundance of thermal cover and the microclimate produced by that vegetation.

7. Riparian zones along intermittent and permanent streams and rivers provide migration routes for wildlife such as birds, bats, deer, and elk. Deer and elk frequently use such areas as travel corridors between high elevation summer ranges and low elevation winter ranges (fig. 19).

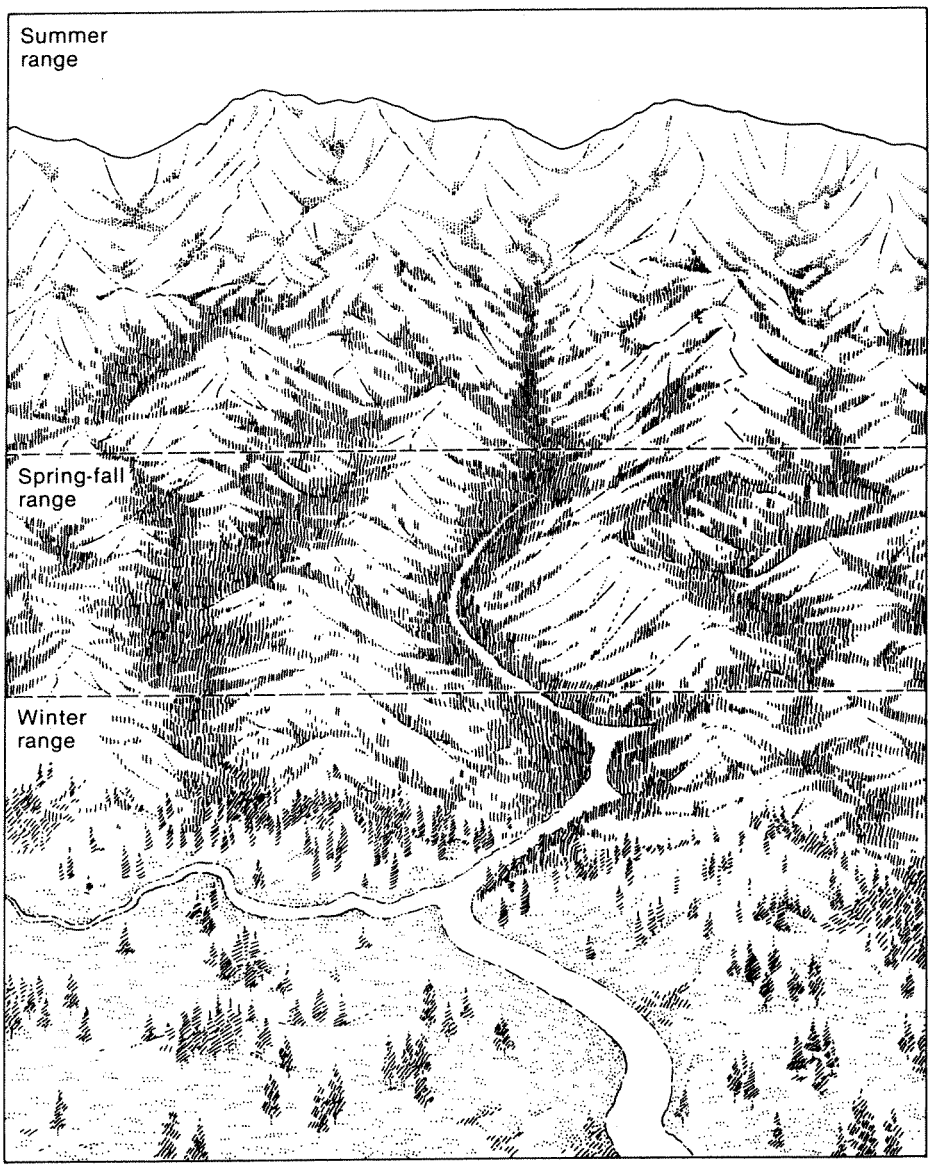


Figure 19. Riparian zones along rivers and streams are frequently used as migration routes by wildlife. A migration corridor used by elk between summer range at high elevation and winter range at low elevation is illustrated.

Riparian zones are disproportionately important for some wide-ranging species such as elk.

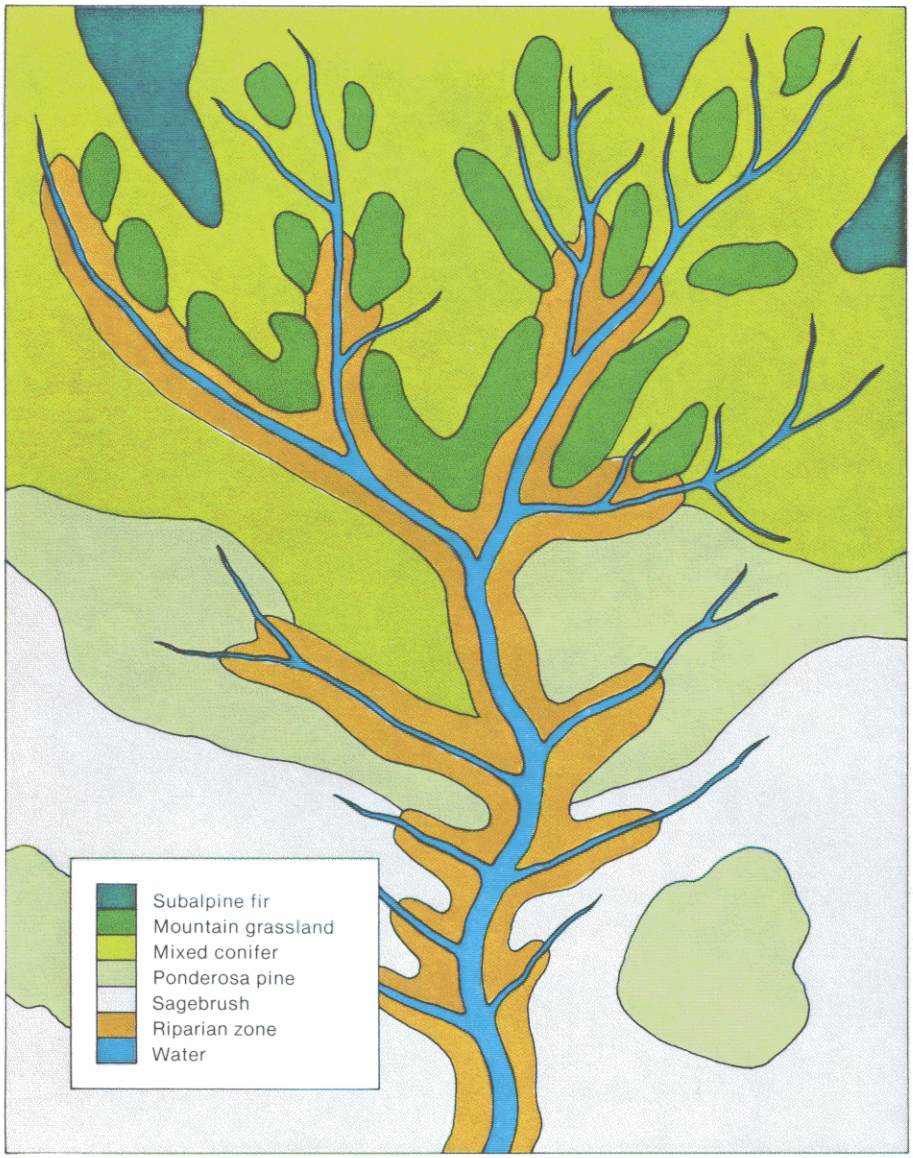


Figure 20. Riparian zones along rivers and streams serve as connectors between habitat types; they provide cover, food, and water as the animals move from one location to another.

8. Riparian zones, particularly along rivers and streams, may serve as forested connectors between forested habitats. Wildlife may use such riparian zones for cover while traveling across otherwise unforested areas. Some species, especially small mammals and birds, may use such routes in dispersal from their original habitats. This may be caused by population pressure or by shortages of food, water, or cover. The riparian zones provide cover and often provide food and water during such movements (fig. 20).

Sensitivity to Disturbance

Riparian zones occupy relatively small areas and should be considered vulnerable to severe alteration. Because of the distinct vegetative community and the structure of riparian zones, they must also be considered fragile. The more mature the vegetative complex of the riparian zone, the more apt it is to assume distinct edges and strata that intensify edge-effect and increase diversity. This mature condition is sensitive to management activities that occur in the riparian zone itself or in the surrounding conifer forest (fig. 21).

The sensitivity of the vegetatively mature riparian zone as wildlife habitat can also be attributed to its distinct microclimate. This includes both the terrestrial portions of the riparian zone and the characteristics of water quality, including temperature, of the associated aquatic zone. Changes in the canopy cover can alter these characteristics markedly (Meehan 1970, Brown et al. 1971, Brown and Krygier 1967). For example, an increase of a few degrees in water temperature may eliminate a stream as a trout fishery.

Management Considerations

Riparian zones are so different from one another that specific animal-to-habitat relationships are difficult to develop for these areas. Forest land managers should consult both fishery and wildlife biologists when management activities are planned within the riparian zone. The following considerations can be helpful:

1. Road construction in riparian zones will reduce the effectiveness of the zone as habitat for many wildlife species (fig. 22). This results from alteration in the vegetative complex and increased disturbance from traffic along the road. Increased sedimentation from road construction may be detrimental to water quality and hence to aquatic life. Many streams in the Blue Mountains are already paralleled by roads. Each time a new streamside road is considered, managers need to determine how much riparian habitat is already seriously impaired by such roads. This can be done by comparing the percent of streams with roads alongside with the percent of streams without roads. Road construction probably has a more critical and long-lasting impact on riparian zones than any other management activity.

2. The narrower the riparian zone the more easily it is altered by management action.

3. Construction of campgrounds in riparian zones enhances the opportunity for human-wildlife contacts but simultaneously decreases effectiveness of the riparian zone as wildlife habitat because of disturbance caused by humans, trampling, soil erosion and compaction, and loss of vegetation (Settergren 1977).

4. Improper grazing practices in riparian zones can reduce water quality, eliminate streamside shrubs, cause soil compaction, accelerate erosion, and break down streambanks (Marcuson [1977], Ames 1977). Proper grazing management should include particular attention to insuring the welfare of riparian zones.

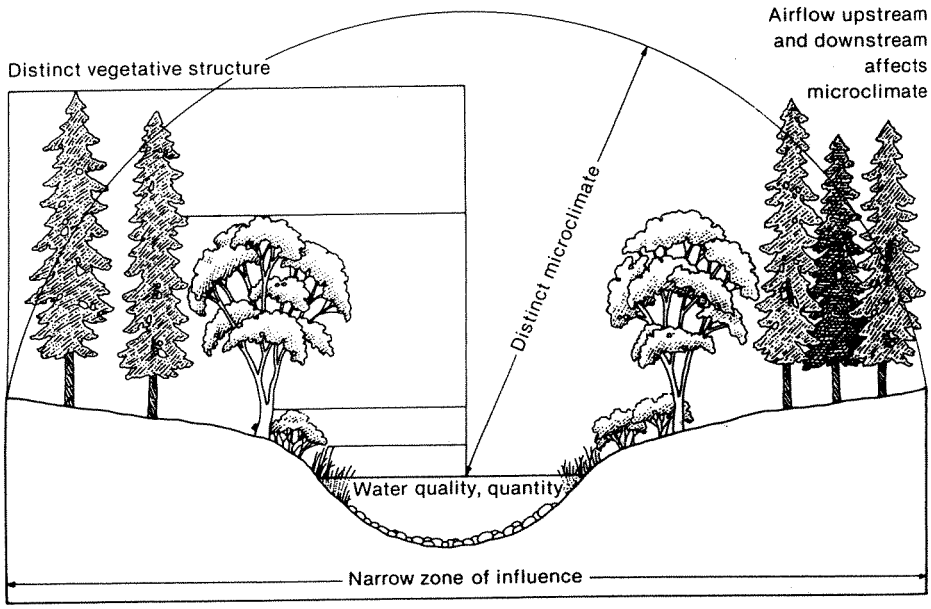


Figure 21. A combination of factors makes riparian zones especially sensitive to management activities.

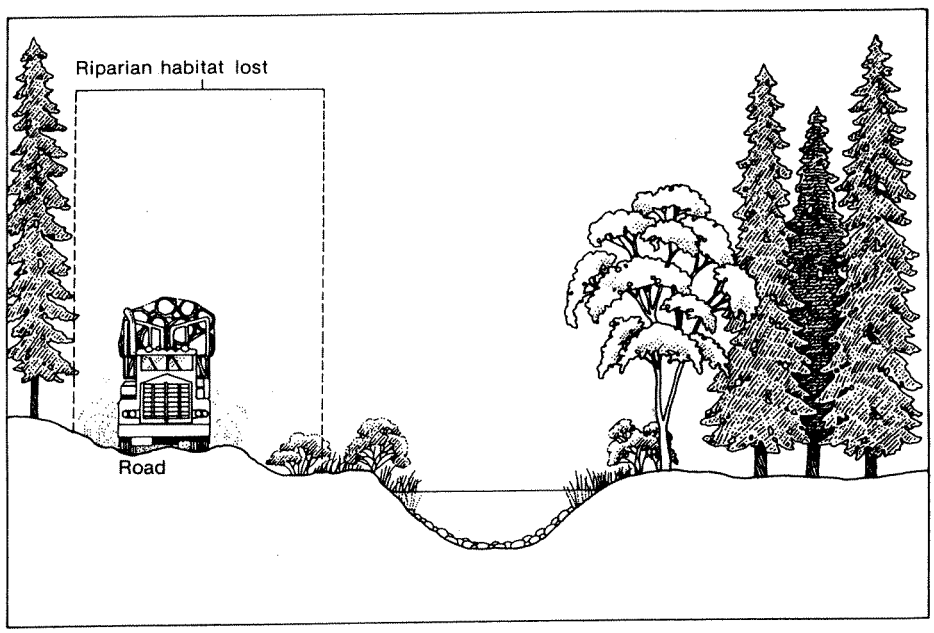
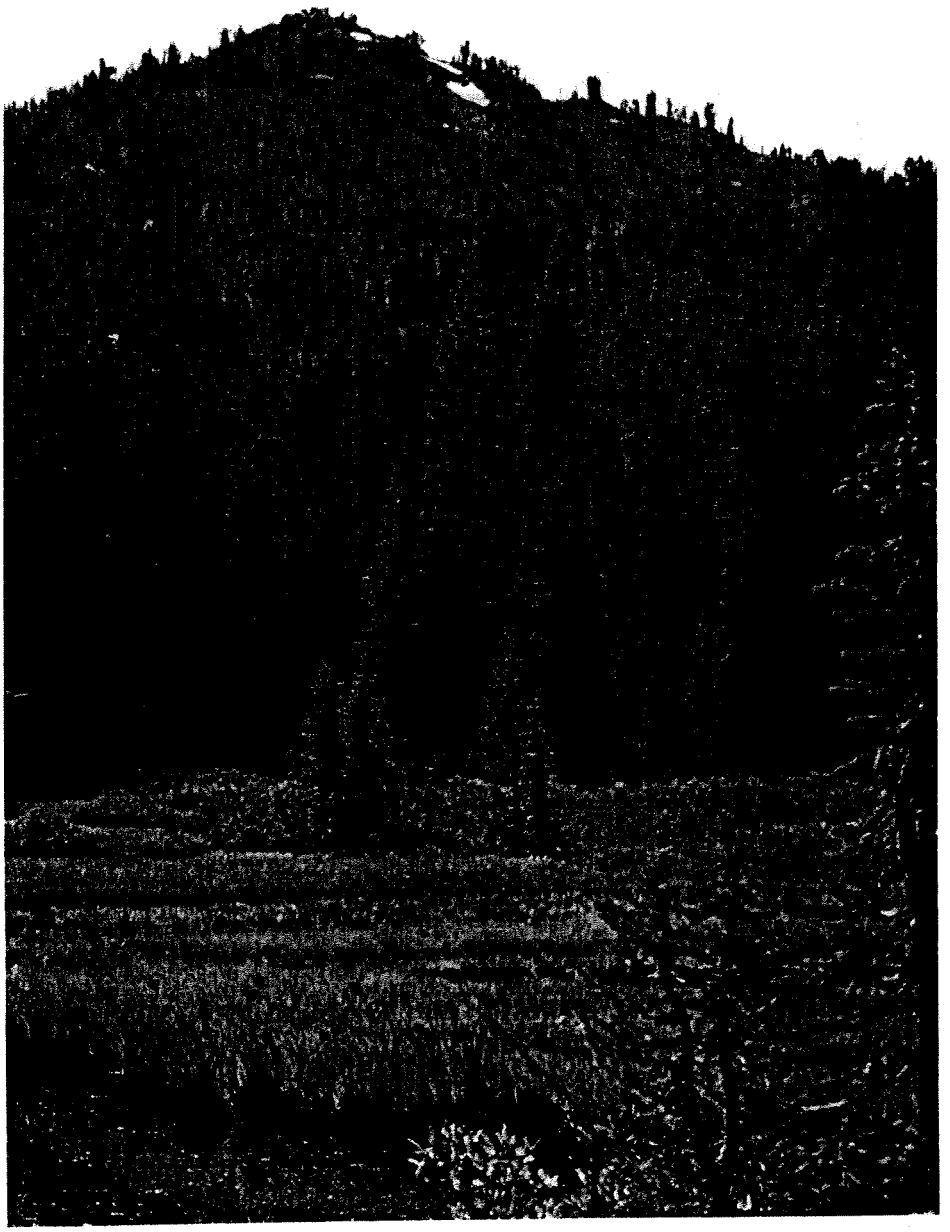


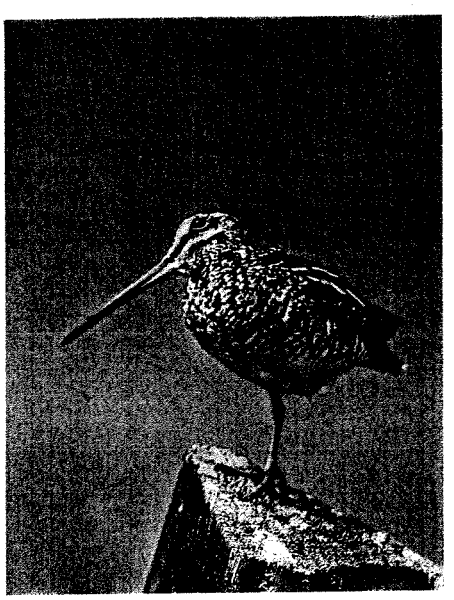
Figure 22. Road construction in riparian zones reduces their usefulness as wildlife habitat. Roads in riparian zones: (1) alter vegetative structure, (2) alter microclimate, (3) reduce the size of riparian zones, (4) disturb the wildlife, (5) impact water quality in the aquatic zone, and (6) destroy the wildlife habitat.



5. If logging is planned in riparian zones, the environmental impacts should be carefully evaluated. The more dramatic type of regeneration cuts—clearcutting, shelterwood, and seed tree—will have more impact than single tree selection and group selection harvests (fig. 23). Removal of significant amounts of canopy cover results in increased solar radiation reaching the ground or water surface. This in turn affects microclimate and stream temperature. By using the group and single tree selection harvest methods, it may be possible to cut some timber in riparian zones and still retain the integrity and function of the zone as wildlife habitat. The closer logging is to a riparian zone, the more severe the erosion impacts and the greater the danger of reducing water quality in associated aquatic zones.

6. Man-caused debris should usually be removed, but the watercourse should not be overcleaned. Debris existing prior to disturbance by management activities might be left intact since it sometimes serves as a critical habitat component for reproduction of reptiles and amphibians. Other semiaquatic species use such debris for resting and entry into and exit from the water.

7. Recreational use of the riparian zone is many times that of other habitats (North Central Forest Experiment Station 1977). The impact of such use on wildlife varies with the season and with the type, intensity, and duration of use. Construction of trails, picnic tables, and docks encourages recreational use and increases conflict with wildlife. Alternatives should be carefully evaluated. Recreational use may also reduce water quality because of proliferation of human wastes (Aitchison et al. 1977).



The long bill of the common snipe is a special adaptation for probing in wet soil. The bird nests in marshes, bogs, and wet meadows.

8. Timber management activities that take place outside the riparian zone may also affect the quantity and quality of water that enters and influences the riparian zone and associated aquatic habitats (Environmental Protection Agency 1976). Such activities may change suspended solids, nutrients, electrical conductance, and mineral content as well as water temperature and volume (Snyder et al. 1975, Sharpe 1975).

A "Red Flag" for Riparian Zones

The riparian zone is the most important type of wildlife habitat in the Blue Mountains. It is also the area of maximum potential conflict between users of timber, grazing, recreation, water, and wildlife resources. Riparian zones are usually quite sensitive to management activities and should be cautiously managed. As each riparian zone is somewhat different, the land manager should consult a wildlife biologist and a fishery biologist during the planning process. The purpose of this chapter has been to raise a "red flag" where riparian zones are concerned. Habitat alterations will affect wildlife far more than indicated by the proportion of the total area disturbed.

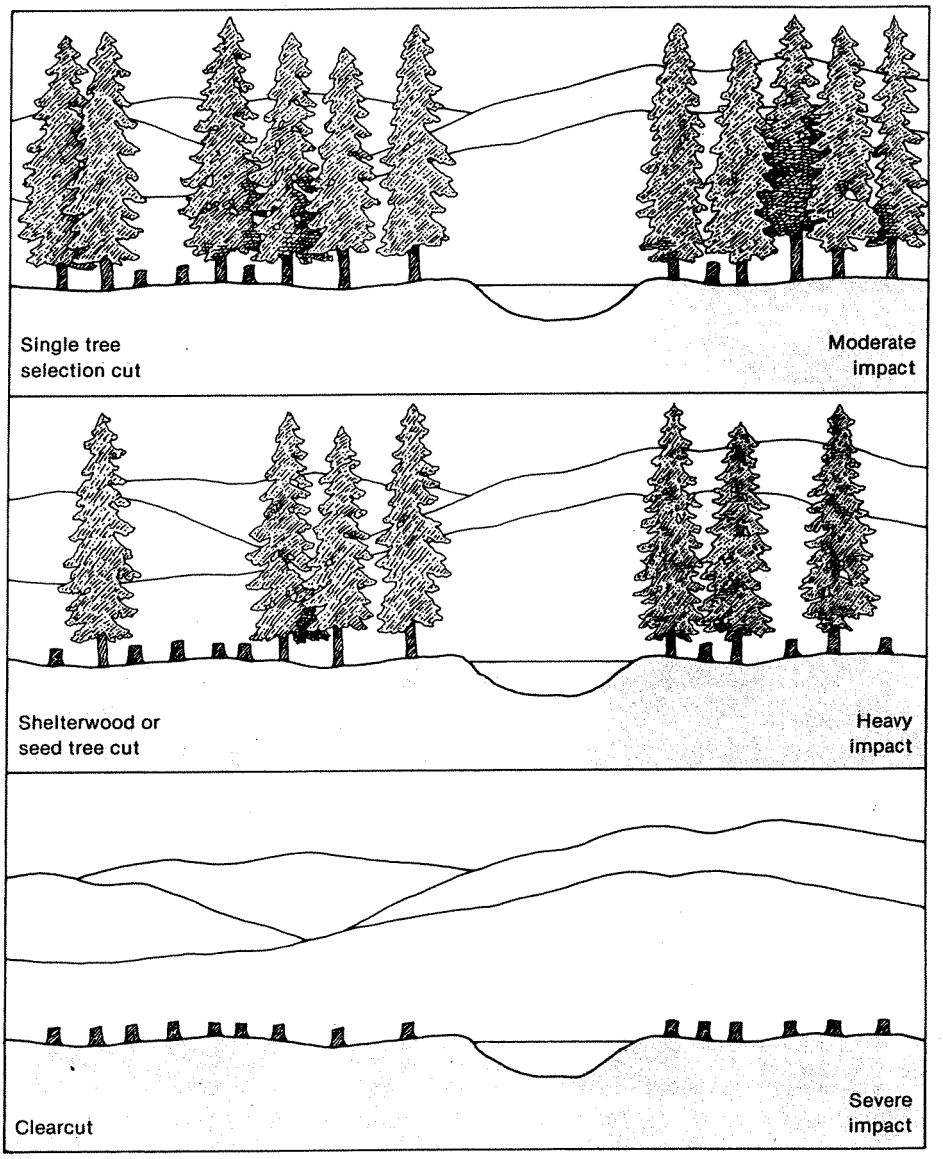


Figure 23. When timber is cut in riparian zones, environmental impacts should be carefully evaluated.

In the Blue Mountains, the raccoon is highly dependent on riparian zones.

4
Edges

by
Jack Ward Thomas
Chris Maser
Jon E. Rodiek

An edge (fig. 24) is the place where plant communities meet or where successional stages or vegetative conditions within plant communities come together. The area influenced by the transition between communities or stages is called an ecotone (fig. 25). Edges and their ecotones are usually richer in wildlife than the adjoining plant communities or successional stages. As a result, they are an important consideration in wildlife management.

Aldo Leopold (1933, p. 131) was the first to state that "game [wildlife] is a phenomenon of *edges.*" Wildlife "occurs where the types of food and cover which it needs come together, *i.e.,* where their edges meet . . . . We do not understand the reason for all of these edge-effects, but in those cases where we can guess the reason, it usually harks back either to the desirability of *simultaneous access* to more than one environmental type, or the *greater richness* of border vegetation, or both."

As biologists investigated the effects of edge on wildlife, they began to recognize other relationships that helped explain the phenomenon. These concepts have become known as the "laws" of dispersion and interspersion.

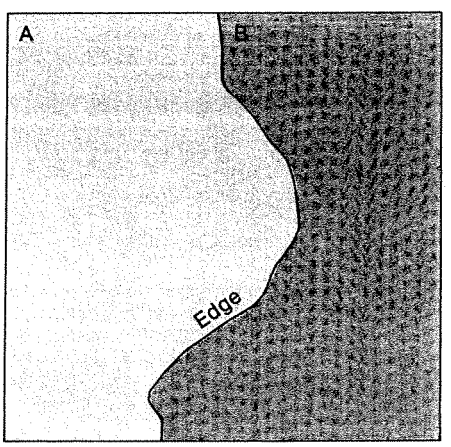


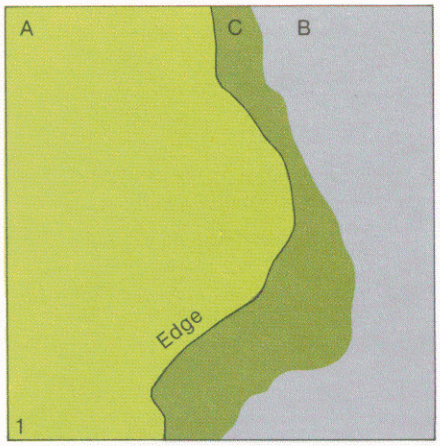
Figure 24. An edge is the place where plant communities (A and B) or successional stages within a plant community come together.

Dispersion describes the pattern of distribution of individuals in an animal population. In the mathematical sense, dispersion describes the probability of occurrence of such individuals in particular places (Hanson 1962, p. 111). The law of dispersion says that the potential density of wildlife species with small home ranges that require two or more types of habitat is roughly proportional to the sum of the peripheries of those types (Leopold 1933, Dice 1931). This means that species which are adapted to particular edges and their ecotones increase in proportion to an increase in edges of the appropriate kind.

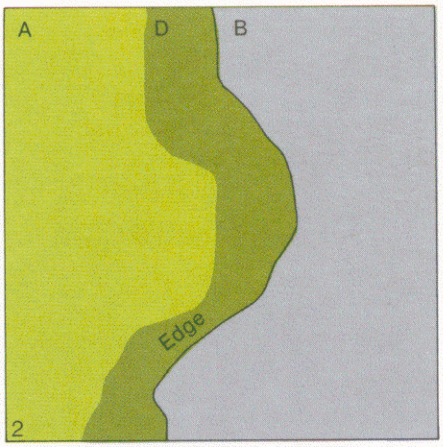
The law of dispersion was developed from studies of small animals with small home ranges. Later research indicates that some larger mammals with wider home ranges also use edges and ecotones disproportionately more than other habitats. This is particularly true where the edge occurs between relatively open areas and cover areas (Harper 1969; Reynolds 1962, 1966a).

Interspersion is the intermixing of plant species and plant communities that provide habitat for animals within a defined area (Hanson 1962, p. 191). The law of interspersion says that the number of resident species requiring two or more types of habitat depends on the degree of interspersion of numerous blocks of such types (Kelker 1964).

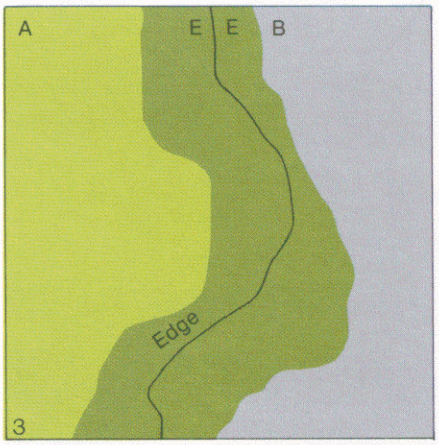
The laws of dispersion and interspersion work together to show the forest manager how to increase wildlife populations associated with edge. More edge of a particular type will produce more individuals of the wildlife species associated with that edge. Edge effect can be magnified by increasing the interspersion of the types of habitat creating those edges. Wildlife managers, then, have two factors to consider in evaluating the role of edge—the amount of edge and how it is arranged.



Some influence of community A extends into B along the edge forming ecotone C.

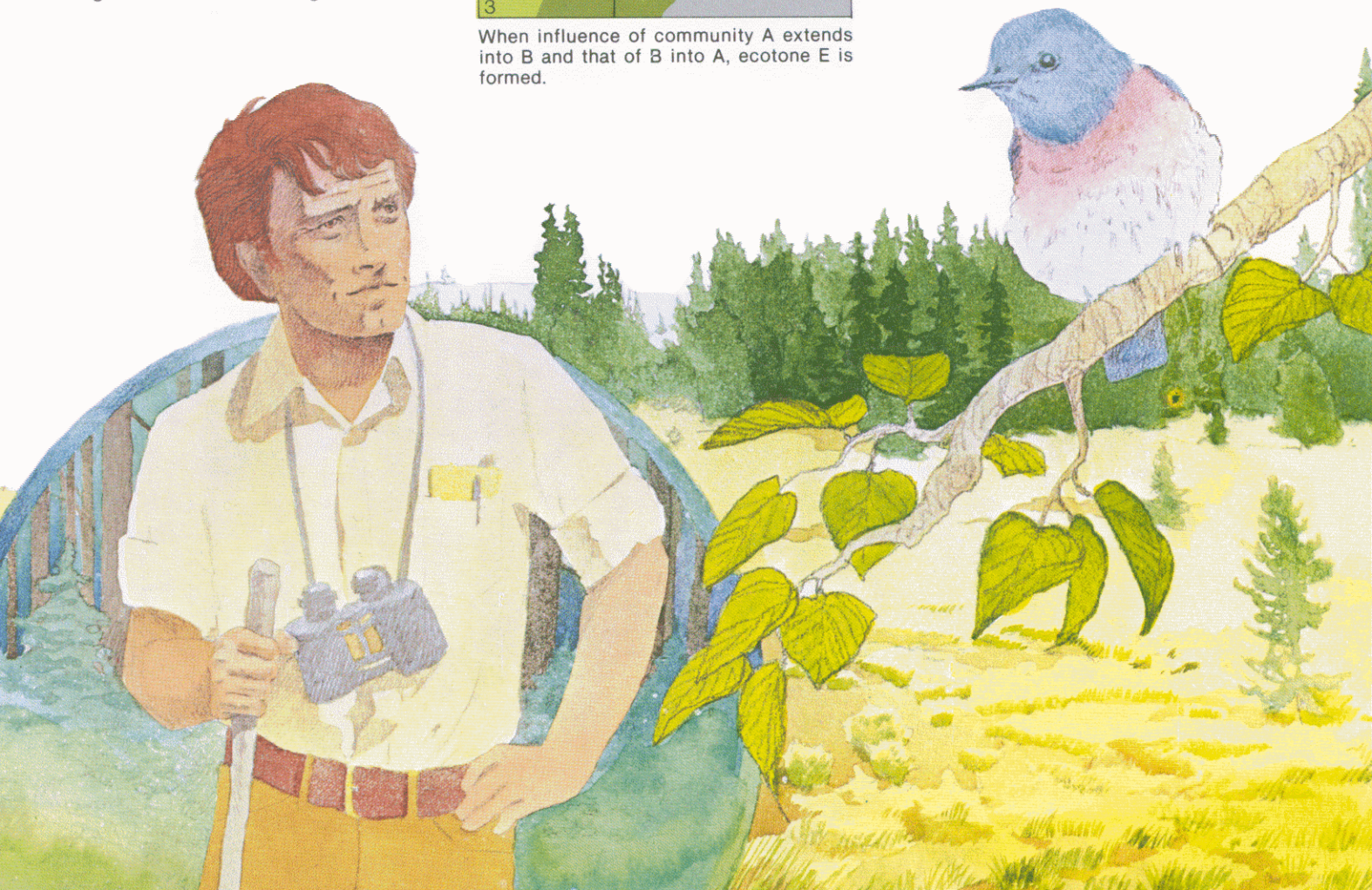


Some influence of community B extends into A along the edge forming ecotone D.



When influence of community A extends into B and that of B into A, ecotone E is formed.

Figure 25. Ecotones are formed along edges and may be created in several ways.



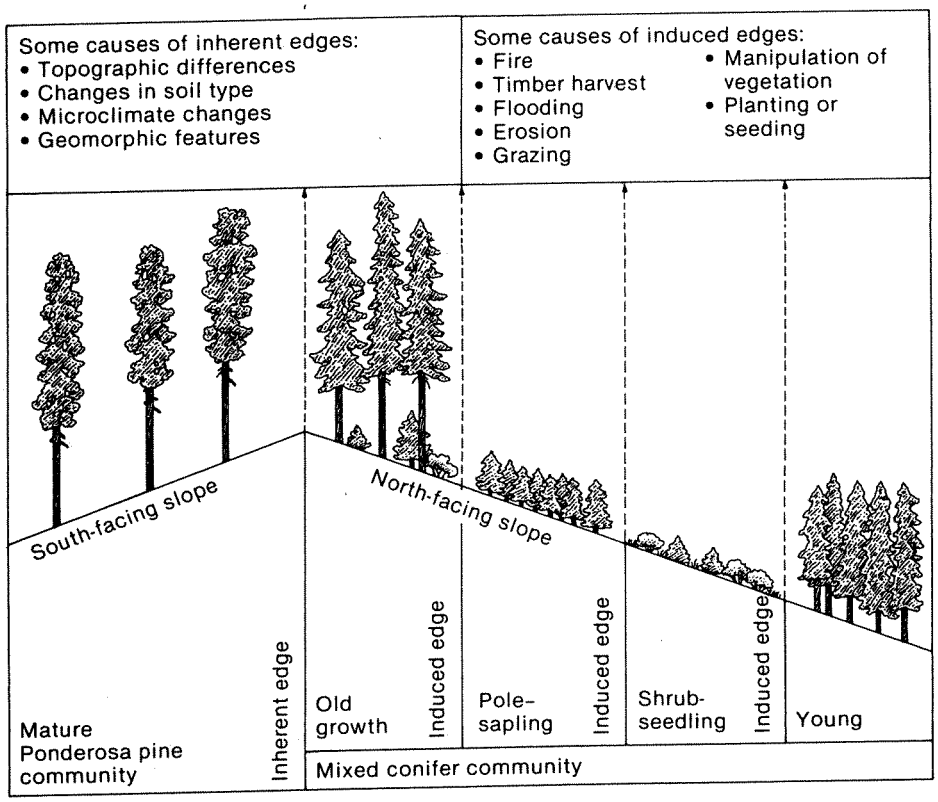


Figure 26. Inherent edges are created where plant communities meet; for example, where a ponderosa pine community meets a mixed conifer community. Induced edges are created where successional stages within communities come together. Inherent and induced edges are influenced by many factors.

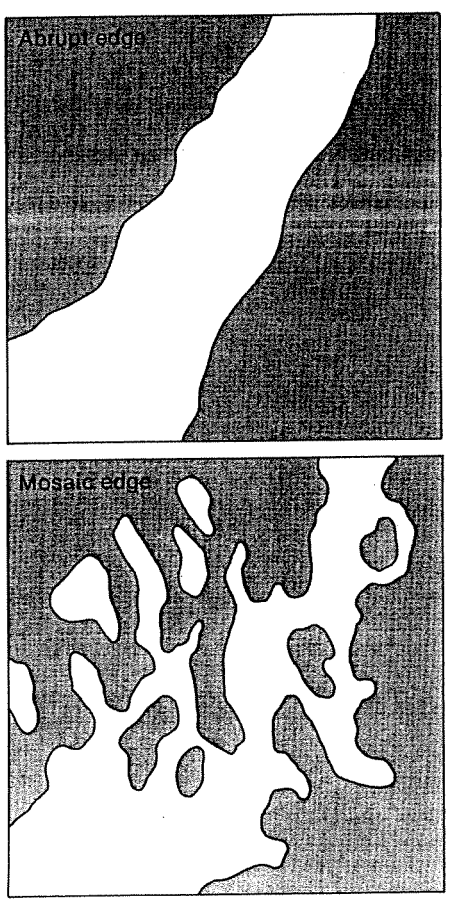


Figure 27. Inherent edges may be abrupt or mosaic.

Inherent Edge

An edge that results from the meeting of two plant communities is called an inherent edge (fig. 26). The plant community is the tangible expression or integrator of myriad influences acting on a particular site (Daubenmire 1976). The edges between plant communities, as far as the land manager is concerned, are issued with the area—that is, they are inherent. Four of the most obvious natural factors that work separately and in combination to produce inherent edges are: (1) abrupt changes in soil type, (2) topographic differences, (3) geomorphic differences, and (4) changes in microclimate.

Inherent edges are long-term features of the landscape; they result from geomorphic conditions or other factors that create the plant communities involved. For all practical purposes, inherent edges are relatively stable and permanent features of the landscape. They can change, however. For example, subtle modifications in microclimate and soils over many decades may result in a shifting of the plant communities along the edge until it becomes less abrupt. Sometimes the plant communities are broken into patterns of islands and peninsulas until a mosaic pattern emerges (fig. 27). In other situations, a broadened ecotone may result. An inherent edge can also be created suddenly, for example, by landslides or severe sheet erosion.

The conditions of the plant communities that form an inherent edge may be altered by management activities or other short-term phenomena. But since the underlying causes for that edge are related to geomorphic factors, inherent edges are very stable and tend, over time, to return to their earlier vegetative state.

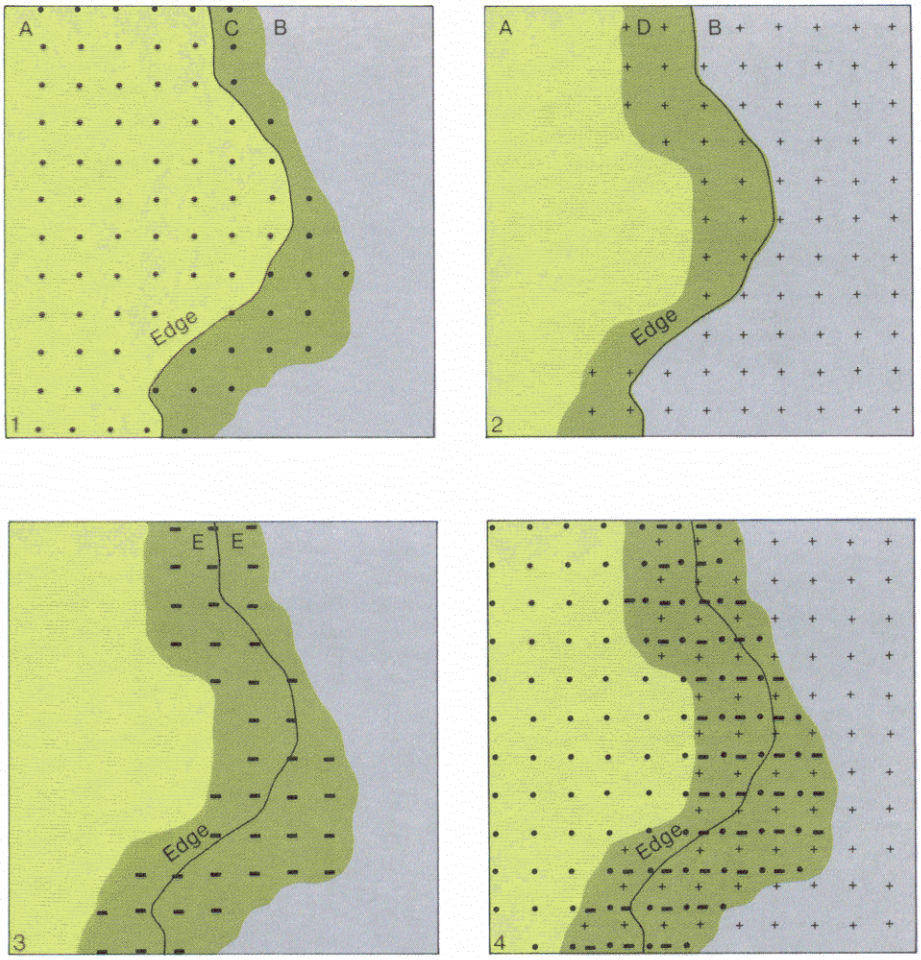
Induced Edge

An edge that results from the meeting of successional stages or vegetative conditions within a plant community is called an induced edge (fig. 26). Such edges can be created by management practices or short-term natural phenomena—that is, they can be induced.

Under natural conditions, induced edges are created by drastic short-term environmental factors, such as grazing, manipulation of vegetation, planting or seeding, fire, disease, insect outbreaks, floods, logging, and erosion. All of these factors, except planting or seeding, tend to shift plant communities toward earlier, less mature, successional stages. Compared with inherent edges, induced edges are relatively short lived. Although they may last for many years, they are constantly changing and are not permanent features of the landscape.

Importance to Wildlife Management

The biological importance of edges to wildlife managers is expressed by the term "richness." Edges and their ecotones are rich in wildlife, both in number of species and of individuals, because of the additive effect on the fauna when two plant communities or successional stages come together. In the ecotone there is a mingling of the species common to each type and the addition of other species that may be products of the ecotone itself (fig. 28). In another sense, wildlife richness is related to the plant and habitat diversity expressed in the ecotone.



Some wildlife is particularly adapted to ecotone E.

The total wildlife use in the ecotone indicates the habitat and species richness associated with edges.

Figure 28. Species richness associated with edges is an additive effect.

The stark contrast of a clearcut-forest edge is softened over time as young trees begin to take over the area.

Characteristics of Edges

Edges have characteristics (fig. 29) that influence the amount of edge habitat and the degree of habitat richness. In combination, these two factors determine the total impact of edges as wildlife habitat.

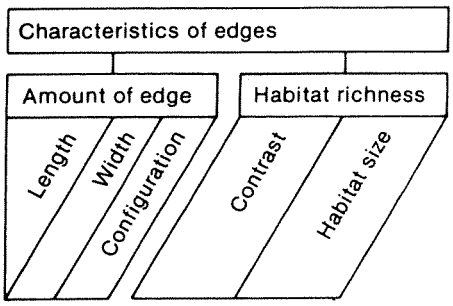


Figure 29. Edges have characteristics that influence habitat and species richness.

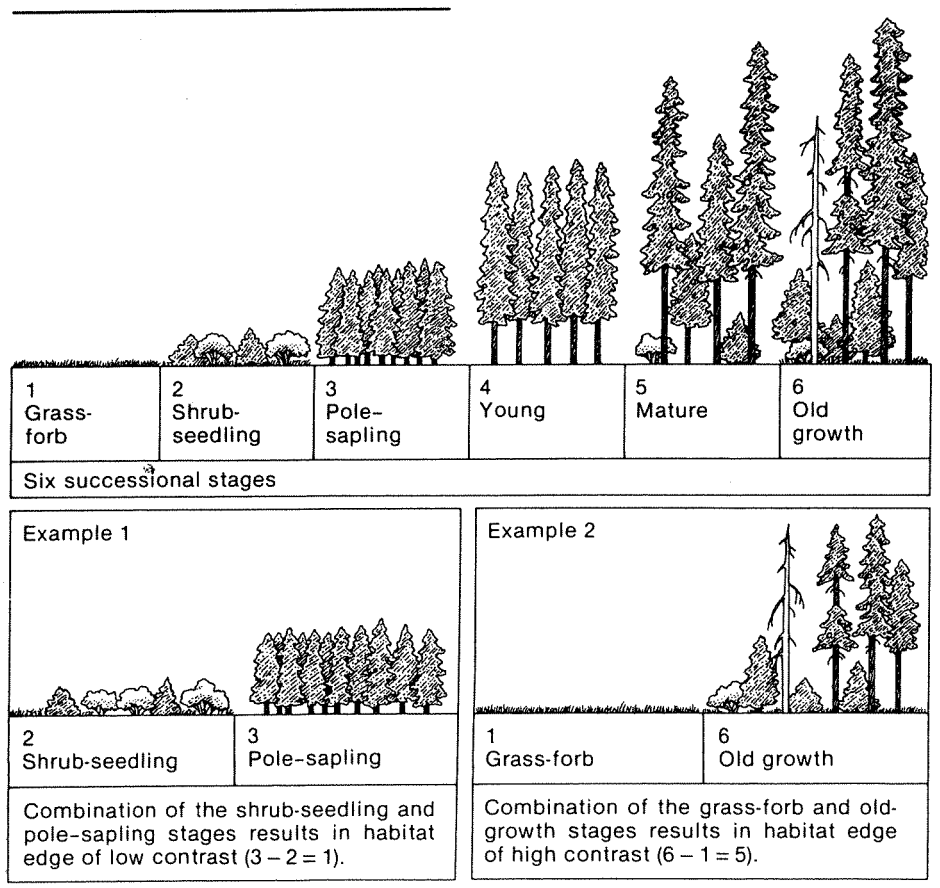
The amount of edge habitat or ecotone in an area is a function of edge width, the length of the edge, and its configuration. The width and length measurements can be used to determine the area of ecotone. An abrupt narrow edge yields less ecotone habitat than a wider edge. Configuration is the arrangement of edges in a pattern that may range from simple to mosaic (fig. 27).

The degree of habitat richness associated with a particular edge is influenced by the size of the forest stand and the type of habitats coming together in the edge. The size of the habitat block has a direct effect on the number of wildlife species in that area (Galli et al. 1976). The species associated with each habitat have a tendency to lap over the edge into the other habitat. So, the larger the habitat blocks, the more species will be associated with them—and the richer the species diversity along the edge.

In addition, habitat richness is associated with the degree of contrast in vegetative structure along the edge. The greater the contrast, the more likely the adjoining habitats are to be very different in structure and in the wildlife species they support. This tends to increase the species richness of the ecotone.

As an example of the effect of contrast, consider the idealized successional stages in figure 30. There are 6 successional stages that can be formed into 15 combinations by the joining of 2 stages. Each combination produces a different degree of contrast. Little contrast is produced by combining closely related stages. Contrast can be dramatic, however, if an early successional stage is joined with a late stage. The degree of contrast may be determined by subtracting the smaller identifying numbers from the larger. The greater the difference, the greater the contrast.

Figure 30. Edges differ in their degree of contrast.



Stand Size and Diversity

At some point, increasing diversity tends toward homogeneity and tends to become decreasing diversity. Galli et al. (1976, p. 356) say that "The number of species present in a particular habitat is strongly influenced by the size of that habitat." The number of species of both animals and plants in an area is another indicator of diversity. Arrhenius (1921) and Gleason (1922) seem to have pioneered this concept. The rather voluminous literature on the subject that has developed since that time is well summarized and reviewed by Cain and Castro (1959) and Greig-Smith (1964).

Hopkins (1955), Preston (1960), and MacArthur and Wilson (1967) discuss "species-area curves" or the relationship of numbers of plant and animal species to increasing size of an area. After review of this literature Galli et al. (1976) concluded that there was usually a direct linear relationship between the number of species and the logarithm of the area, and that there were distinct relationships for different areas. This simply means that the number of species occupying an area usually increases with the size of the area.

Increasing wildlife diversity tends to become decreasing diversity when the average size of the habitat blocks becomes larger than that required to maximize the number of species present (fig. 31). Galli et al. (1976) studied the relationship between the number of bird species present and the size of blocks of forest habitat interspersed with agricultural lands in New Jersey. They found (p. 363) that "Bird species richness increases significantly through an island size of 24 ha [59.30 acres] and is likely to continue increasing significantly at forest sizes beyond 24 ha." Increase in bird species with increase in size of habitat was attributed to: (1) the addition of new species as their minimum habitat size requirements were met, (2) the inclusion of specific habitat components in sufficient quantity, and (3) the presence of specialized conditions in the interior of the forest stands.

Study of a 44-hectare (108.72-acre) plot showed a decline of species numbers predicted by their "best-prediction" equation relating species richness to the size of the forested area (Galli et al. 1976). This relationship accounted for 85 percent of the variation in species richness. Furthermore, the number of species was less than that encountered on the next largest plot of 24 hectares (59.30 acres). The decline was attributed to a loss of species adapted to edges.

Data are lacking for these relationships in the Blue Mountains. A best estimate is that species richness, at least for birds, will increase significantly with stand size to about 34 hectares (84 acres). Bird species richness is assumed to be a reasonable indicator of the relationship of all vertebrate wildlife to stand size (fig. 31).

If the average stand size is about 34 hectares (84 acres), wildlife species richness attributable strictly to stand size should approach maximum. The word average is important.

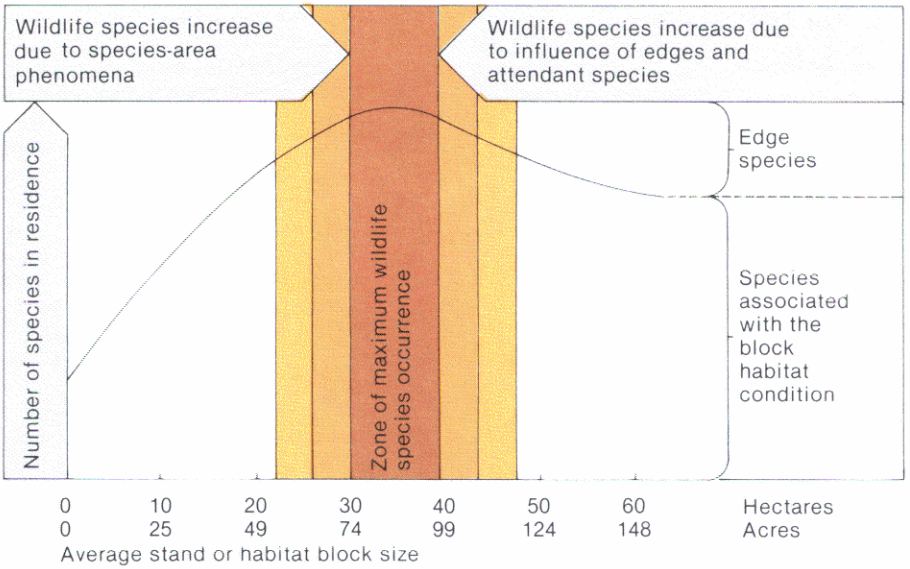


Figure 31. Wildlife diversity is related to the average size of habitat blocks. The curve is generalized from data presented by Galli et al. (1976) for bird populations.

This indicates the existence of stands both larger and smaller than 34 hectares (84 acres). Stands larger than the average may accommodate the few species that require larger blocks of habitat, whereas the smaller stands increase the edge effect that accommodates species adapted to edge.

Some species may require extremely large areas of contiguous and similar habitats. These would suffer if smaller areas were substituted. The requirement of some species for habitat blocks of specific size should not be confused with the animals' need for solitude or protection from the intrusions of man. In some cases, regulation of man's activities may suffice in lieu of preservation of large areas of pristine habitat. This must be determined on a species-by-species basis.

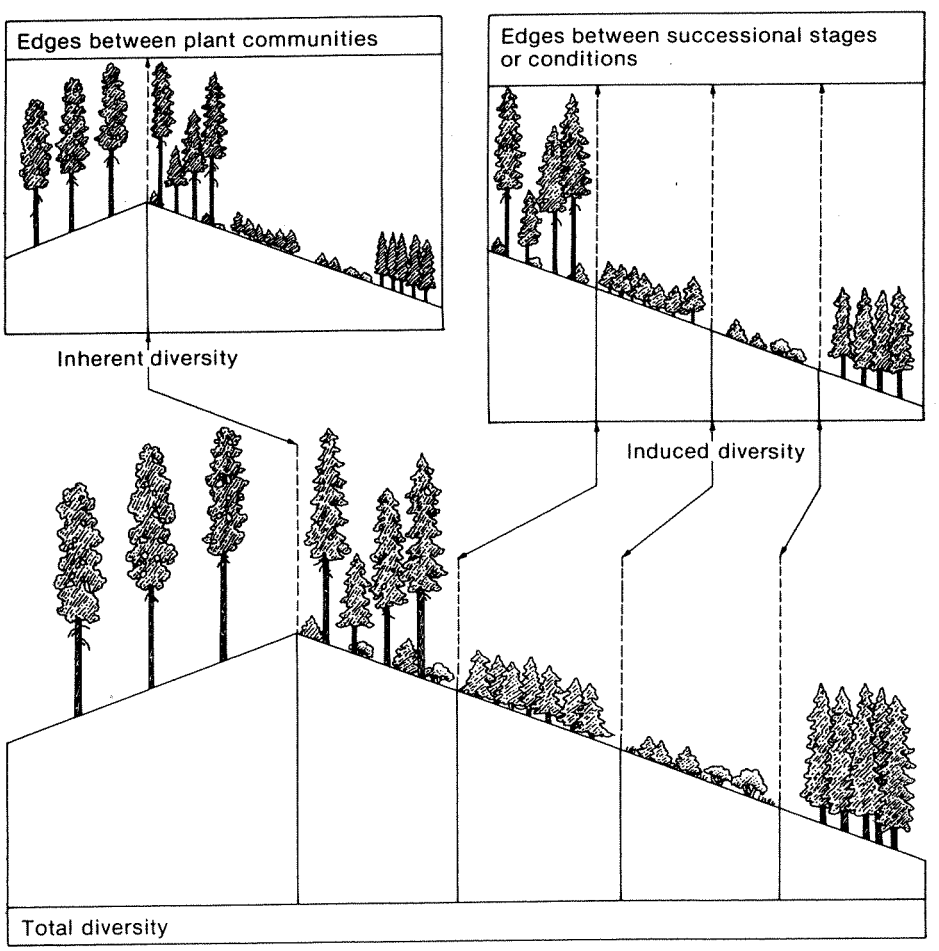
Edge as a Measure of Diversity

Emphasis on management for diversity in forest ecosystems will help insure the continued existence of the living components of the system—plants as well as animals. That goal is laudable for esthetic or moral reasons alone, but it is also a practical management objective. In the ecological sense, diversity is thought to be related to stability or the ability of a system, when changed from a steady state, to develop forces that tend to restore it to its original condition (Margalef 1969). Diversity acts as insurance for the system by increasing its ability to withstand disaster.

It has been said that the first rule of intelligent tinkering is to save all the pieces (Leopold 1949). A concern for diversity is a step toward insuring the continued existence of all the pieces in managed forest ecosystems.

Some land management agencies are beginning to be concerned about diversity. The Chief of the Forest Service, for example, has said that the wildlife goal for the National Forests is to insure wildlife diversity and to maintain or enhance wildlife populations (USDA Forest Service 1976a, 1976b). If diversity is a goal in forest land management, it behooves managers and planners to be able to measure it and account for it in their activities.

Figure 32. The amount and arrangement of edge is an expression of habitat diversity.



Both inherent and induced edges are a direct reflection of the total diversity (fig. 32) in an area. Patton (1975) indicated that edge can be used as a measure of diversity. Standard diversity indexes (see Pielou 1975) require information about numbers of plant and animal species and their frequency of occurrence. This approach is too expensive for planners and managers who must operate under severe constraints of budgets, personnel, and time. A feasible alternative is to use edge as an indicator, or index, of diversity.

There are at least three uses for a diversity index in forest land management: (1) to investigate trends in habitat diversity, (2) to evaluate management alternatives for their immediate and long-term effects on diversity, and (3) to evaluate the effect of the shape of timber harvest areas on diversity.

Derivation of Diversity Index

Patton (1975) described a system that expressed, by index, the amount of edge within an area of any given size. Because of the relationship between edge and interspersion and because these factors are a measure of diversity, he referred to this measure as the diversity index. Patton worked entirely with English measurements, but the same results may be achieved with metric measurements.

The following is taken directly from Patton (1975, p. 172). DI signifies the diversity index:

> The geometric figure with the greatest area and the least perimeter or edge is a circle. If the ratio of circumference to area of a circle is given an index value of 1, a formula can be derived to compute a comparable index for any area to compare with a circle. Any index larger than 1 is a measure of irregularity and can be used as a DI. A 1-acre circle has a circumference of 739.86 feet and an area of 43,560 square feet. The formula to set the ratio equal to 1 is:

$$\frac{C}{2\sqrt{A \cdot \pi}} = 1;$$

where C is the circumference, A is the area, and π is 3.1416. This same formula is often used by limnologists to express shoreline irregularity of a lake. The next step is to restate the formula for habitat diversity as:

$$DI = \frac{TP}{2\sqrt{A \cdot \pi}};$$

where TP is the total perimeter around the area plus any linear edge within the area.

Several examples will show how the DI is computed and what it means. A 1-acre square has 208.71 feet on a side . . . [fig. 33A], and the perimeter of the block is 834.84 linear feet. Substituting these values in the formula:

$$DI = \frac{834.84}{2\sqrt{43560 \times 3.1416}} = 1.13.$$

This indicates a square of 1 acre has 0.13 times more edge than a circle of 1 acre. Dividing the 1-acre block into 4 units of different vegetation types increases the DI to 1.69 . . . [fig. 33B]. If the 1-acre block is divided into 4 blocks in a long, narrow unit . . . [fig. 33D], the DI is increased to 1.83. In . . . [fig. 33D] the TP (1356.68 feet) is computed by adding the outside perimeter (1043.60 feet) to the 3 inside edges (313.08 feet).

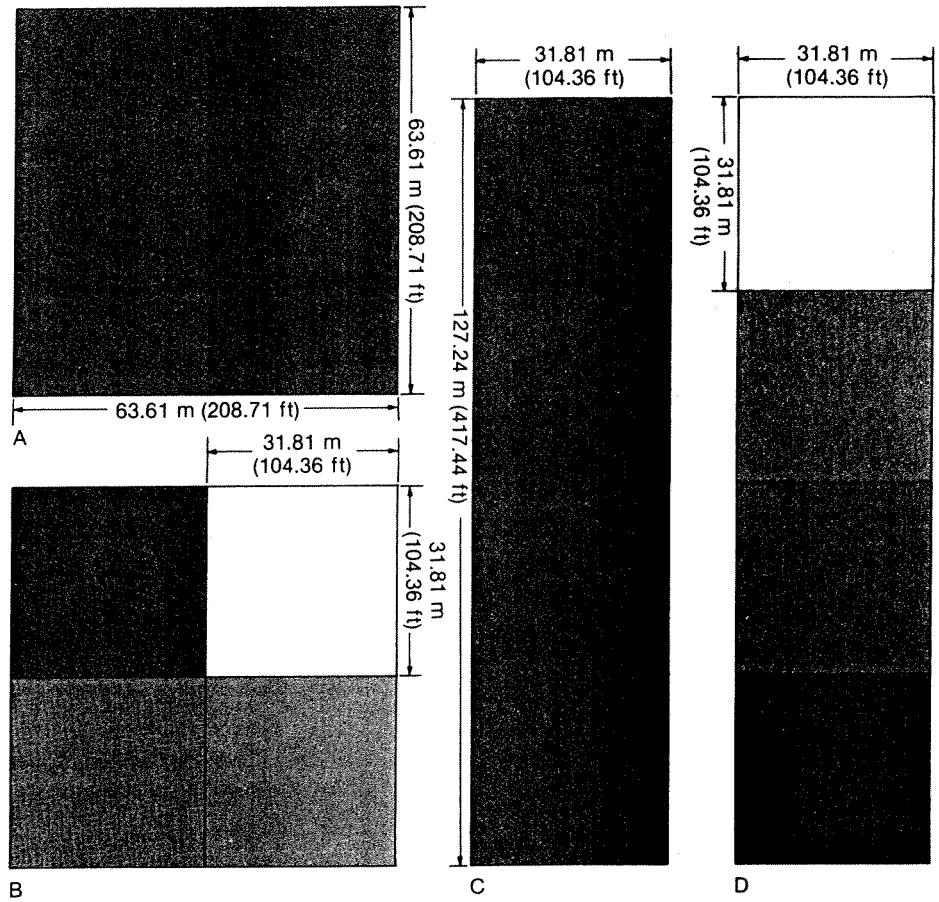
The DI can be expressed as a percentage figure when convenient. It is only necessary to rewrite the formulas as:

$$\text{Percent} = (DI - 1)100.$$

For the 1-acre square with a DI of 1.13 the percent is:

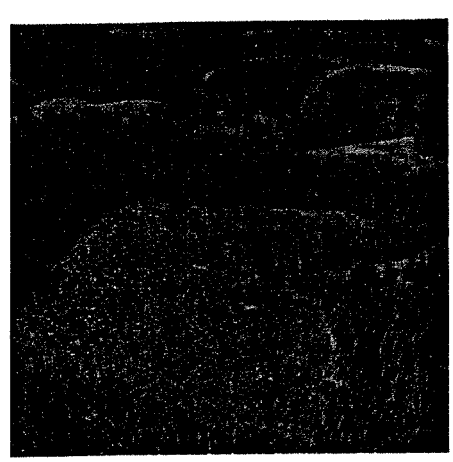
$$(1.13 - 1) \times 100 = 13\%.$$

This percent figure simply means that the 1-acre square has 13 percent more perimeter than a 1-acre circle. A square-mile block also will have 13 percent more perimeter than a circle of the same area.



Configurations of 1-acre area	Total edge		Diversity index
	Meters	Feet	
A	254.46	834.84	1.13
B	381.69	1,252.26	1.69
C	318.09	1,043.60	1.41
D	413.52	1,356.68	1.83

Figure 33. Comparison of diversity indexes for four 1-acre configurations (adapted from Patton 1975, p. 172).



Mosaic pattern of small clearcut areas is a distinct contrast to the straight edges of a large clearcut.

Patton's diversity index assumes that the total perimeter of an area is actually edge. In that case, the index would be applicable. All or part of the perimeter of an area under consideration, however, is usually not an edge in the ecological sense. Thus, in the majority of cases, the index will not be applicable. When Patton expressed DI as a percentage there was a factor in the formula that subtracted the "perfect circle" of assumed peripheral edge from consideration. This is the "minus one" in the formula quoted from Patton (1975, p. 172). The formulas that follow in this chapter do not assume that the perimeter of an area is necessarily edge. Therefore, the "minus one" adjustment factor used by Patton has been eliminated.

Furthermore, if diversity is expressed as a product of edge, it seems best to consider it as derived from two sources: inherent edge and induced edge (fig. 32). As a result, Patton's index has been modified in the following discussion to make it more applicable in land-use planning and land management.

Inherent edges are site related and are created when plant communities meet. Such edges may be considered as the degree of diversity "given" to the area. Induced edges occur when successional stages or conditions within plant communities come together. Induced edges can be produced when and where desired by the forest land manager; however, they are certain to result from any activity that alters vegetative structure.

Inherent Diversity Index

The Inherent Diversity Index is computed as follows:

$$\text{Inherent DI} = \frac{TE_c}{2\sqrt{A \cdot \pi}};$$

where TE_c is the total edge between plant communities in meters or feet found within or on the perimeter of the area under consideration, A is the area expressed in square meters or square feet, and π is 3.1416. The Inherent DI is expressed as a percentage increase over perfect simplicity by this process:

Inherent DI, percent = (Inherent DI)100.

Perfect simplicity may be expressed as DI = 0. Perfect simplicity may also be viewed as any delineated area which has no edge present—either internally or on the periphery.

In figure 34, a 61- × 61-meter square of 3 721 square meters (200- × 200-ft square of 40,000 ft²) is divided into four plant communities of equal size. In this case the perimeter of the area is also inherent edge. The Inherent DI in percent is computed as follows:

$$\text{Inherent DI (in meters)} = \frac{TE_c}{2\sqrt{A \cdot \pi}}$$

$$= \frac{366 \text{ m}}{2\sqrt{(3\,721 \text{ m}^2)(3.1416)}} = 1.69;$$

$$\text{Inherent DI (in feet)} = \frac{TE_c}{2\sqrt{A \cdot \pi}}$$

$$= \frac{1{,}200 \text{ ft}}{2\sqrt{(40{,}000 \text{ ft}^2)(3.1416)}} = 1.69.$$

Inherent DI, percent = (Inherent DI)100
= (1.69)100 = 169%.

The number of plant communities represented is also an important component of inherent diversity. Although the number of plant communities will obviously increase the Inherent DI, percent, an added descriptor showing the number of communities seems appropriate (Patton 1975). The descriptor may be added in parentheses after the Inherent DI, percent. In this case:

Inherent DI, percent (number of communities) or 169%(4).

In this example the total perimeter represents inherent edge and was included in calculating TE_c. If all or part of the perimeter had not been inherent edge, those parts would not have been used in computing TE_c. In other words, only the portions of the perimeter that are inherent edge are used in deriving TE_c. This is a modification of the approach described earlier (Patton 1975).

The northern flying squirrel is associated with ecotones formed by the junction of forest and shrubs.

Induced Diversity Index

Induced diversity can be expressed in the same manner:

$$\text{Induced DI} = \frac{TE_s}{2\sqrt{A \cdot \pi}};$$

where TE_s is the total length of the edges (in meters or feet) created between successional stages or conditions, within plant communities or along their peripheries, for the area under consideration. Then,

Induced DI, percent = Induced DI(100).

Again, consider figure 34. The dotted lines represent induced edge within plant communities A and B. The TE_s is 61 meters (200 ft) and the total area is 3 721 square meters (40,000 ft^2). The induced DI in percent is computed as follows:

$$\text{Induced DI (in meters)} = \frac{TE_s}{2\sqrt{A \cdot \pi}}$$

$$= \frac{61\text{ m}}{2\sqrt{(3\,721\text{ m}^2)(3.1416)}} = 0.28;$$

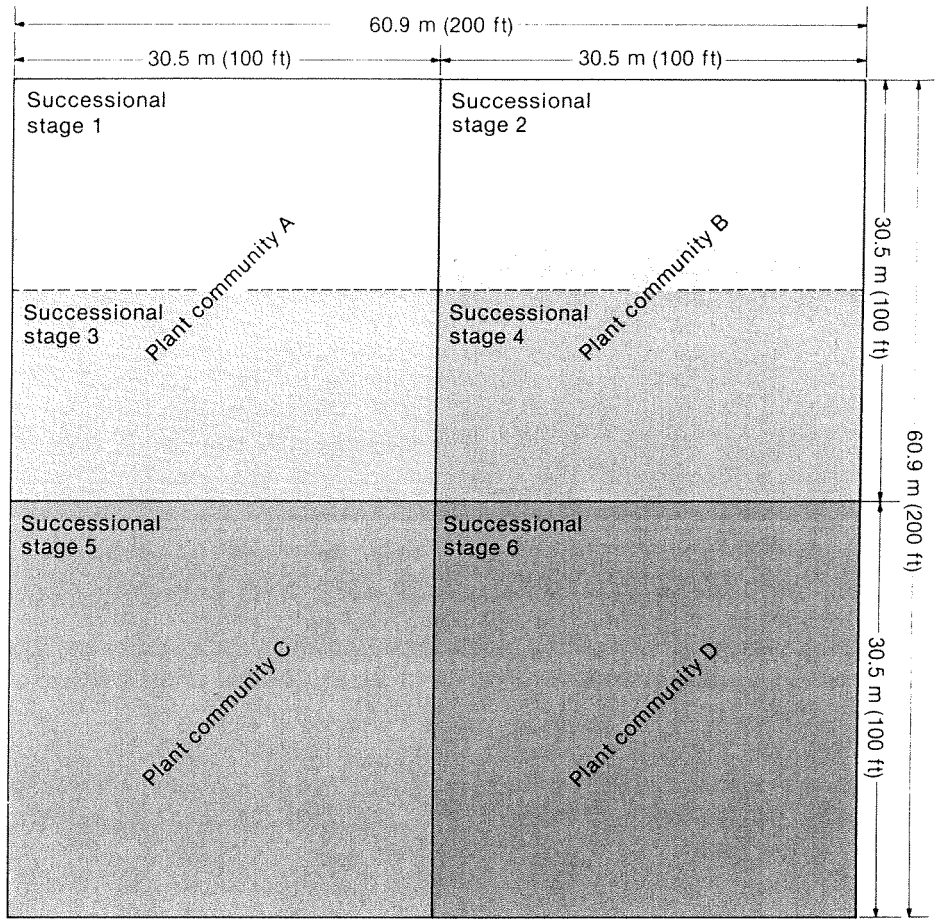
$$\text{Induced DI (in feet)} = \frac{TE_s}{2\sqrt{A \cdot \pi}}$$

$$= \frac{200\text{ ft}}{2\sqrt{(40{,}000\text{ ft}^2)(3.1416)}} = 0.28.$$

Induced DI, percent = Induced DI(100)
= 0.28(100) = 28%.

The number of successional stages or conditions represented should be added in parentheses after the Induced DI, percent as a further descriptor of induced diversity:

Induced DI, percent (number of successional stages or conditions) or 28%(6).



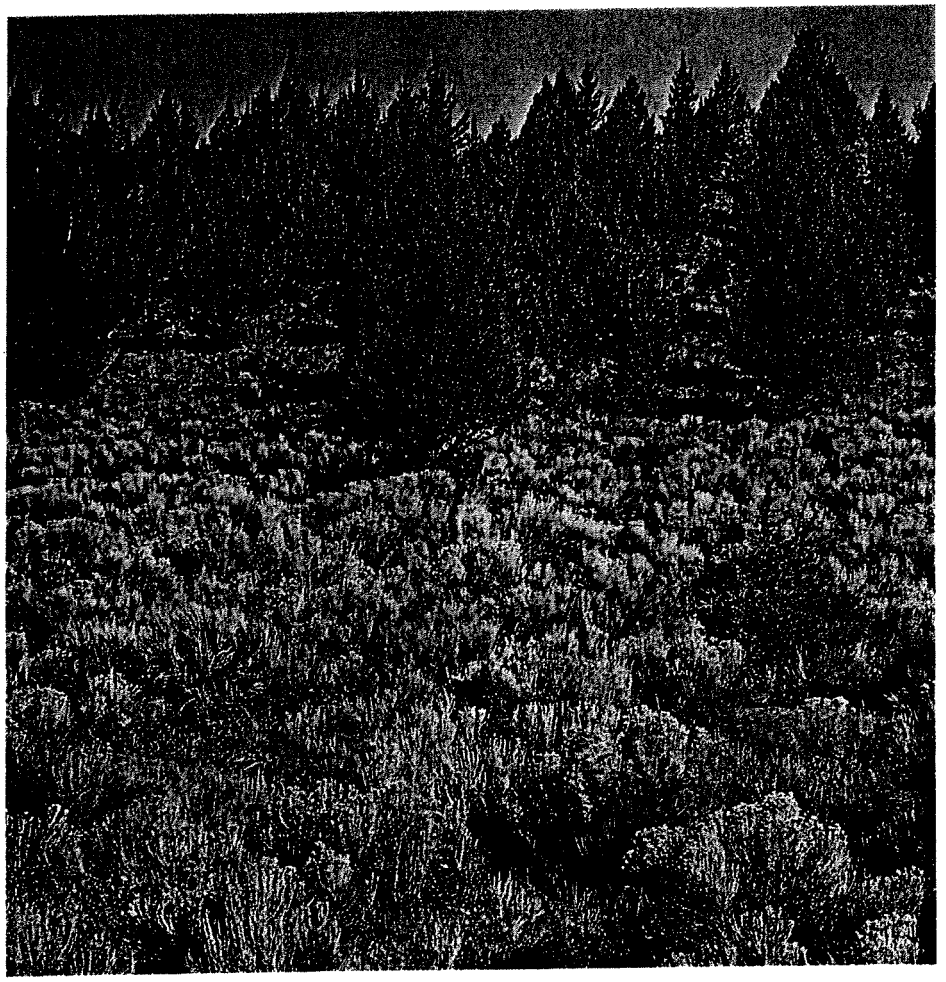
Inherent edges ———— Induced edges - - - - - -

Total area in meters = (60.9 m)(60.9 m) = 3 708.8 m^2

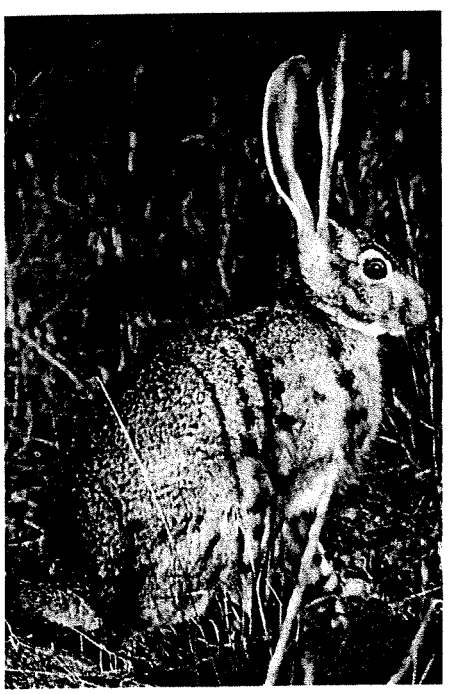
Total area in feet = (200 ft)(200 ft) = 40,000 ft^2

Total inherent edge =	365.8 m	1,200 ft
Total induced edge =	+ 60.9 m	+ 200 ft
	426.7 m	1,400 ft total edge

Figure 34. An area showing plant communities, successional stages, and edges.



The blacktail jackrabbit is especially adapted to the grass-shrub ecotone. Some edges, such as this sagebrush-juniper edge, result from differences in soils.



Total Diversity Index

Total DI is an index of the combined effects of Inherent DI and Induced DI. This is computed as follows:

$$\text{Total DI} = \frac{TE_{c+s}}{2\sqrt{A \cdot \pi}}, \text{ and}$$

$$\text{Total DI, percent} = (\text{Total DI})100;$$

where TE_{c+s} is the total length, in meters or feet, of all inherent and induced edges. This is computed as follows (see fig. 34):

$$\underset{\text{(in meters)}}{\text{Total DI}} = \frac{TE_{c+s}}{2\sqrt{A \cdot \pi}}$$

$$= \frac{427 \text{ m}}{2\sqrt{(3\,721 \text{ m}^2)(3.1416)}} = 1.97;$$

$$\underset{\text{(in feet)}}{\text{Total DI}} = \frac{TE_{c+s}}{2\sqrt{A \cdot \pi}}$$

$$= \frac{1{,}400 \text{ ft}}{2\sqrt{(40{,}000 \text{ ft}^2)(3.1416)}} = 1.97.$$

Total DI, percent = Total DI(100) = 1.97(100) = 197%.

Total DI, percent can be enhanced by showing the contributions of the number of plant communities and the number of successional stages or conditions as follows:

Total DI, percent (number of communities) (number of stages or conditions) or 197%(4)(6).

Note that when the expressions of inherent and induced diversity are added they equal total diversity:

Inherent DI, percent	169%
+ Induced DI, percent	+ 28%
Total DI, percent	197%

Therefore, if any two of the indexes are known, the third may be derived by appropriate addition or subtraction.

Mapping Codes

The indexes just discussed can be helpful in evaluating the general status of edge and diversity in a planning area. The forest manager may find it desirable to account for the amount and characteristics of individual edges in an area. The following coding system and order is suggested:

Edge type:	T = induced; P = inherent
Community:	Community-community for inherent edges, community for induced edges; the code is the first two letters of the genus and species names (Garrison et al. 1976)
Length:	In meters or feet
Average width of ecotone:	In meters or feet
Contrast:	1 to 5
Configuration:	A = abrupt; M = mosaic
Example:	T-PIPO-1,700-25-5-A

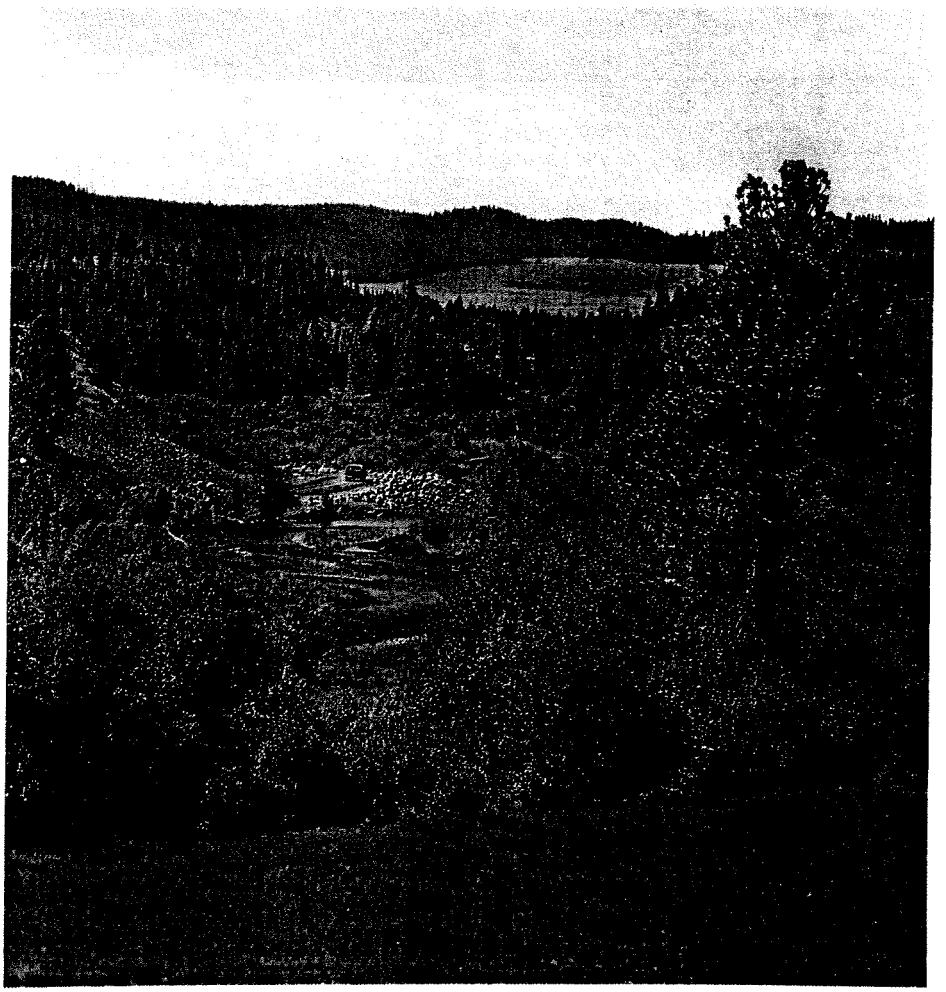
The codes in the example mean that the area has an edge that is induced; it is within the *Pinus ponderosa* community; it is 1,700 feet long and 25 feet wide; the contrast is 5; and it has an abrupt edge.

Management Considerations

Each forest area has a unique set of possibilities for diversity. One area may have a high degree of diversity as a result of its inherent mixture of communities. Such an area may have low priority for management to increase diversity. Conversely, an area may have only one or a few communities all in the same successional stage or condition and may be a good candidate for improvement in diversity if that is in keeping with management objectives.

The diversity of an area cannot be increased indefinitely by making more and smaller "islands" and more edges. Beyond some point the area's increasing heterogeneity tends toward homogeneity (fig. 32). The pieces become so small and mixed that they assume a sameness.

Diversity as a concept and goal of wildlife habitat management has become a shibboleth for many land-use planners and forest managers. This is because diversity seems to be a worthy goal. First, a wide variety of habitats are maintained which assures the presence of many kinds of wildlife. Second, all pieces of the system are preserved. Third, the system is protected to some extent from potential disasters.



A scenic vista provides an opportunity to study edges in the landscape.

As a result, the use of diversity as a goal has a certain biopolitical appeal. Diversity goals that are too broad are essentially non-constraining. The forest manager can talk a good story about wildlife habitat management, never state the objectives precisely, and never have to show exactly how the goal of diversity was accomplished. This is a misuse of the concept.

Diversity as a goal in management must be used with caution. The degree of habitat diversity can be "good" or "bad" only in relation to management goals and objectives. And maximum diversity may not always be an appropriate choice. For example, it is impossible to maximize diversity and at the same time maximize numbers of a particular species. Thus, diversity is a measure of habitat condition and must be considered in combination with the needs of the affected species. A mix of management for species richness and featured species management is feasible and will probably preclude the loss of any species while insuring desired yields of the featured species—usually game or threatened or endangered species (Gill et al. 1976).

Diversity is meaningful only in the context of clearly stated forest management objectives. If diversity is a goal of land management, it can be accomplished only if the manager is willing and able to measure changes in diversity. Without a concise statement of goals and adequate measurement of the status of diversity, forest managers cannot be held accountable.

5
Snags

by
Jack Ward Thomas
Ralph G. Anderson
Chris Maser
Evelyn L. Bull

The pileated woodpecker, a primary excavator, requires snags at least 50.8-centimeter (20-in) d.b.h. for nesting.

Snags provide a portion of the life support system for many species of plants, invertebrates, birds, and mammals (fig. 35). In the Blue Mountains, 39 bird and 23 mammal species use snags for nesting or shelter. These species can be divided into those that excavate their own cavities and those that occupy existing cavities (fig. 36) (USDA Forest Service [n.d.]). Cavities can occur naturally, be excavated, or be formed by the spaces under loose bark. Such cavities nearly always occur in dead or partly dead trees (fig. 37). Table 13 shows some examples of the types of excavation and uses made of cavities by selected wildlife species. Appendix 20 has a complete list of all 62 cavity users.

It has been persuasively argued that the absence of suitable nest sites is the usual limiting factor for cavity nesting birds. See literature reviews by Thomas et al. (1975), Beebe (1974), Jackman (1974b), Poznanin (1956), Bruns (1960), Franz (1961), Herberg (1965), Haapanen (1965), and Gysel (1961). In this discussion, a direct relationship has been assumed between the number of snags and the number of snag-dependent wildlife in the forest.

The extensive literature that was surveyed to provide information on individual species for this chapter is listed in appendix 29.

Types of Snags

The common forestry definition of a snag is a standing dead tree from which the leaves and most of the limbs have fallen. If the dead tree is broken off and more than 6.1 meters (20 ft) tall it is still properly called a snag. If shorter than that it is called a stub (Ford-Robertson 1971, p. 246). This definition, however, does not meet the requirements for management of snag-dependent wildlife. For purposes of this discussion, a snag is any dead or partly dead tree at least 10.2 centimeters (4 in) in diameter at breast height (d.b.h.) and at least 1.8 meters (6 ft) tall. This definition is based on the minimum diameter and height of dead trees used by birds for nesting.

Snags can be classified as either hard or soft. There are two reasons for making this breakdown—a forestry reason and a wildlife reason. The forestry reason is that hard snags are frequently marketable but soft snags are usually without market value. Hard snags are essentially composed of sound wood, especially on the outside. Soft snags are in advanced stages of decay and deterioration. Gale (1973) classified types of snags by striking them with an ax. If

the ax sank in with difficulty, the snag was termed "hard"; if it penetrated easily, the snag was called "soft." Hard snags usually have many dead branches and an intact top. Soft snags usually have broken tops and few limbs (Gale et al. 1973).

The wildlife reason for designating types of snags is that some species can excavate only in soft wood. Soft snags also produce the substrate for invertebrates on which many wildlife species feed. Other wildlife species excavate only in hard snags. Some authorities believe that woodpeckers test for the presence of heart rot—which usually makes snags easier to excavate (Conner et al. 1976).

Forest Insect Control

There has been a recent surge of interest in retaining snags for wildlife habitat in managed forests. This interest has been brought about by two factors: (1) the increased emphasis of recent Federal laws on management of publicly owned forest lands for wildlife and (2) the recognition that birds may play a significant role in regulation of insect populations. Most of the snag-dependent birds and mammals in the Blue Mountains are insectivorous and represent a major portion of the insectivorous forest fauna.

The role of insectivorous birds in control of forest insect pests has been reviewed by the German workers Bruns (1960), Franz (1961), and Herberg (1965). Beebe (1974) reviewed relationships between insectivorous hole-nesting birds and forest management. Buckner (1966, 1971) discussed the role of other vertebrate predators in insect control.

Early workers (Beal 1906, 1911; Forbush 1907; McAtee 1911, 1915, 1926; and many others) vividly described the number of insects consumed by birds, but they had a tendency to overstate the case. For example, McAtee (1926) referred to many instances of control or suppression of insect populations by birds alone. Later studies cast doubt on such simplistic interpretations (Tinbergen 1960, Morris 1963).

Form of life	Uses of snags	Examples
Fungi, mosses, and lichens	Decayed wood serves as a growth substrate.	Fungus, Moss, Lichen
Invertebrates	Spaces under bark serve as cover and as places for feeding.	Pseudoscorpion, Moth, Beetle, Ant
Birds	Cavities are used for nesting or roosting. Snags are used as perches and to support nests.	Flicker, Nuthatch, Pileated
Mammals	Cavities serve as dens or as resting or escape cover. Areas under loose bark are used by bats for roosting.	Bat, Flying squirrel, Marten

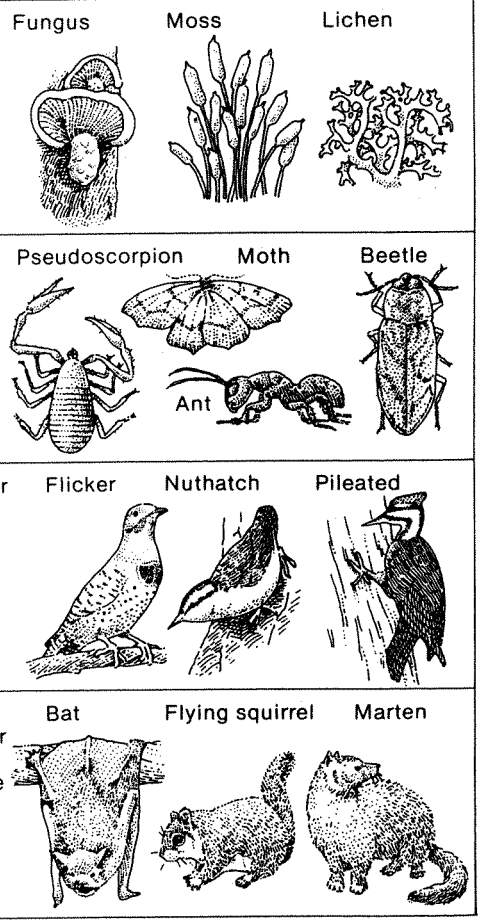


Figure 35. Snags support many forms of life.

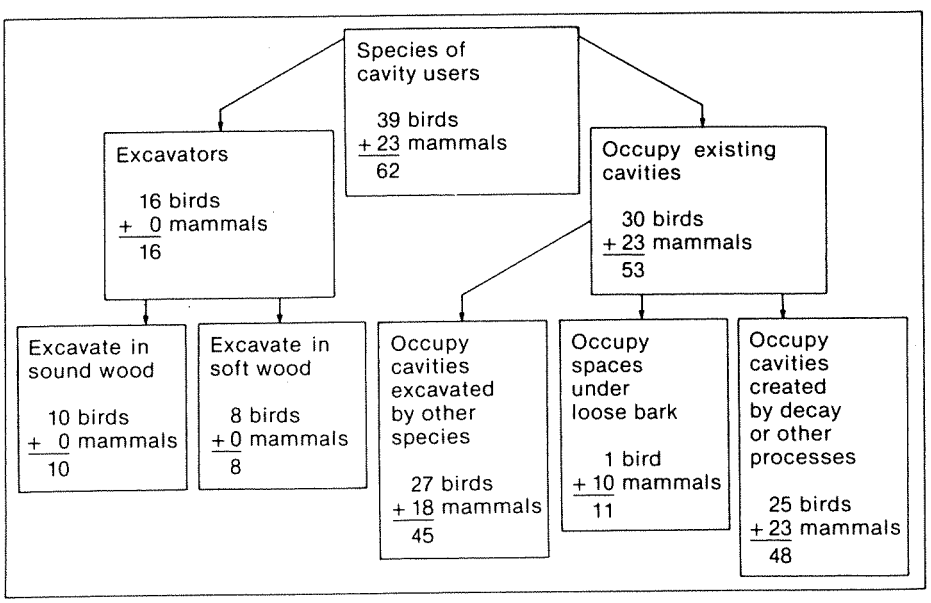


Figure 36. Wildlife species that excavate and/or occupy cavities in trees and snags can be divided into several categories (source: appendix 20).

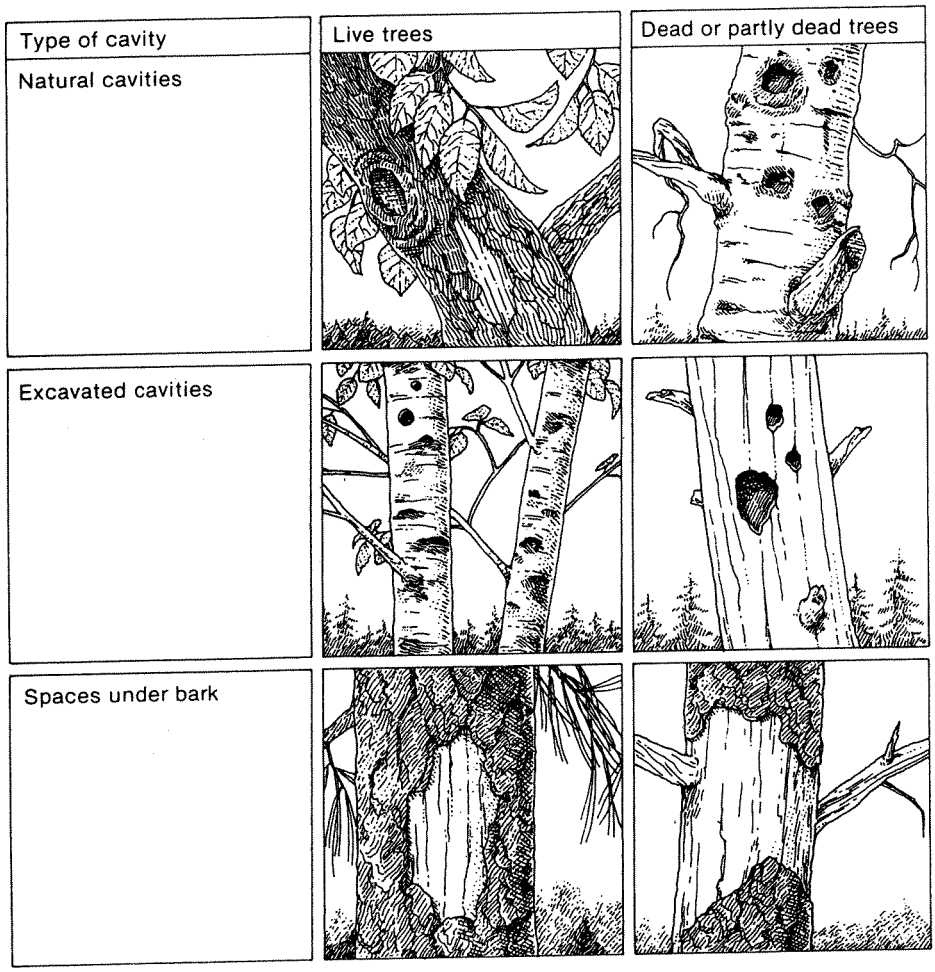


Figure 37. Most cavities occur in dead trees, but they may also be found in live or partly dead trees.

Owls, such as the saw-whet, use cavities excavated by other species.

Tinbergen (1960) contended that the exact relationship of birds to insect population dynamics could be shown only by intensive study of a single bird species over a large area for a prolonged period. Pospelov (1956, as quoted in Otvos 1965) indicated that the relationship of birds to insect population dynamics must be determined for each bird and insect species and for each forest stand. Beebe (1974) listed a number of studies which suggested that birds help regulate spruce budworm populations at endemic levels (Kendeigh 1947, Morris et al. 1958, Morris 1963, Dowden and Carolin 1950, Dowden et al. 1953, George and Mitchell 1948). Others have reported similar regulation of the larch sawfly by insectivorous vertebrates (Buckner and Turnock 1965), western pine beetle (Otvos 1965), and other beetles by woodpeckers (Massey and Wygant 1973), and moth larvae by tits (Gibb 1958, 1960).

There are many instances in which birds may have reduced outbreak populations of forest insects. Woodpeckers seem to have had such an effect on outbreaks of southern hardwood borers (Solomon 1969, Solomon and Morris 1971), Knight (1958) and McCambridge and Knight (1972) reported control of Engelmann spruce beetle by woodpeckers.

Insect control has also been reported when large numbers of birds drift into or congregate in outbreak areas during the winter. This phenomenon has been most frequently noted for woodpeckers by Blackford (1955), Koplin (1969), and Baldwin (1960). It has also been reported in many other species by Turcek (1948), Blais and Parks (1964), Sloan and Coppel (1968), Coppel and Sloan (1970), Mattson et al. (1968), and Dahlsten and Herman (1965). The importance of birds as biological control agents has received more attention in Europe where shorter rotations, intensive forestry, and loss of snag habitat have been evident longer than in North America.

Letter code	Life form	Species	Minimum d.b.h., in centimeters (inches), suitable for nesting	1 Excavates cavity, usually in sound wood	2 Excavates cavity, usually in soft or decayed wood	3 Occupies cavity made by another species	4 Occupies "natural" cavities created by decay, etc.	5 Occupies space under loose bark	6 Construction part of courtship ritual	7 Nests and/or raises young	8 Roosting	9 Overwintering	10 Hibernating
PAAT	14	black-capped chickadee[1]	10.2 (4)		•	•	•			•	•	•	
GAGA	14	mountain chickadee[1]			•	•	•			•	•	•	
DEPU	13	downy woodpecker[2]	15.2 (6)	•	•				•	•	•	•	
SPVA	13	yellow-bellied sapsucker[2]	25.4 (10)	•					•	•	•		
DEVI	13	hairy woodpecker[2]		•					•	•	•	•	
PADO	14	house sparrow				•	•			•	•		
EUAM	15	yellow pine chipmunk				•	•			•			
FASP	14	American kestrel	30.5 (12)			•	•			•			
OTAS	14	screech owl				•	•			•	•	•	
BUAL	14	bufflehead	38.1 (15)			•	•			•			
LOCU	14	hooded merganser				•	•			•			
AISP	14	wood duck	50.8 (20)			•	•			•			
BUCL	14	common goldeneye				•	•			•			

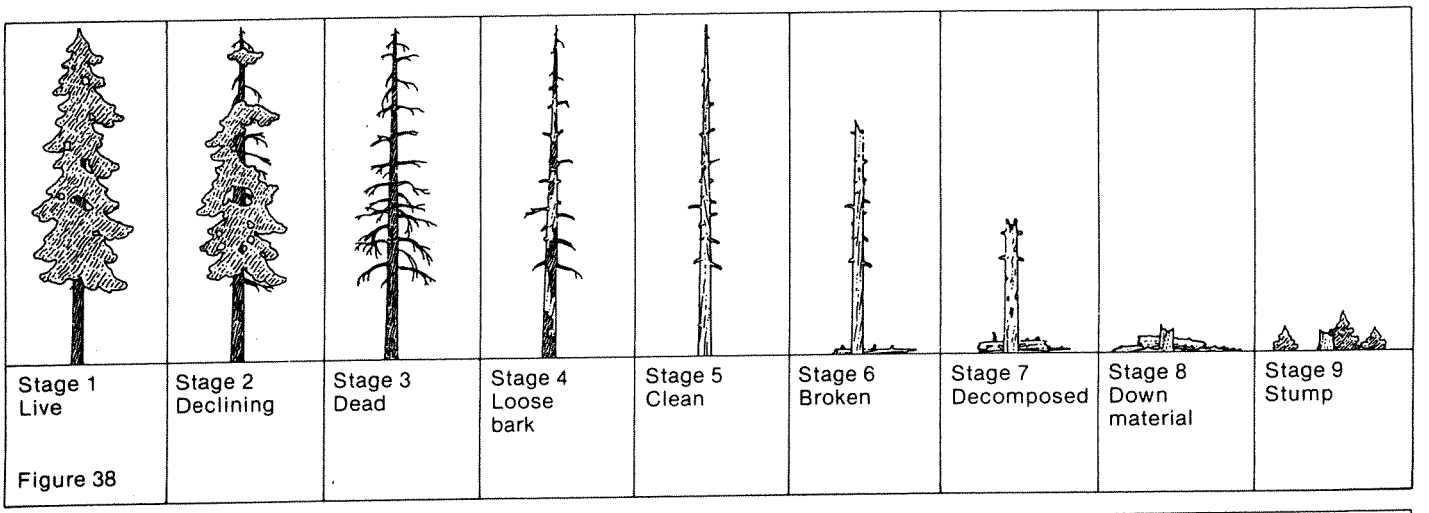
[1]Primary excavators in soft wood.
[2]Primary excavators in sound wood.
• Symbol denotes occurrence only.

Types of cavities utilized: 1–5. Uses of cavities: 6–10.

Table 13. Types of excavation and uses made of cavities by selected wildlife species (source: appendix 20)

Literature reviews by Poznanin (1956), Bruns (1960), Franz (1961), and Herberg (1965) also address the role of birds in insect control. Franz (1961) cites 229 references to support his conclusion that birds, along with insectivorous bats, small mammals, microbes, and predatory insects, help hold insect populations at endemic levels or exert some control during early stages of an outbreak. Bruns (1960) did a thorough review of the European literature dealing with insect control programs that satisfactorily used nest boxes to enhance populations of hole-nesting birds. Appel and Schwartz (1921), Freiberger (1926-27), Hähnle (1936), and Herberg (1965) reported satisfactory results with such techniques.

The importance that some European forest managers place on insectivorous birds as biological control agents is reflected in the funds expended to provide artificial nesting cavities. Cole [n.d.] noted that installation of boxes is common in Bavarian forests and that some 400,000 boxes have been placed in an area of 140 000 hectares (345,947 acres). Another 300,000 were planned in Spain (Molina 1971). It might be well to reflect on the cost of constructing, installing, and maintaining bird boxes in lieu of retaining snags.



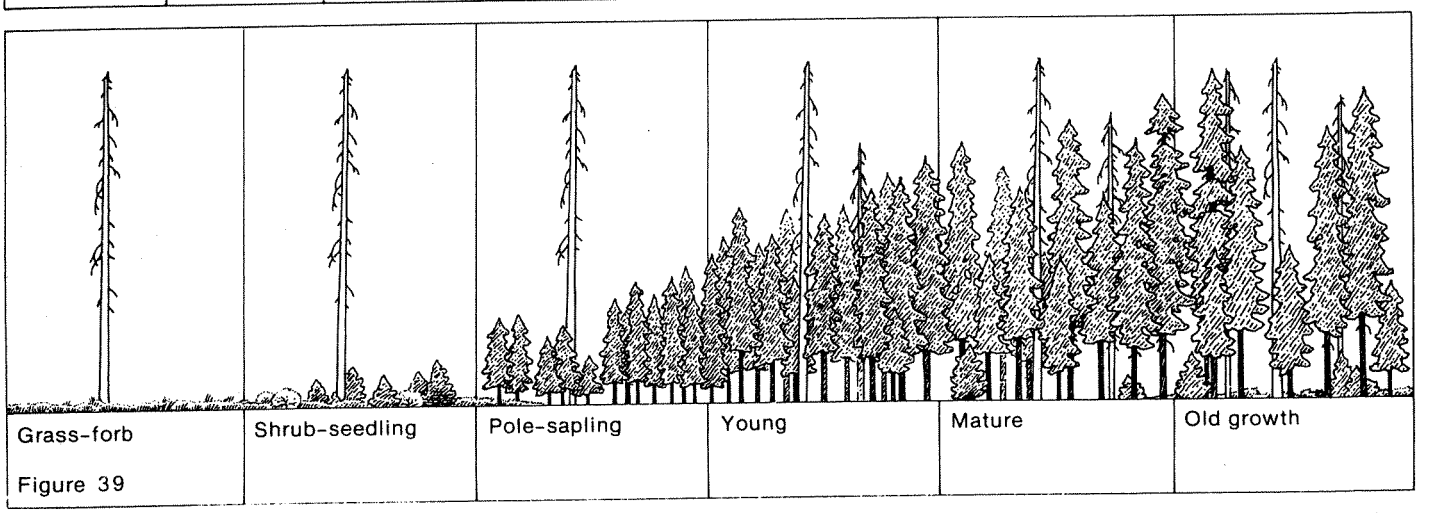


Figure 38. Snags undergo a series of successional changes from death of the tree to final decomposition.

Figure 39. The wildlife species that use snags are influenced by the stage of forest succession in which a snag occurs.

Beebe (1974, p. 27-28) summarized his extensive literature review on the relationship between insectivorous hole-nesting birds and forest management:

> . . . With few exceptions the conclusions of literally hundreds of papers dealing with the impact of avian predators on their insect prey have been that, in many instances, birds act as important components of natural biological regulation of insect population dynamics at endemic . . .levels. In some rather unusual circumstances birds may act together, each species and sometimes each sex in its own specialized way, to be a major cause of the suppression of an insect outbreak. . . .the most important role of birds is in the prevention of insect epidemics, rather than their suppression. This important role is probably still underestimated because the vast majority of research has been conducted during insect epidemics in which the sheer numbers of insects simply overwhelm the bird's ability to exert regulatory influence.

Bruns (1960, p. 204) provides an apt conclusion to the discussion:

> Birds are not a complete remedy. On the balance of opinions and considering recent investigations, the truth may lie neither in the one, nor in the other extreme direction, but in between. . . . within the community of all animals and plants of the forest, birds form an important factor. The birds generally are not able to break down an insect plague, but their function lies in *preventing* insect plagues. It is our duty to preserve birds from aesthetic as well as economic reasons, and to create artifical [*sic*] compensation in the form of nest-boxes, where nesting chances are diminished by the forestry work.

. . .the wood is still able to defend itself biologically against insect plagues. It is our duty to further these biological forces (birds, bats, wood ants, parasites) and to conserve or create a rich and diverse community. By such a prophylactic, carrying out of 'hygiene' before a possible outbreak of an insect pest, the forests will be better protected than by any other means. If there should be further insect plagues their effect will at least be diminished, so that we will only need to use chemical control in exceptional circumstances.

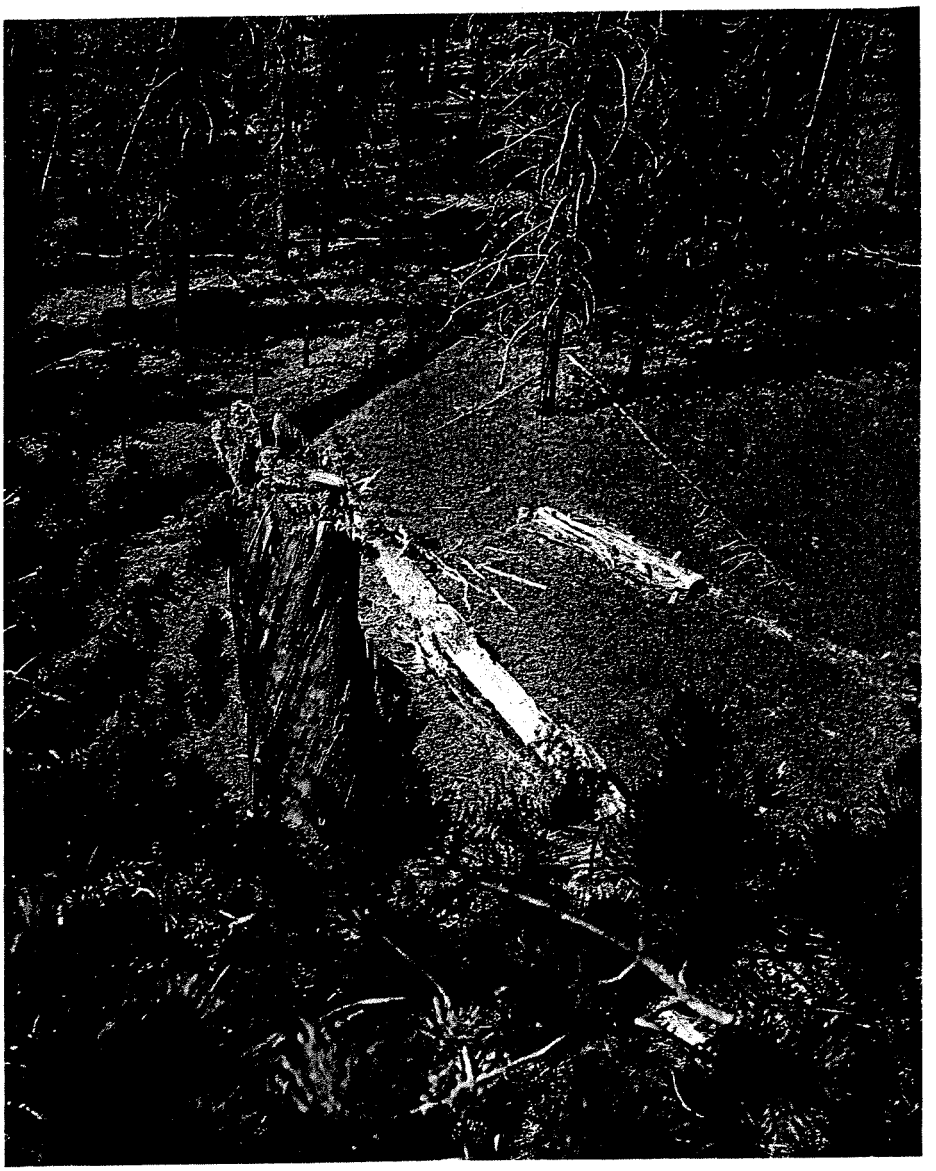
Snag Succession

Two successional processes influence the use of snags by wildlife: (1) the internal and external characteristics of the snag itself (fig. 38) and (2) the successional stage of the plant community that surrounds the snag (fig. 39).

A snag undergoes a series of changes from the time the tree dies until final collapse (Keen 1955) (fig. 38). Hard snags become soft snags through a gradual process of deterioration and decay. The rate at which a hard snag becomes soft depends on a combination of factors, including the tree's species and cause of death, its condition prior to death, the decay organisms present, its location, and site conditions.

Each stage in the decay process has particular value to certain wildlife species. For example, stage 4 in figure 38 is important to bats because they roost under loose bark. Stage 6 is most heavily used by excavating woodpeckers such as the pileated woodpecker. Stage 7 provides nest sites for birds such as the chickadee and Lewis' woodpecker which excavate in soft wood. Stages 8 and 9 provide feeding sites for insectivorous birds and small mammals.

The successional stage of the surrounding plant community also influences the way wildlife use snags (fig. 39). Bluebirds and house wrens will use cavities in a snag that occurs in the grass-forb stage or shrub-seedling stage and will not ordinarily use the same snag if it is surrounded by more advanced successional stages. The pileated woodpecker, however, will nest in a snag surrounded by trees but tends to avoid nesting in snags located in earlier successional stages.



Snags are frequently used by birds as nest sites and perches. The broken top of this snag has become a nesting site for a great gray owl.

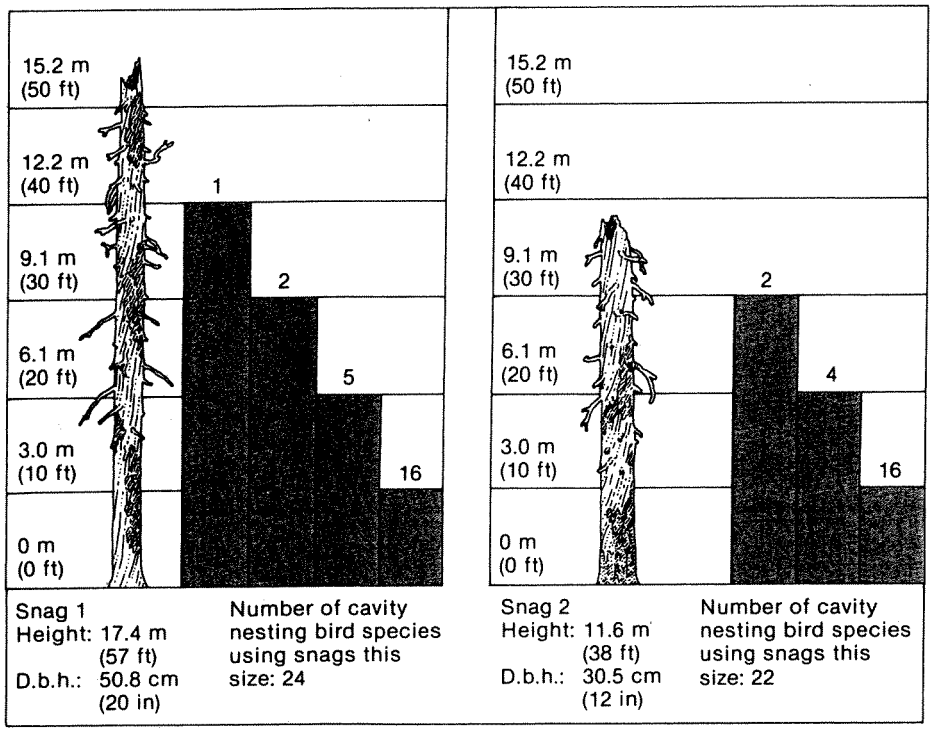


Figure 40. The potential use of a snag by wildlife depends on its diameter and height.

The size and height of snags also determine which species will use a snag for nesting. Each cavity nesting species exhibits a decided preference for a specific height at which to build its nest. The size of the species dictates the minimum diameter of the snag that can provide a large enough nesting site. Figure 40 shows the number of cavity nesting species that can be accommodated by two snags of different heights and diameters.

It has been pointed out that soft snags are critical habitat components for a number of wildlife species. They are relatively rare in managed forests because they evolve from hard snags, only a few of which stand long enough to become soft snags (Keen 1955).

But there is little reason to remove soft snags or keep them from developing in the managed forest. They have little or no commercial value and, because of decay, are hazardous to cut down. Furthermore, they present little fire hazard as their tops are usually broken off and do not attract lightning. All soft snags that are not distinct safety or fire hazards should be retained in the stand.

If the requirements for hard snags are met, their gradual deterioration will probably provide sufficient soft snags for cavity excavators. If the birds that chisel out cavities (primary excavators) are provided for, then the cavities they leave will probably provide nesting sites for secondary cavity nesters. As a result, if the requirements of woodpeckers for hard snags are met and all possible soft snags are retained, the requirements of all snag-dependent species should be met.

Site Selection by Primary Excavators

A number of investigators have pointed out the relationship between the sites selected for excavation by primary excavators and the presence of softened heartwood caused by fungal heart rots. Woodpeckers probably select these sites because it takes less energy to excavate in rotten wood (Odum 1941a, 1941b; Steirly 1957; Shigo and Kilham 1968; Dennis 1969; Ligon 1970; Kilham 1971b; Conner et al. 1975, 1976; Crockett and Hadow 1975; Jackson 1977).

Conner et al. (1976) think that woodpeckers detect the presence of heart rot by pecking the tree and listening for a particular resonance. The system is obviously not foolproof as woodpeckers make many "false starts" and have to abandon the excavation when they encounter solid heartwood. This phenomenon has also been observed in the Blue Mountains (Bull, unpublished, see "References Cited").

Conner (1978) suggested that to classify a tree as a suitable nest site for cavity excavators there should be some sign of heart rot at the height and diameter required by the primary excavator. According to Conner, trees that harbor heart rot can sometimes be identified by:

1. Conks of species of fungi associated with heart rot (Shigo and Larson 1969, Hepting 1971, Conner et al. 1976).
2. Stubs of broken branches (Shigo and Larson 1969, Baumgartner 1939b, Conner et al. 1976).
3. Wounds or scars resulting from fire, lightning, or mechanical damage (Hepting 1935, Hepting and Hedgcock 1937, Stickel 1940, Wright and Isaac 1956, Toole 1960, Shigo and Larson 1969).

Letter code	Life form	Species		1 Western juniper	2 Quaking aspen	3 Riparian (cottonwood)	4 Ponderosa pine	5 Mixed conifer	6 White fir (grand fir)	7 Lodgepole pine	8 Subalpine fir
		BIRDS									
MEME	14	common merganser	S	●	●	●	●				
TYAL	14	barn owl	S			●	●	●	●		
STVA	14	barred owl	S			●	●	●	●		
CHVA	14	Vaux's swift	S			●		●	●	●	●
DRPI	13	pileated woodpecker	P				●	●	●		
SPVA	13	yellow-bellied sapsucker	P		●	●					
DEVI	13	hairy woodpecker	P				●	●	●	●	●
DEPU	13	downy woodpecker	P		●	●					
PAAT	14	black-capped chickadee	P		●	●					
PAGA	14	mountain chickadee	P	●			●	●	●	●	●
PARU	14	chestnut-backed chickadee	P					●	●	●	
		MAMMALS									
DIMA	5	opossum	S			●					
PRLO	14	raccoon	S			●					
MAPE	14	fisher	S			●		●	●	●	●
SPPU	15	spotted skunk	S		●		●	●			
		Occurrence by major habitat (plant community)		1	2	3	4	5	6	7	8

P Primary cavity excavator
S Secondary cavity user
● Symbol denotes primary occurrence

Table 14. Each forest community supports a distinct combination of primary excavators and secondary cavity users; some examples are shown (source: appendix 17)

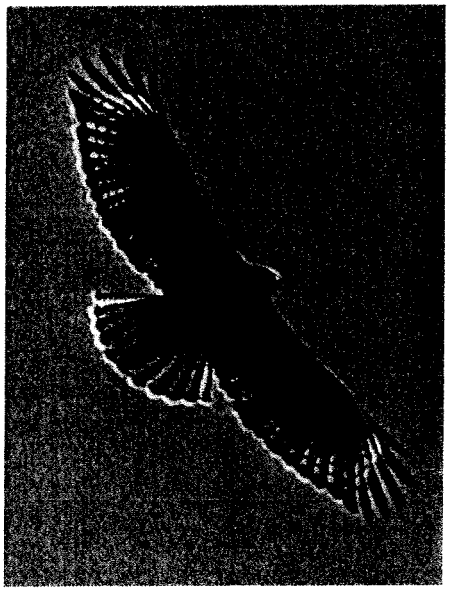
4. Discolored or soft, decayed wood in samples taken with an increment borer (Toole 1960, Shigo and Larson 1969, Conner et al. 1976, Jackson 1977).
5. Woodpecker holes or cavities.
6. Dead areas on living trees.
7. Heart rot fungi in cultures of wood from increment cores (Davidson et al. 1942, Nobles 1965, Conner et al. 1976).
8. Positive indication of wood decay using the "Shigometer" (Northeastern Forest Experiment Station [n.d.]).

Letter code	Life form	Species	≧1.8 (≧6)	≧4.6 (≧15)	≧9.1 (≧30)	≧9.5 (≧31)	Minimum d.b.h. required for nesting in centimeters (inches)
			Minimum nesting height, in meters (feet)				
PAAT	14	black-capped chickadee	•				10.2 (4)
PAGA	14	mountain chickadee	•				
DEPU	13	downy woodpecker		•			15.2 (6)
SPVA	13	yellow-bellied sapsucker		•			25.4 (10)
DEVI	13	hairy woodpecker		•			
FASP	14	American kestrel		•			30.5 (12)
OTAS	14	screech owl		•			
BUAL	14	bufflehead	•				38.1 (15)
LOCU	14	hooded merganser	•				
AISP	14	wood duck	•				50.8 (20)
BUCL	14	common goldeneye	•				

• Symbol denotes occurrence only.

Table 15. Each species has specific requirements in the height and diameter of snags which can be used for nesting and shelter; some examples are shown (source: appendix 19)

Hawks sometimes build their bulky nests of sticks high in snags or on cliffs. The red-tailed hawk is a common resident of forests in the Blue Mountains.



Snag Requirements

Each forest community supports a distinct combination of primary excavators and secondary cavity users (table 14 and appendix 17) (Dennis 1971). Furthermore, each species has distinct requirements in terms of the minimum diameter and height of the snags used for nesting and shelter (table 15 and appendix 19). Each forest community has different requirements in terms of the number, species, and size of snags necessary to support all the cavity users associated with that community. The forest manager must consider snag requirements on a community-by-community basis. Development of criteria that are too general may lead to an oversupply of snags in one timber type and a grossly inadequate supply in another.

The number and size of available snags affect not only the presence or absence of snag-dependent wildlife but also wildlife population levels. If information is available on the relationship of the number of snag-dependent wildlife to the size and height of snags, it should be possible to manage for a desired population of cavity users. Appendix 22 has been developed to show the snag requirements of woodpeckers for nesting by each timber type (table 16). The information was developed in the following manner:

1. The territorial requirements of each woodpecker species were determined from the literature and from unpublished research information (table 17 and appendix 21) (Anderson [n.d.], unpublished, see "References Cited"). The territory is the area around the nest site that the occupants will defend against others of the same species.

Letter code	Life form	Species	Minimum snag d.b.h. in centimeters (inches)	Snags required per 100 hectares (100 acres) to support various percentages of maximum woodpecker populations									
				100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Ponderosa pine community													
DRPI	13	pileated woodpecker	≧50.8 (≧20)	32 (14)	28 (12)	25 (11)	22 (9)	19 (8)	16 (7)	13 (5)	9 (4)	6 (3)	3 (1)
SPTH	13	Williamson's sapsucker	≧30.5 (≧12)	371 (150)	333 (135)	296 (120)	259 (105)	222 (90)	185 (75)	148 (60)	111 (45)	74 (30)	37 (15)
ASLE	13	Lewis' woodpecker	≧30.5 (≧12)	249 (101)	224 (90)	199 (80)	174 (70)	149 (60)	125 (50)	100 (40)	75 (30)	50 (20)	25 (10)
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
DEAL	13	white-headed woodpecker	≧25.4 (≧10)	558 (225)	502 (203)	446 (180)	391 (158)	335 (135)	279 (113)	223 (90)	167 (68)	112 (45)	56 (23)
DEVI	13	hairy woodpecker	≧25.4 (≧10)	446 (180)	401 (162)	356 (144)	312 (126)	267 (108)	223 (90)	178 (72)	134 (54)	89 (36)	45 (18)

Table 16. Hard snag requirements for woodpeckers in the ponderosa pine community; the minimum snag diameter is the smallest snag each species can use for nesting and roosting (source: appendix 22)

2. The potential maximum population of each species per 100 hectares or 100 acres of habitat was derived by dividing the area by the territorial requirement of the species:

$$P = \frac{100 \text{ hectares}}{Th}, \text{ or}$$

$$P = \frac{100 \text{ acres}}{Ta};$$

where P is the potential maximum population of the species in number of pairs, Th is the territorial requirement of the species in hectares, and Ta is the territorial requirement in acres. This formula is based on the assumption that there are enough suitable nest snags to prevent snags from being a limiting factor on the number of nesting pairs of woodpeckers—which seldom occurs except in isolated situations such as areas of insect damage or old burns. These requirements are illustrated in table 17 and appendix 21.

3. Possible management levels for each species were selected at intervals between 10 and 100 percent of the potential maximum population. The number of snags per 100 hectares (100 acres) at each management level was determined by multiplying the potential maximum population by the selected percentages:

$$N = (P)(M);$$

where N is the number of nesting pairs per 100 hectares (100 acres) at this level, P is the potential maximum population in number of pairs, and M is the percentage of the maximum population selected.

4. The snag requirement for nesting of each pair was derived by considering that: (a) depending on the species, each pair excavates one to three holes a year for nesting and roosting (table 17 and appendix 21); (b) the same tree is usually used only once by a particular pair of woodpeckers; and (c) there are approximately 16 snags without nest cavities for each one that has a cavity. The ratio of snags without cavities to snags with cavities was determined from a sample of about 8,000 snags in the Blue Mountains. The snag requirement per pair was computed for each species:

$$S = (C)(16 - 1)(N);$$

where S is the snags required per species pair per 100 hectares (100 acres), C is the number of cavities excavated per pair per year, 16 is the number of snags without cavities compared with each snag with a cavity, 1 accounts for the tree in which the species in question excavates in that year, and N is the number of nesting pairs per 100 hectares (100 acres) at this level.

The estimated hard snag requirements for each forested plant community are displayed in appendix 22. The communities are: riparian (cottonwood-alder), aspen, juniper, ponderosa pine, mixed conifer, white fir, lodgepole pine, and subalpine fir. The woodpeckers listed for each type are those that show primary association with that type; species that show secondary or incidental association are not listed.

Species			1	2	3	4	5	Comments
DRPI	13	pileated woodpecker	40-243 (100-600)	121 (300)	0.7 (0.3)	3	50.8 (20)	
DEVI	13	hairy woodpecker	2.4-3.6 (6-9)	10.1 (25)	9.9 (4)	3	25.4 (10)	Territory based on data of Evelyn Bull (unpublished, see "References Cited")
Letter code	Life form		Reported territory sizes in hectares (acres) 1	Territory sizes used in this book in hectares (acres) 2	Maximum pairs/100 hectares (pairs/100 acres) 3	Number of cavities excavated per pair per year 4	Minimum d.b.h. size of nest tree in centimeters (inches) 5	

Table 17. Habitat requirements for the pileated and hairy woodpeckers (source: appendix 21)

Appendix 22 displays options and trade-offs. Consider the example in table 16. Six woodpecker species (primary excavators) commonly nest in the ponderosa pine community. The column headed "Minimum snag d.b.h. in centimeters (inches)" is the *smallest* diameter snag that each species can use for nesting or roosting. Note that the average diameter of the snags occupied will exceed the minimum snag diameter because woodpeckers tend to select snags that are larger than the minimum size required for nesting.

By examining such displays the manager can determine which primary excavators will occupy the community and the number and size of snags required to maintain each species at various population levels. The manager can also determine the impact on cavity nesters of maintaining different combinations of snag densities and sizes.

If the manager decides, for example, to manage a ponderosa pine stand with a strict periodic harvest of all trees ≧30.5-centimeter (≧12-in) d.b.h., the pileated woodpecker, which requires a larger diameter tree, will disappear from the stand as a breeding species along with its associated secondary cavity users.

Large Snags Can Be Substituted for Smaller Ones

Table 16 and appendix 22 show the requirements for each woodpecker species that nests in the ponderosa pine community. But the forest manager must be concerned with the requirements of all cavity nesters. Table 16 and appendix 22 can be modified to reflect those requirements. Three biological considerations are relevant: (1) the same snag can be used by several cavity excavating species; (2) birds of the same species will not usually excavate twice in the same snag; and (3) larger snags can be substituted for smaller snags—the reverse is not true, however.

For example, a common flicker will not usually excavate in a tree smaller than 30.5-centimeter (12-in) d.b.h., but it can excavate in any suitable tree that is larger. Therefore, a tree smaller than 30.5 centimeters (12 in) cannot be considered a substitute when snags for the common flicker are provided; any satisfactory snag larger than 30.5 centimeters (12 in) can be substituted.

The overall needs of the primary excavators can be computed by using these substitutions and the data in table 16 and appendix 22 as a base. For example, a decision may be made to manage a ponderosa pine forest for all six resident woodpecker species at 100 percent of their potential nesting density. Refer to the snag requirements by species in table 16.

The requirements for all primary excavators can be determined. For example, if 32 snags per 100 hectares (247 acres) ≧50.8-centimeter (≧20-in) d.b.h. are provided for the pileated woodpecker, these snags will also provide 32 of the 371 snags required for the Williamson's sapsucker, leaving a need for 339 snags ≧30.5-centimeter (≧12-in) d.b.h. (371 – 32 = 339). If these 339 snags are provided, requirements for the Lewis' woodpecker and the common flicker will also have been met. These snags (32 + 339) also provide 371 of the 558 snags ≧25.4-centimeter (≧10-in) d.b.h. needed for the white-headed woodpecker and reduce the need to an additional 187 snags ≧ 25.4-centimeter (≧10-in) d.b.h. (558 – 371 = 187). When these 187 snags are provided, requirements for 446 snags ≧25.4-centimeter (≧10-in) d.b.h. for the hairy woodpecker will have been met. At this point the snag requirements are fulfilled for all resident woodpeckers.

When the requirements of species that need the largest number of snags of a particular d.b.h. class are met, the requirements of all other species within that group will also be met. In this example, the provision of 32 snags per 100 hectares (247 acres) of ≧50.8-centimeter (≧20-in) d.b.h., plus 339 additional snags of ≧30.5-centimeter (≧12-in) d.b.h., plus 187 more snags of ≧25.4-centimeter (≧10-in) d.b.h. will provide the anticipated nesting and roosting sites necessary for all woodpecker species and secondary cavity users.

The principle of substitutability was used in converting the information on individual woodpecker requirements for snags on a community-by-community basis (table 16 and appendix 22) to the total snag requirements for all resident woodpeckers for each community at each population level. If the general population levels of the primary excavators (woodpeckers) are used as the management criteria, the snag management requirements are much simplified. Table 18 shows the snag requirement in the ponderosa pine community as an example of the information given in appendix 23 for all forested plant communities.

To see how this principle works, examine the 50-percent population level in table 18. It shows that to manage all primary excavators at that level would require for each 100 hectares at least 16 snags of ≧50.8-centimeter (≧20-in) d.b.h., at least 169 snags ≧30.5-centimeter (≧12-in) d.b.h., and at least 94 snags ≧25.4-centimeter (≧10-in) d.b.h. for a total of 279 snags per 100 hectares (247 acres). Note that this does not preclude further substitution of larger snags for smaller ones. For example, all 279 snags could be ≧50.8-centimeter (≧20-in) d.b.h. and meet the snag requirements for all primary excavators at the 50-percent level.

Meeting Partial Requirements for Woodpeckers

Different population levels of woodpeckers can be produced on a species-by-species basis. For example, it may be decided to manage for 100 percent of the potential population of the pileated woodpecker. This species has a comparatively large territorial requirement (table 17 and appendix 21) and excavates a large cavity that is also needed by large secondary cavity users (table 13 and appendix 20). At the same time a decision could be made to manage for Williamson's sapsucker, common flicker, and Lewis' woodpecker at the 60-percent level. This would yield a much lower snag requirement than managing for all species at the 100-percent level.

The common flicker will not usually excavate a tree smaller than 30.5-centimeter (12-in) d.b.h.

Snag d.b.h. size class in centimeters (inches)[2]	Percent of maximum potential populations									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the ponderosa pine community[1]										
≧50.8(≧20)	32(14)	28(12)	25(11)	22(9)	19(8)	16(7)	13(5)	9(4)	6(3)	3(1)
≧30.5(≧12)	339(136)	305(123)	271(109)	237(96)	203(82)	169(68)	135(55)	102(41)	68(27)	34(14)
≧25.4(≧10)	187(75)	169(68)	150(60)	132(53)	113(45)	94(38)	75(30)	56(23)	38(15)	19(8)
Total	558(225)	502(203)	446(180)	391(158)	335(135)	279(113)	223(90)	167(68)	112(45)	56(23)

See appendix 23 for footnotes.

Table 18. Snag management requirements for woodpeckers in the ponderosa pine community (source: appendix 23)

The information in appendix 22 and table 16 can also be used another way. Consider a ponderosa pine stand that has no snags or trees larger than 27.9-centimeter (11-in) d.b.h. The models show that it is impossible in this case to provide for the pileated woodpecker, Williamson's sapsucker, Lewis' woodpecker, and the common flicker and their associated secondary cavity users because they all require snags larger than 30.5-centimeter (12-in) d.b.h. It is possible, however, to manage for the two species (white-headed woodpecker and hairy woodpecker) that use smaller snags. Furthermore, the decision could be made to provide larger snags when the stand is older.

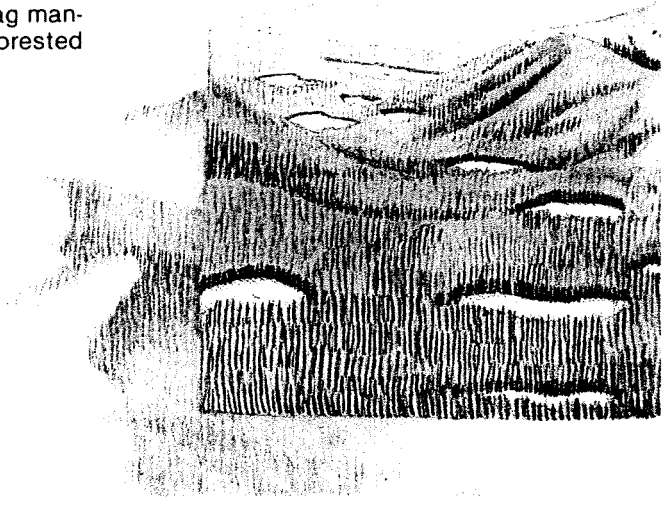
Selecting a Population Level

The population level selected for management of woodpeckers and other cavity users should be determined for the entire forest area under consideration (fig. 41). The management level is a function of the amount of forest area containing snags and the number of snags present. For example, if 70 percent of the forested acres met 70 percent of the maximum snag level, the result would be a 49-percent snag management level for the entire forested area (70% × 70% = 49%).

The lower the population level selected, the larger the risk of excluding a species from the area. Management below the 40-percent level may be too low to maintain self-sustaining populations of a species. Any snags are better than no snags, however, and at some point factors other than snags will become limiting.

It is unlikely that the snag requirements at any selected level can be met on all forested acres all of the time. Several points that can be discerned from figure 41 should be emphasized:

1. There are many combinations of hectares (acres) with snags and snag levels that will yield satisfactory results. This means there is a large degree of management flexibility.
2. The response of snag-dependent wildlife to the number of snags in an area is not precise, but snag-dependent species tend to increase along with the number of snags.
3. An increase in the overall snag management level is likely to increase the probability that viable populations of snag-dependent species will continue to exist in an area.

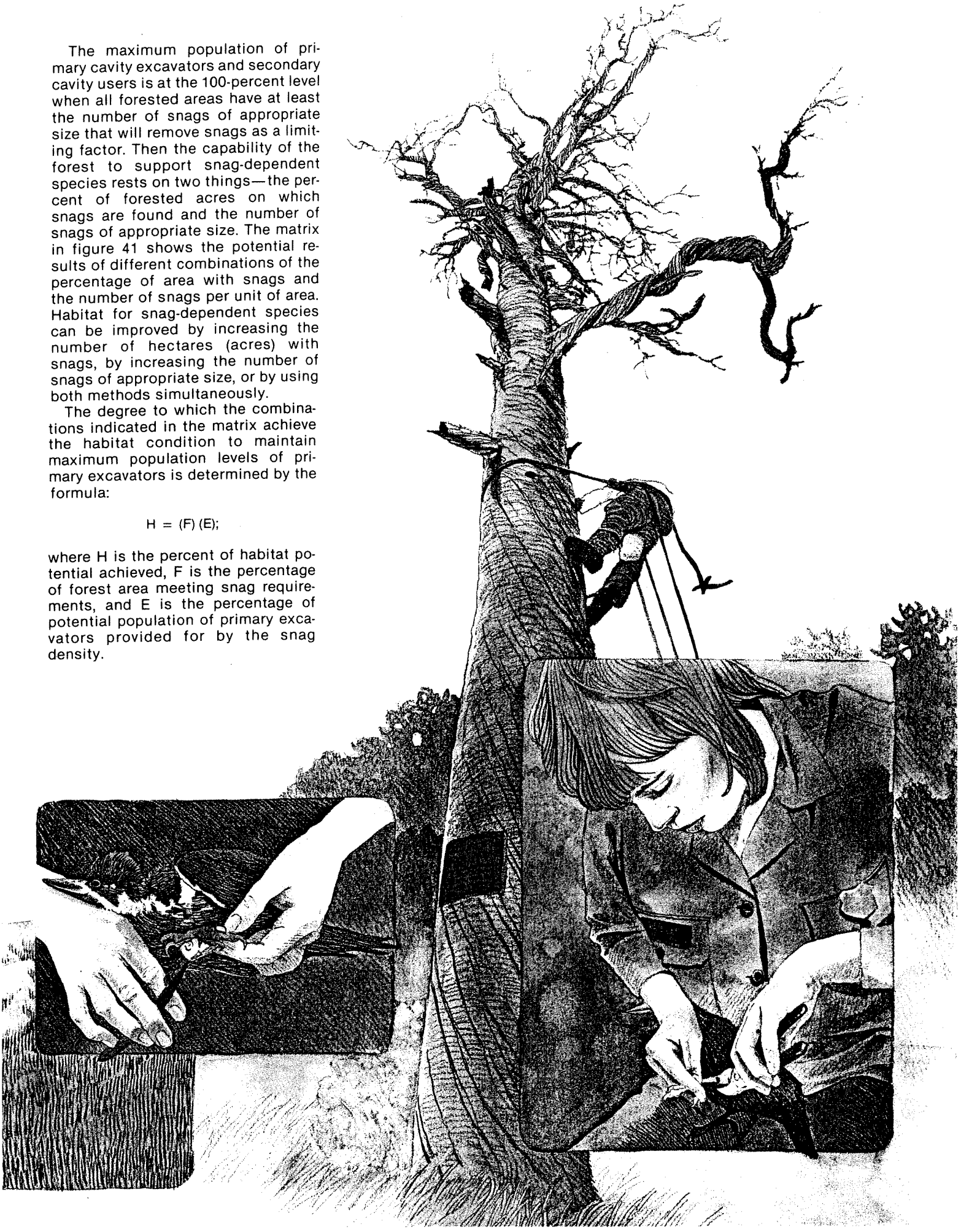


The maximum population of primary cavity excavators and secondary cavity users is at the 100-percent level when all forested areas have at least the number of snags of appropriate size that will remove snags as a limiting factor. Then the capability of the forest to support snag-dependent species rests on two things—the percent of forested acres on which snags are found and the number of snags of appropriate size. The matrix in figure 41 shows the potential results of different combinations of the percentage of area with snags and the number of snags per unit of area. Habitat for snag-dependent species can be improved by increasing the number of hectares (acres) with snags, by increasing the number of snags of appropriate size, or by using both methods simultaneously.

The degree to which the combinations indicated in the matrix achieve the habitat condition to maintain maximum population levels of primary excavators is determined by the formula:

$$H = (F)(E);$$

where H is the percent of habitat potential achieved, F is the percentage of forest area meeting snag requirements, and E is the percentage of potential population of primary excavators provided for by the snag density.



Increasing distribution, probability of occurrence, and welfare of cavity nesting species

Increasing distribution, probability of occurrence, and welfare of cavity nesting species

Snag level (percent)

Forested land area with snags (percent)	Highly viable									Viable				Marginal				Nonviable		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5
100	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5
95	95	90	86	81	76	71	67	62	57	52	48	43	38	33	29	24	19	14	10	5
90	90	86	81	77	72	68	63	59	54	50	45	41	36	32	27	23	18	14	9	5
85	85	81	77	72	68	64	60	55	51	47	43	38	34	30	26	21	17	13	9	4
80	80	76	72	68	64	60	56	52	48	44	40	36	32	28	24	20	16	12	8	4
75	75	71	68	64	60	56	53	49	45	41	38	34	30	26	23	19	15	11	8	4
70	70	67	63	60	56	53	49	46	42	39	35	32	28	25	21	18	14	11	7	4
65	65	62	59	55	52	49	46	42	39	36	33	29	26	23	20	16	13	10	7	3
60	60	57	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3
55	55	52	50	47	44	41	39	36	33	30	28	25	22	19	17	14	11	8	6	3
50	50	48	45	43	40	38	35	33	30	28	25	23	20	18	15	13	10	8	5	3
45	45	43	41	38	36	34	32	29	27	25	23	20	18	16	14	11	9	7	5	2
40	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2
35	35	33	32	30	28	26	25	23	21	19	18	16	14	12	11	9	7	5	4	2
30	30	29	27	26	24	23	21	20	18	17	15	14	12	11	9	8	6	5	3	2
25	25	24	23	21	20	19	18	16	15	14	13	11	10	9	8	6	5	4	3	1
20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
15	15	14	14	13	12	11	11	10	9	8	8	7	6	5	5	4	3	2	2	1
10	10	10	9	9	8	8	7	7	6	6	5	5	4	4	3	3	2	2	1	1
5	5	5	5	4	4	4	4	3	3	3	3	2	2	2	2	1	1	1	1	0

Snag habitats produced by these combinations will almost certainly support highly viable populations, but other factors may preclude attainment of maximum population densities

Snag habitats produced by these combinations will probably maintain viable populations

Snag habitats produced by these combinations are marginal and will probably not support viable populations

Snag habitats produced by these combinations almost certainly will not support viable populations

Figure 41. The management level for snags is a combination of the percentage of forested land area with snags and the intensity of snag management (table 18 and appendix 23). To determine the snag requirements for each management level, it is necessary to know the hard snag requirements for woodpeckers in each plant community (table 16 and appendix 22).

For example, if 100 percent of the forested area was managed at the 100-percent snag level required to maximize populations of primary excavators, the habitat for all cavity users would be maximized (100% × 100% = 100%). If only 60 percent of the forested area met the snag requirement at the 40-percent level, the habitat would be at 24 percent of its potential (60% × 40% = 24%). Approximately the same result could be achieved by reducing the area meeting the requirements to 40 percent and increasing the snag level to 60 percent (40% × 60% = 24%).

The relationship between woodpecker population levels and number of snags is shown for each forest community in appendix 22. Such information is given in table 16 for the ponderosa pine community. This information is used to determine the snag requirements for each management level. Note in figure 41 that the management level for snags is a combination of the percentage of forested land area with snags and the snag level on that area. The data in appendix 22 (table 16) are used to convert those population levels to snag densities by snag size class.

Trees Preferred by Woodpeckers

The species of trees preferred by each woodpecker species for cavity excavation in the Pacific Northwest are shown in appendix 18. Of the conifers, ponderosa pine, larch, and fir are used most often. These species should be selected for snags if possible. Deciduous trees, particularly aspen, cottonwood, and willows, are heavily used where they occur. This does not mean that other tree species are not used. In essence, the primary excavators display distinct preferences for particular species of trees but will use others, at least to some extent, when necessary. The upshot is that any species of snag is better than none, but some are much preferred.

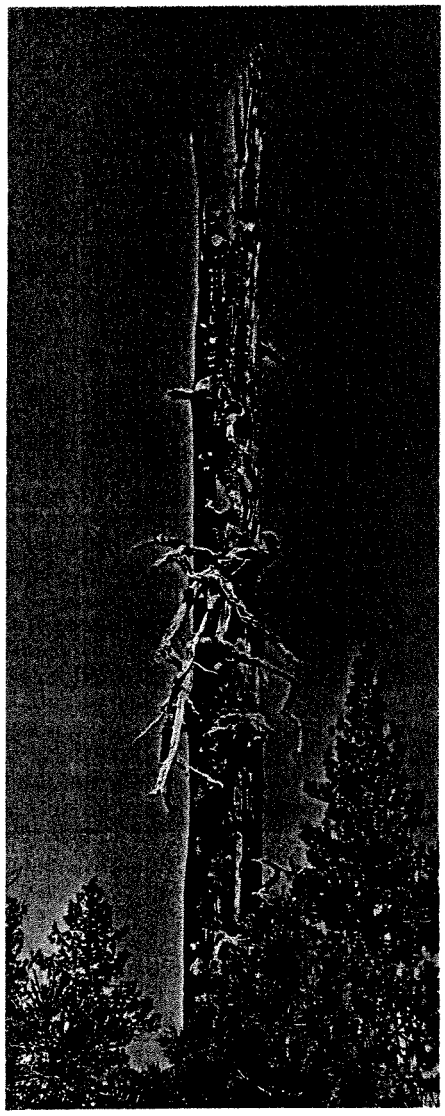
Meeting Snag Requirements Over Time

Snags come and go throughout the life of a stand. The tables are built on the assumption that snag requirements will be met over time. For example, if a ponderosa pine stand (table 18 and appendix 23) is clearcut and enough snags are left to provide for 100 percent of the potential population of all woodpeckers, this snag level will be maintained only until the snags begin to deteriorate. Over the years, their natural demise will continuously reduce the number of snags until replacement snags begin to occur naturally or can be created in the new stand.

Careful management will be required to provide snags of sufficient size to insure the long-term welfare of dependent wildlife species. As forest management is intensified, there will be a tendency to eliminate the old-growth stands that produce the large snags most used by cavity dwellers (Meslow and Wight 1975, Thomas et al. 1975, Jackman 1974a). Careful planning will be required to see that snags of appropriate species, size, and density are available at all times (Bull 1975, Jackman 1974a). A number of methods can be used by the forest manager to produce snags: long rotations of either stands or selected trees, killing of suitable trees, and retention of snags in managed stands.

The intensively managed forest will probably be harvested when trees are below the 50.8-centimeter (20-in) d.b.h. minimum size required for nest trees by pileated woodpeckers and their associated secondary cavity users. One way to provide such large trees and, in turn, large snags is to manage some selected stands on a longer rotation, delaying harvest until the dominant trees are considerably larger than 50.8-centimeter (20-in) d.b.h. The same goal might be achieved by selecting individual trees or small groups of trees and allowing them to reach larger size.

It is possible to create snags by intentionally killing appropriately located trees of the correct size and species. This approach should be used with caution, however. It has not yet been conclusively demonstrated that such trees will ultimately be suitable for use by the primary excavators.



Snags undergo successional stages as they gradually decay. This broken snag is well on its way to becoming dead and down woody material which will be used as habitat for many wildlife species.

Broken-topped, twisted, and many-limbed snags can be retained for wildlife, such as the flammulated owl, with minimum effect on timber harvest.

The retention of snags is essential. This means that salvage logging of some commercially valuable trees must be forgone to meet wildlife habitat goals. Astute selection of trees to be retained, however, can mitigate some of the economic loss. One way is to leave broken-topped, twisted, and many-limbed snags while selecting the more valuable whole, straight, and clear-trunked snags for harvest. Another way is to leave snags in areas that are difficult to log and take snags in areas more amenable to logging.

When determining snag management goals for large forested areas, managers need to know the present distribution, species, and size of snags in the area, the snag management goal, and the steps necessary to reach that goal.

Time is an important factor in the cost of meeting snag management goals. The longer the time frame selected, the less costly and easier it will be to achieve such goals. For example, assume the area to be managed is a mixed-age ponderosa pine stand containing a variety of trees up to 76.2-centimeter (30-in) d.b.h. that has been recently heavily salvaged. All merchantable snags have been removed, and probably few snags are left. Assume that the goal selected is 60 percent (table 18). If the management decision is to meet that goal within 2 years, it will be necessary to kill trees to produce snags. If the decision is to meet the requirement within 20 years, it will be necessary to forgo additional salvage of snags or dying trees until the appropriate number of snags is available.

Some trees could also be killed at the 20th year if natural mortality has not been sufficient to meet the goal. On the other hand, a decision could be made to forgo all or a portion of the potential additional salvage until the snag requirement is met regardless of the time required.

Which way to go? That is a management decision. But it should be remembered that short time frames have the potential to exact large costs in timber production and labor required to simulate natural tree mortality. These costs are aggravated by the difference between the snag management goal and the existing snag condition if it is below the goal.

Distribution of Snags in the Forest

Snags must be well distributed to be most effective in the number of pairs of cavity-nesting birds they will support because of the territorial requirements of the primary excavators. Consider a unit of 364 hectares (900 acres) managed so that enough snags are present to support the maximum number of pileated woodpeckers. This is about three pairs because the territorial requirement is about 121 hectares (300 acres) per pair. If the snags are evenly distributed over the entire area, as many as three pairs might nest there. If all the snags are concentrated in one-third of the area, however, probably only one pair would nest there.

This does not imply that snags must always be evenly distributed. Clumping of snags in small patches seems to enhance the nesting habitat for some species, particularly the pileated woodpecker (Bull 1975), the black-backed three-toed woodpecker, and the northern three-toed woodpecker (Jackman 1974b).

The Bird Box Alternative

An alternative often suggested as a partial substitute for snags is to locate bird boxes throughout the forest. Nest boxes can be valuable for some species of secondary cavity nesters. They are not generally a good alternative for woodpeckers, however, because woodpeckers seem to excavate cavities as a necessary part of their mating rituals.

In addition, reliance on bird boxes requires the placement of many types and sizes of nest boxes at various heights and densities throughout the forest. The boxes must be constructed, installed, cleaned, and replaced periodically. The cost would be formidable and the results probably less successful than if snags were present. Imagine trying to provide nest boxes for all 62 cavity-using species in the Blue Mountains!

Cavity Nesters Are Vulnerable

Most species that use snags are not considered highly vulnerable to management activities that alter forest structure because they can occupy several plant communities and successional stages. In an unmanaged forest, or one that is not intensively managed, they are in little danger. Intensive timber management as currently practiced, however, tends to eliminate older stands, eliminate dead and dying trees, and remove snags as fire and safety hazards. As a result, it is increasingly necessary to manage for snags and the wildlife that use them.

Current forest management activities are making snags an endangered habitat. Intensive timber management, the gathering of firewood, and fire prevention and safety activities tend to accelerate the removal of existing snags, reduce the recruitment of new snags, and diminish the probability of trees ever becoming big enough to provide the large snags required by some species. This vulnerability of snags makes snag-dependent wildlife equally vulnerable. If snag-dependent wildlife species are to remain as part of the managed forest, forest managers must provide the necessary habitat.

6
Dead and Down Woody Material

by
Chris Maser
Ralph G. Anderson
Kermit Cromack, Jr.
Jerry T. Williams
Robert E. Martin

Dead and down woody material on the forest floor serves many functions, for example, as hiding cover for wildlife.

Dead and down woody materials have long been viewed by foresters as unsalvaged mortality, the utilization of which is an important objective of good timber management. This material is also viewed as a fire hazard, and steps are frequently taken to reduce the amount of flashy fuels from timber harvest areas. Woody materials are also recognized as home for small vertebrate animals that are considered "pests" which impede reforestation.

These are all valid considerations, but dead and down woody material in various stages of decay serves many important functions, one of which is habitat for wildlife. Instead of viewing logs left in a forest as unsalvaged mortality or a fire hazard, this chapter examines their role as wildlife habitat. Elton (1966, p. 279) put it this way:

> When one walks through the rather dull and tidy woodlands—say in the managed portions of the New Forest in Hampshire [England]—that result from modern forestry practices, it is difficult to believe that dying and dead wood provides one of the two or three greatest resources for animal species in a natural forest, and that if fallen timber and slightly decayed trees are removed the whole system is gravely impoverished of perhaps more than a fifth of its fauna.

Logs and other woody debris, such as stumps, root wads, bark, and piles of limbs, occur on the floor of most forest ecosystems. These features provide diversity in the environment and are of varying significance as habitat for terrestrial wildlife (Winn 1976) (figs. 42 and 43). In the Blue Mountains 179 species of vertebrates (5 amphibians, 9 reptiles, 116 birds, and 49 mammals) make some use of logs. Elton (1966, p. 279) said that in England:

> ...indexes of the Ecological Survey contain 456 species of animals [including invertebrates] at Wytham living in wood or under bark where decay has begun or already gone far. Another 518 species are known to occur in this habitat elsewhere in Britain....

The large amount of slowly decomposing woody debris in western forests has important ecological implications in terms of mineral cycling, nutrient immobilization (Fogel and Cromack 1977, MacMillan et al. 1977), nitrogen fixation (Cornaby and Waide 1973), fire, and wildlife habitat.

In an unmanaged stand, logs are recruited to the forest floor by the fall of either living or dead trees. Living trees fall as a result of natural catastrophic events such as windstorms, snowslides, and floods.

Logs are often recruited to the forest floor as a result of natural catastrophic events such as windstorms, snowslides, and floods.

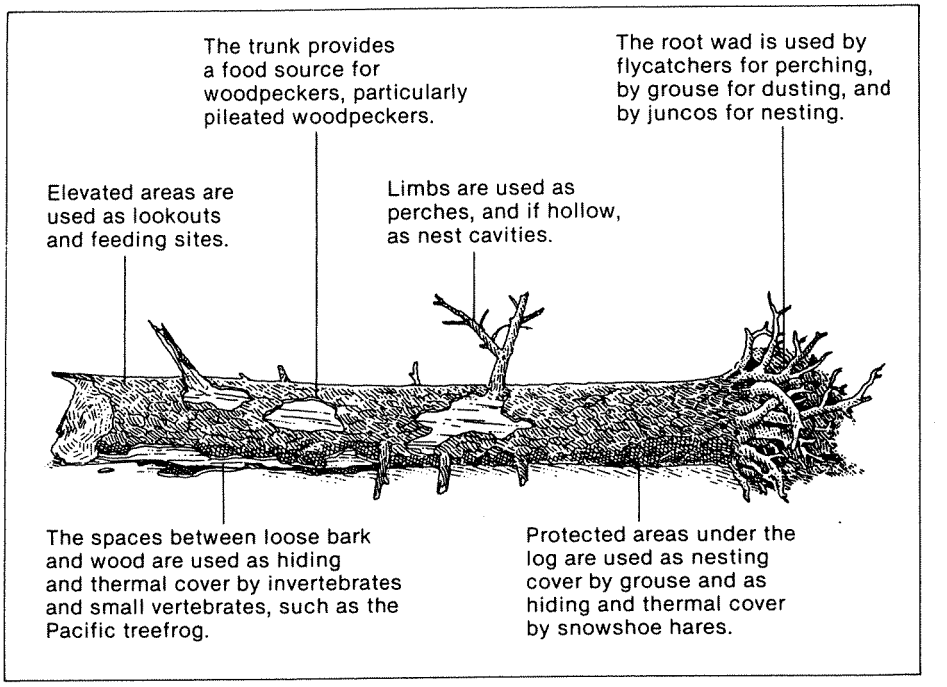


Figure 42. A class 2 log showing some of the structural features important to wildlife.

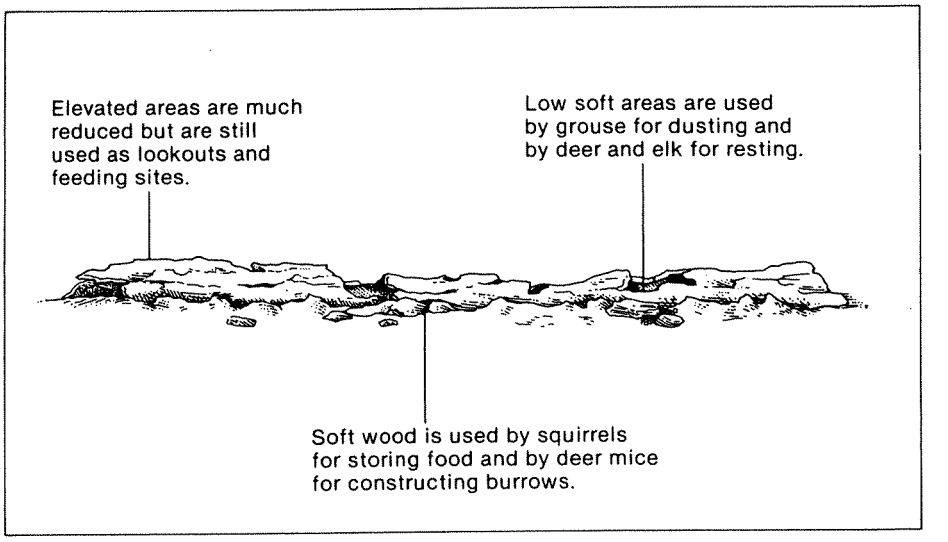


Figure 43. A class 4 log showing advanced stage of decay and some of the structural features important to wildlife.

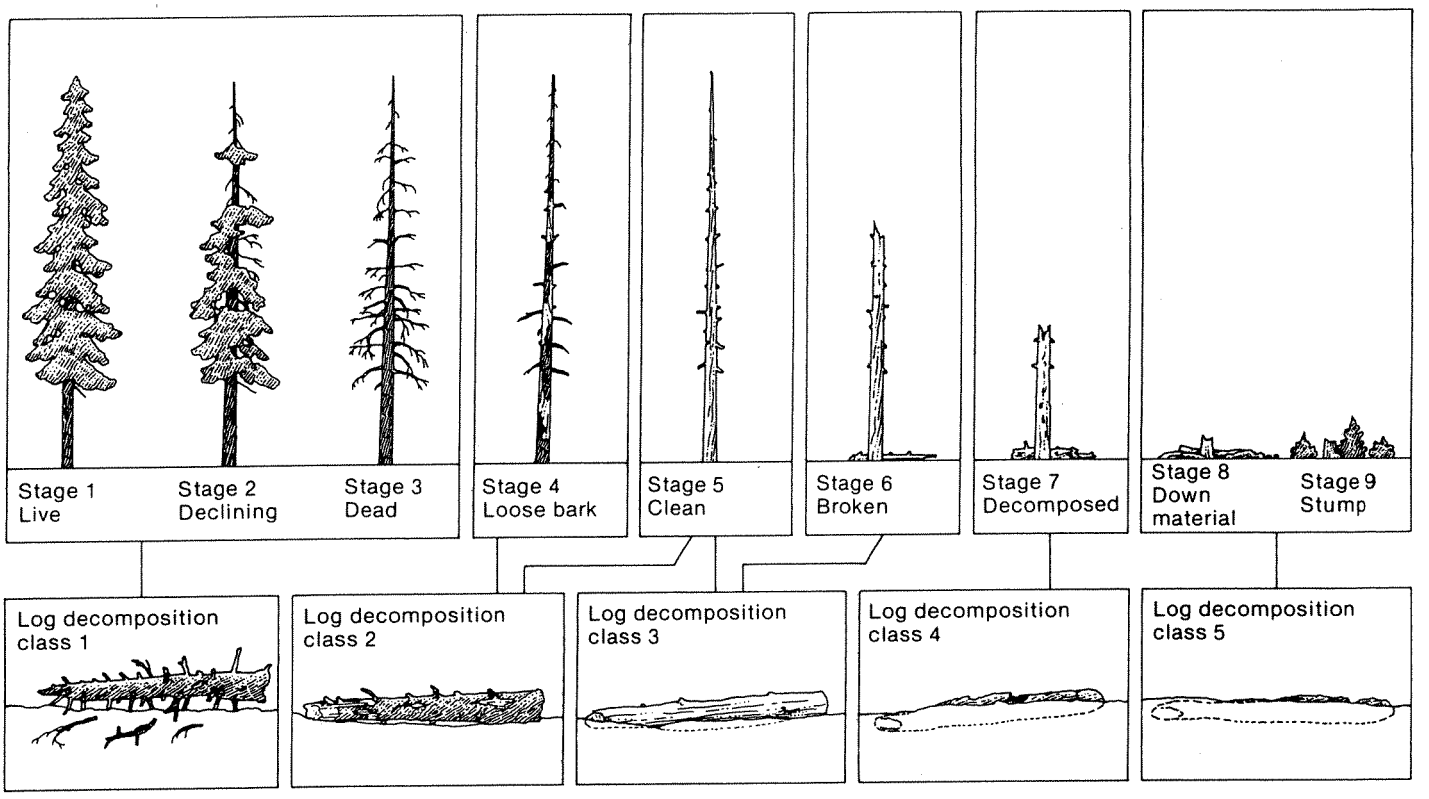


Figure 44. When they fall, trees and snags immediately enter one of the first four log decomposition classes.

Table 19. Snag condition translated into log decomposition class

Snag stage	Snag condition	Log class
1-3	Hard snag	1
4-5	Hard snag	2
5-6	Soft snag	3
7	Soft snag, 70% + soft sapwood	4

Log characteristics	Log decomposition class				
	1	2	3	4	5
Bark	intact	intact	trace	absent	absent
Twigs <3 cm (1.18 in)	present	absent	absent	absent	absent
Texture	intact	intact to partly soft	hard, large pieces	small, soft, blocky pieces	soft and powdery
Shape	round	round	round	round to oval	oval
Color of wood	original color	original color	original color to faded	light brown to faded brown or yellowish	faded to light yellow or gray
Portion of log on ground	log elevated on support points	log elevated on support points but sagging slightly	log is sagging near ground	all of log on ground	all of log on ground

Table 20. A 5-class system of log decomposition based upon work done on Douglas-fir (adapted from Fogel et al. 1973, used with permission, see also Minore 1966)

Snags, on the other hand, usually just deteriorate and collapse. The condition of standing live trees and snags can be translated into log classes (fig. 44; tables 19, 20, and 21). When they fall, snags immediately enter one of the first four log decomposition classes (Boyce and Wagg 1953, Wright and Isaac 1956).

No data are available on the accumulation of woody debris or the rate of litter fall in forests of the Blue Mountains. Research in western Oregon, however, has resulted in more complete data than anywhere else in the Western United States. Much of

that information is presented to demonstrate the function of woody debris in the forest environment. The accumulation of woody debris and litter in the Blue Mountains is not nearly as great as in western Oregon. The concepts, however, are applicable to the Blue Mountains and to forested areas in other parts of North America.

Natural Accumulation and Decay of Logs

The natural accumulation and decay of logs vary with the type of forest. Preliminary data for a mid-elevation, unmanaged 470-year-old Douglas-fir stand was reported by MacMillan et al. (1977). They estimated the rate of log recruitment to be 1.2 logs per hectare (0.49 log/acre) per year. These data showed that decaying Douglas-fir logs represented from 120 to 595 metric tons per hectare (53.5 to 265.4 short tons/acre). Grier and Logan (1978), working in a 450-year-old Douglas-fir stand, found that as much as 60 percent of the annual litter fall may be woody debris. They estimated that the accumulated logs on the forest floor ranged from 55.2 to 580.6 metric tons per hectare (24.6 to 259 short tons/acre). In fact, decaying logs in western Douglas-fir forests represent more aboveground volume than is present in the entire aboveground woody debris of typical deciduous forests in the Eastern United States (Day and Monk 1974, McFee and Stone 1966). MacMillan et al. (1977) also estimated the number of logs in various stages of decomposition in unmanaged old-growth Douglas-fir stands (table 22).

The rate at which woody material decomposes depends on climate, species, and the size of the plant material. A study in England indicated that at least 12 to 29 years may be necessary for the decomposition of small hardwood branches 2 centimeters (0.79 in) in diameter (Swift et al. 1976). Fogel and Cromack (1977) found that it may take from 36 to 50 years for Douglas-fir branches, 2.5 centimeters (1 in) in diameter, to reach 95-percent decomposition. In contrast, Douglas-fir needles require only 10 to 14 years to decompose. Litter decomposition models are available for a variety of temperate and tropical forest types (Jenny et al. 1949, Minderman 1968, Olson 1963).

Stage of decay	Characteristics
Standing, dead	Trees or snags, erect or leaning, but having no photosynthetic capability
Sound, felled	Logs which have been recently windthrown or struck by lightning
Diseased, felled	Timber only recently felled; pathological conditions obvious but with the invertebrate community absent
Colonization, conditioning	Wood moist, no channelizing invertebrates present, diplopods and other surface-inhabiting invertebrates present, blue-stain fungi present, mycelia of imperfect fungi present, little discoloration
Channelization	Presence and colonization by channelizing invertebrates, specifically termites, carpenter ants, and passalid beetles
Succession and secondary colonization	Colonization by channelizing invertebrates and large numbers of invertebrates without channelizing mouthparts, soil-dwelling microarthropods, predators, earthworms, large amounts of fecal material, soil, and high diversity of microbial community within channels
Maceration	Extensive fungal rizomorphs, root invasion, soil and fecal material clogging chambers, secondary colonizing invertebrates, fungal dominance obvious
Incorporation	Wood no longer recognizable by species, 20 to 30 percent soil mixed into wood, mass of mycelia, fibrous and woody root systems colonizing throughout

Table 21. Stages of wood decay and their characteristics (after Ausmus 1977, used with permission)

Decomposition class	Number of logs per hectare	Number of logs per acre	
1	27	11	
2	15	6	
3	31	13	
4	39	16	
5	185	75	
	297	121	Total

Table 22. Downed logs by decomposition class in an old-growth Douglas-fir stand (from MacMillan et al. 1977, used with permission)

A coyote made its den in this ponderosa pine log.

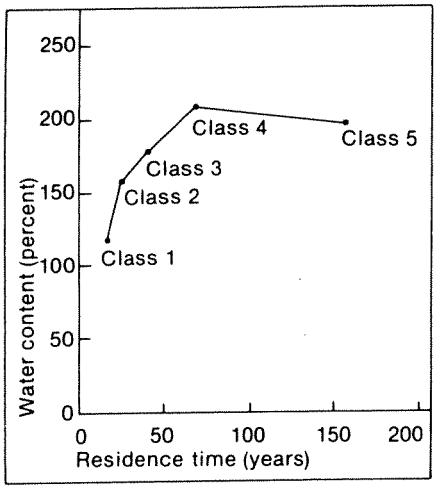


Figure 45. Average concentration (percent dry weight) of water in logs by decomposition class in a midelevation old-growth Douglas-fir stand (after MacMillan et al., unpublished, see "References Cited," used with permission).

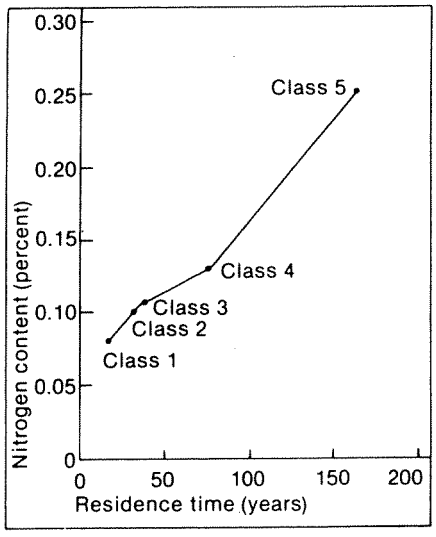


Figure 46. Average concentration (percent dry weight) of nitrogen by decomposition class in a midelevation old-growth Douglas-fir stand (after MacMillan et al., unpublished, see "References Cited," used with permission).

Nutrient Cycling

Logs absorb significant quantities of water early in the decomposition process (fig. 45). As they decompose, fallen trees can serve as "nurse logs" for tree seedlings. By the time such seedlings colonize class 3 and 4 logs, the nitrogen concentration is approximately 1½ times that of fresh wood (fig. 46). As a result, these logs are excellent sites for tree establishment. The presence of young seedlings, in turn, increases habitat diversity for invertebrate and small vertebrate animals.

Class 3 and 4 logs are well colonized by fungi, and nutrients have begun to accumulate due to the presence of fungal hyphae, rhizomorphs, and sporocarps (Cromack et al. 1975, Ausmus et al. 1975). Harvey et al. (1976) demonstrated the importance of decaying logs as sites for colonization by ectomycorrhizal fungi where most of the active fungi were associated with organic material—66 percent with humus, 21 percent with decayed wood, 8 percent with charcoal, and 5 percent with mineral soil.

Mycorrhiza means "fungus-root" and is a symbiotic association of certain fungi with the roots of most vascular plants. Ectomycorrhiza is a type of root fungus association necessary for survival of several families of trees, including the pines, hemlocks, spruces, true firs, Douglas-fir, larches, oaks, and alders.

Mycorrhizal fungi aid the process of nitrogen concentration. For example, MacMillan et al. (1977) estimated that Douglas-fir logs contain an average of 326 kilograms per hectare (290 lb/acre) of nitrogen in old-growth Douglas-fir stands. In addition, these fungi are an important food source for both invertebrate and vertebrate wildlife (Cromack et al. 1975, Maser et al. 1978, Miller and Halls 1969, Trappe and Maser 1976).

Wildlife Habitat

As a log decomposes, the plant community surrounding it changes and, in so doing, creates a gradually changing myriad of wildlife habitats (Graham 1925, Kimmey and Furniss 1943, Savely 1939). This can be seen as two separate processes—internal succession and external succession (fig. 47).

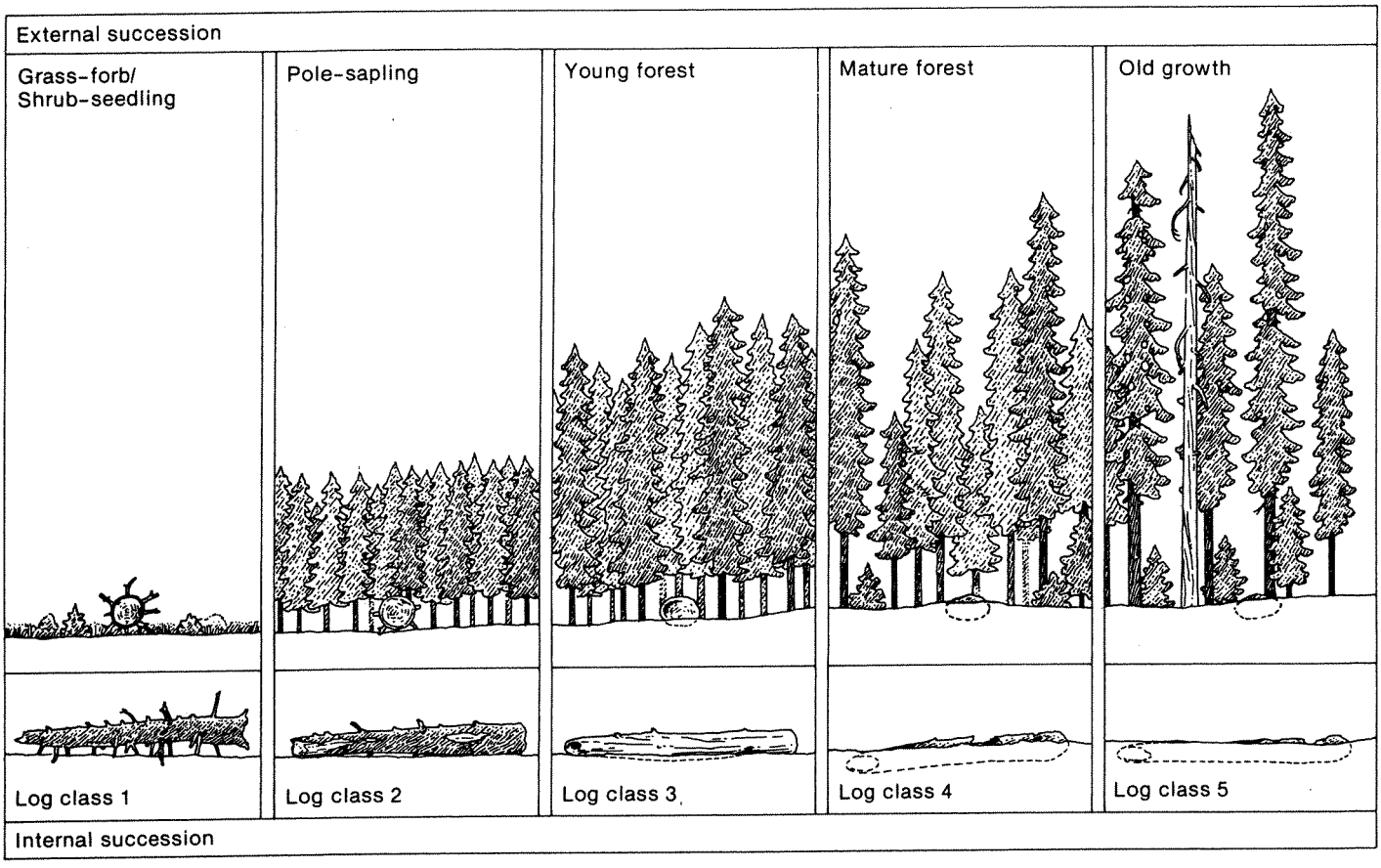


Figure 47. Logs progress through two simultaneous successional processes—internal and external.

Internal succession is related to the persistence or rate of decay of the log—determined primarily by the species of log and its resistance to decay and secondarily by the plant community, site, and microclimate surrounding it.

For example, aspen and cottonwood are both susceptible to decay and persist a relatively short time in moist sites (Hall 1973, Daubenmire 1968). Juniper is resistant to decay and persists a long time in arid sites. In western Oregon, one class 5 Douglas-fir log was found with charcoal on all sides and in contact with mineral soil, indicating that it had fallen when fire established the stand 470 years earlier (MacMillan et al. 1977). The persistence or residence time of some logs on the forest floor is also indicated by very slow rates of decomposition. After 150 years on the ground, the logs in one study had lost only about 75 percent of their original density (fig. 48). Residence time is the length of time it takes a log of a given species and size to decompose.

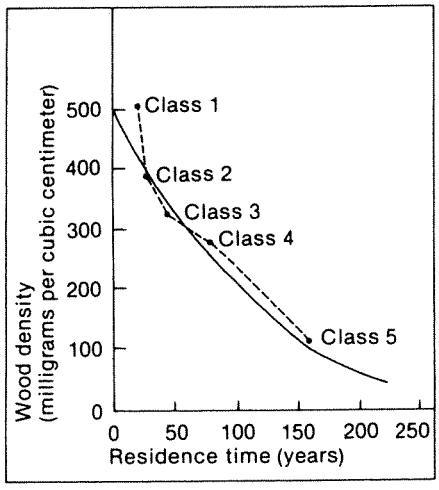


Figure 48. The density of logs changes with residence time in an old-growth Douglas-fir stand. The points are decomposition class means averaged by the connecting dashed line. The smooth curve of the solid line represents the overall fit of the averaged points to a simple negative exponential decay model.

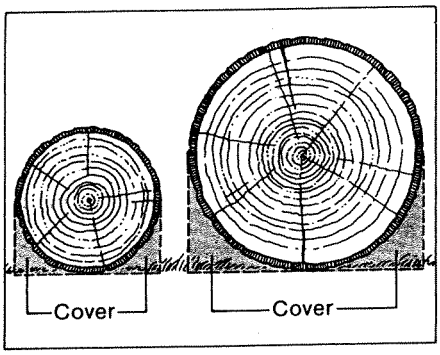


Figure 49. The amount of cover provided by logs for small vertebrates is directly related to size of the log; the larger the log, the longer it takes to decompose and the longer it provides effective cover.

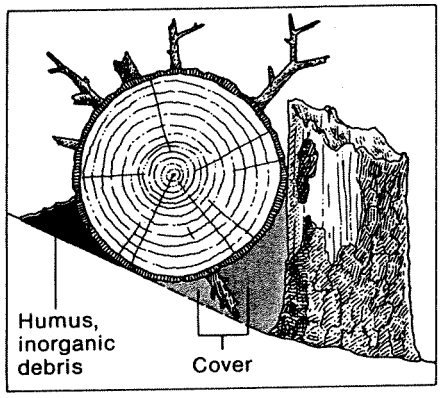


Figure 50. A log oriented along the contour of a slope. The upslope side is filled with humus and inorganic debris which allows small vertebrates to tunnel alongside. The downslope side provides protective cover for larger vertebrates.

As a log loses density, it becomes easier for small mammals to burrow inside, thereby increasing its habitat value. In western Oregon, logs can provide wildlife habitat for centuries. In other places the rate of log decomposition can be 5 to 10 times faster (MacMillan et al. 1977, Odum 1970).

External succession is related to the changes that take place in the plant community surrounding a log. In this context, logs act as connectors between the successional stages of a plant community and provide continuity of habitat from the preexisting forest through subsequent successional stages. Logs on the forest floor may be relics from earlier stands. In the Blue Mountains, for example, many logs are lodgepole pine in the midst of a mixed conifer community. They provide a link through time and across stand stages or conditions. Because of their persistence, these logs provide a long-term stable structure on which some vertebrate populations seem to depend for survival.

The immediate orientation of wildlife to logs as habitat is also based on other factors, primarily the species composition of the plant community, the progression of successional stages of the stand, the existing wildlife community, the size and structural changes of the logs, and their distribution throughout the forest. These are some of the principal factors that determine how each species of wildlife uses the logs.

The size of the material is important for many species (Ruben 1976) (fig. 49). For example, a limb 10 centimeters (4 in) in diameter is large enough to give protective cover to a tiny shrew, but a log 25 centimeters (10 in) in diameter will afford protection to a deer mouse. In general, the larger the diameter and the greater the length of a log the more useful it is; however, small material is better than none.

The main habitat function of logs is for cover and as sites for feeding and reproduction. Logs are effective for the greatest variety of small animals when they are well distributed over the ground (Winn 1976). Too many logs, on the other hand, may hinder the movement of ungulate wildlife (Lyon 1976) and domestic stock (Garrison and Smith 1974, Reynolds 1966b).

Areas of crisscrossed, windthrown timber can be used by porcupines (Taylor 1935), fishers (Coulter 1966), and other small mammals. Such habitats are usually localized. Piled logging debris also concentrates logs into small areas and reduces their effectiveness as wildlife habitat—even if they are not burned (Winn 1976).

Logs oriented along the contours of a slope appear to be used more by small vertebrates than are logs oriented across contours (fig. 50). Logs oriented along the contours may also help check soil erosion by slowing surface-water runoff. Suspended sediments are frequently deposited along the upslope side, thereby reducing nutrient loss from the site and providing excellent sites for establishment and growth of tree seedlings. These sites usually have a higher water-holding capacity than the surrounding soil and may be disproportionately higher in organic constituents. This "new soil" profile is sometimes poor, but as vegetation becomes established, the soil composition continually improves (table 23) and the site becomes stabilized.

Logging Debris

Timber harvesting creates large accumulations of woody debris or slash (Howard 1973). Estimates of the amount of coarse, woody debris left after logging range from less than 29 to more than 115 metric tons per hectare (12.9 to 51.3 short tons/acre) in the Pacific Northwest (Dell and Ward 1971).

The character, density, and distribution of logging debris may significantly affect both the number and species of vertebrate animals that use a site. Wildlife habitats can be manipulated by varying the method and intensity of timber harvest and the techniques used for slash disposal (Dimock 1974).

Dimock (1974, p. 0-5) stated that the effects of logging:

> ... debris are mostly favorable to ... [a] wide spectrum of animals ... Since most small mammals and birds are vulnerable to predation ... the escape cover afforded by residual slash enhances the ... habitat.

The effects of fire on the physical and chemical characteristics of logs and their microenvironments are significant. Fire in and around logs is usually more intense and often severely reduces or eliminates the accumulation of humus (Mitchell and Sartwell 1974).

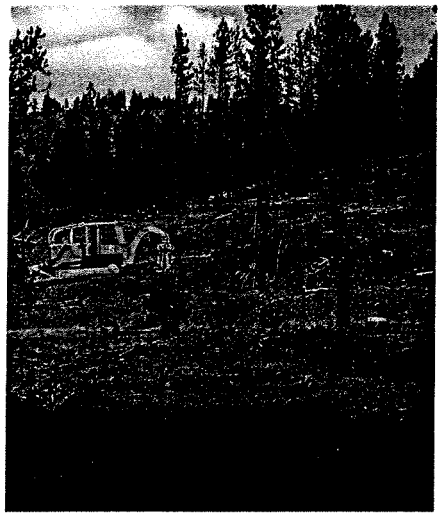
Fire also changes the surface characteristics of logs. The bark is often destroyed, eliminating one of the earliest specialized habitats that develops, along with its plant and animal components. Charring of the exterior wood surface casehardens the sound wood beneath the char and slows or alters decomposition. Changes in the rate of decay and insect infestation (Aho 1974, Mitchell and Sartwell 1974, Nelson and Harvey 1974), in turn, alter the use that wildlife can make of this habitat.

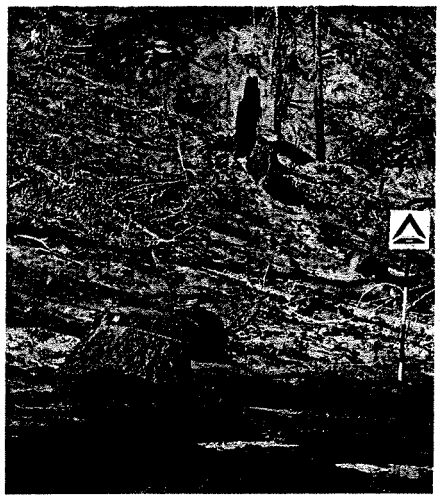
Observations suggest that charring of logs alters and generally reduces some types of wildlife use. For instance, woodpeckers do not always have a readily available source of food because of the dearth of insects in barkless, casehardened, charred logs. The char itself is not conducive to excavation. Small mammals also seem to be deterred from using charred logs. It may be that they are more vulnerable to predation because they are more visible against the black background. Some smaller species, such as rubber boas, shrews, and red-backed voles, may be unable to use charred logs because they are not able to burrow into the logs.

Parameters	Soil under leaf litter	Soil under log litter
Organic matter (percent dry weight)	2.0 ± 0.8	8.5 ± 1.5
ATP[1] concentration (p/m)	1.5 ± 0.8	13.5 ± 3.0
Nematode density (10^3/g)	0.8 ± 0.1	15.6 ± 1.8
Root biomass (g/m^2)	150 ± 75	375 ± 50
Calcium (ug/g)	3 ± 2	15 ± 3

[1]Adenosine triphosphate

Table 23. Soil parameters under litter and under decomposing logs measured on a steep (80-percent) slope in a forest of the Ridge and Valley Province in eastern Tennessee (after Ausmus 1977, used with permission)

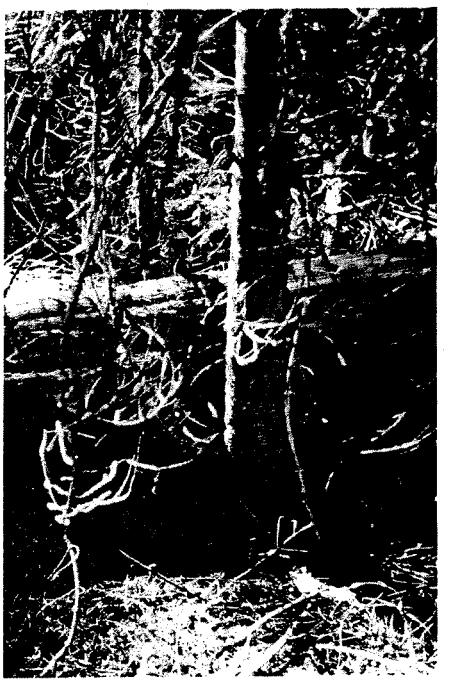




Large amounts of woody debris are created by timber harvest activities (above). The number and species of animals that can use a site is affected by the degree of slash removal.

Fire dramatically affects the physical properties of woody material and its use by wildlife (left).

A red squirrel stored these lodgepole pine cones inside a class 3 log (above).



A pileated woodpecker left its feeding "sign" on a class 3 log (right). Logs are often infested with carpenter ants, a primary item in the diet of pileated woodpeckers.

Few studies have objectively considered the ecological role of small vertebrates in the forest ecosystem or their potentially positive role in reforestation of commercially important trees (U.S. Department of Agriculture Press Service 1921, Maser et al. 1978, Tevis 1953). A review of the literature shows that the primary concern in the past has been to control various nongame wildlife as "pests" that impede reforestation (Adams 1947; Black 1970a; Crouch 1969; Crouch and Radwan 1971; Dimock and Black 1969; Hermann 1969; Hooven 1966, 1970, 1975; Moore 1940; Schmidt and Shearer 1971). Bibliographies have been compiled on individual species of vertebrates (e.g., Godin 1964) and vertebrates in general (e.g., Pank 1974, Radwan 1963) considered detrimental to reforestation.

The extent to which dependent wildlife is affected by slash treatment is related to the availability of food and cover. Essentially, the more radical the change caused by treatment, the more pronounced and long lasting the effects on wildlife (Dimock 1974). As yet, little data exist with which to quantify the effects of the treatment of woody debris on wildlife, but according to Dimock (1974, p. 0-3):

> . . .most observed impacts should be considered localized and short term. Due to the dynamic nature of forest eco-systems, long-term effects on different sites may vary widely.

Use of Logs by Wildlife

Vertebrates use logs for a variety of reasons and in a variety of ways, the most obvious of which are for hiding cover and as sites for feeding and reproduction. A variety of animals use logs as feeding sites (Deyrup 1975). Food is carried to a log where it is eaten or stored, or it can be obtained from the log itself. Some reptiles, birds, and mammals reproduce alongside, under, or within logs.

Log height, log concentration, and log class (residence time) are of variable significance to different vertebrate groups (Graham 1925, Kimmey and Furniss 1943, Savely 1939). Table 24 provides some examples of how vertebrates use logs. Data for the 179 species of vertebrates that are known to use logs in the Blue Mountains are in appendix 24. The following discussion is generalized by log class:

Letter code	Life form	Species (• Symbol indicates extensive use[1])	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		AMPHIBIANS																				
ASTR	2	tailed frog	•	•	•																	
BUBO	2	western toad			•	•	•			•	•	•										
HYRE	2	Pacific treefrog			•	•	•		•	•	•	•						•	•	•		
		REPTILES																				
CHPI	3	painted turtle																•	•			
SCOC	5	western fence lizard	•	•	•			•	•	•	•	•				•	•	•	•	•		
EUSK	3	western skink			•	•	•		•	•	•	•				•	•					
		BIRDS																				
DEOB	5	blue grouse	•	•	•			•	•	•			•	•							•	•
CACA	5	Franklin's grouse	•	•	•			•	•	•			•	•							•	•
BOUM	5	ruffed grouse	•	•	•			•	•	•			•	•							•	•
		MAMMALS																				
SOVA	15	vagrant shrew		•	•	•	•		•	•	•	•			•	•	•	•	•	•		
SOOB	15	dusky shrew		•	•	•	•		•	•	•	•			•	•	•	•	•	•		
SOPA	16	northern water shrew		•	•	•	•		•	•					•	•	•					

See Appendix 24 for footnotes.

Table 24. Use of logs by vertebrates (source: appendix 24)

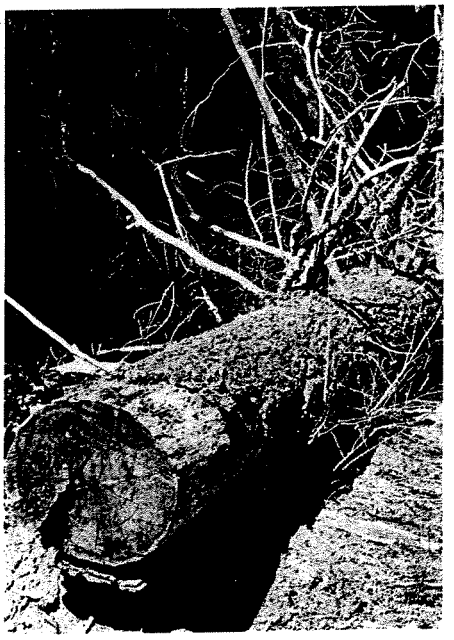
Class 1. Class 1 logs, with support points intact (fig. 42), offer hiding and thermal cover for snowshoe hares (Winn 1976), porcupines (Taylor 1935), and other animals that can get underneath them.

The sides and tops of class 1 logs are often primary feeding sites for western fence lizards. Mammals, such as chickarees, red squirrels, and northern flying squirrels, feed on top of these logs (Winn 1976). Raptors, such as the goshawk, use them as sites on which to pluck feathers or fur from their prey.

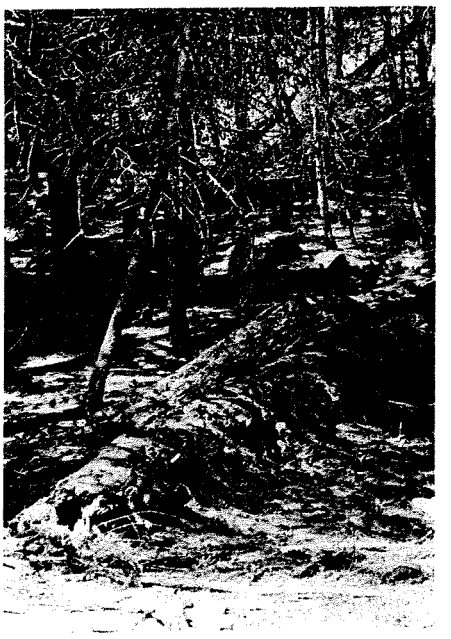
Class 1 logs are high enough off the ground that both the Franklin's and ruffed grouse nest under them. Snowshoe hares may also bring forth their young under the protection of such logs.

Class 2. Class 2 logs are weakened and sag slightly on the support points (fig. 44). As a log settles closer to the ground and duff and soil build up, it becomes cover for smaller animals, such as gopher snakes, dusky shrews, yellow pine chipmunks, and long-tailed voles.

A hollow juniper log persists a long time in open, arid country and provides both hiding and thermal cover. This log was home for a bushy-tailed woodrat.



A class 2 Douglas-fir log in the Blue Mountains. The shaded area under the log acts as thermal cover for small vertebrates on hot days, and the space beneath the loose bark keeps Pacific treefrogs cool, moist, and hidden from predators.



A class 4 Douglas-fir log in the Blue Mountains. By now the log is partly buried, and the wood is soft enough that small vertebrates can burrow inside.

Class 2 logs function similarly to class 1 logs as feeding sites. But as a log settles closer to the ground, a variety of small animals, such as winter wrens and deer mice, begin to glean food from under it. As a log finally sinks to the ground, smaller animals, such as the winter wren, nest under it. Mice also nest under the loose bark.

Class 3. As a log approaches class 3, the bark loosens and the space between the bark and wood becomes hiding and thermal cover. Moist microclimates provide habitat for small animals, such as the Pacific treefrog. With support points gone, a log sags, forming an interface with the ground. At this time, deer mice (Winn 1976) and red-backed voles (Butsch 1954, Getz and Ginsberg 1968, Gunderson 1959, Maser and Franklin 1974, Winn 1976) begin to form runways alongside the log and under it.

When a log reaches late class 2 or early class 3, the bark is loose and small animals, such as the Pacific treefrog and western skink, can catch invertebrates between the loose bark and the wood. Decomposition of a late class 3 log is such that shrews also hunt invertebrate prey alongside and under the log.

Class 3 logs often have tall grasses growing alongside them. These sites are frequently used by juncos for nesting. Shrews, mice, and voles nest in burrows under these logs, and porcupines give birth alongside them (Taylor 1935).

Class 4. By the time a log reaches class 4, it is completely on the ground and may be partly buried. The interior is usually soft enough for small mammals to burrow inside it (fig. 44). Dusky shrews, deer mice, red-backed voles, weasels (Hall 1951), and other small mammals can establish burrow systems beneath a log and begin to use its interior. These burrow systems, in turn, are used by amphibians and reptiles, such as western toads, western skinks, and gopher snakes.

Animals, such as rubber boas, ringneck snakes, dusky shrews, deer mice, and red-backed voles, not only feed around and under these logs but also inside them.

Small mammals, such as deer mice and red squirrels (Hatt 1929), and some reptiles, such as gopher snakes, begin to use the interiors of class 4 logs as reproduction sites.

Class 5. Class 5 logs are soft, powdery, and mostly buried by soil and forest litter (fig. 44). They usually have well-established burrow systems both within and beneath them. These burrows are mainly used by mammals and sometimes by amphibians and reptiles. Such logs provide moist environments most of the year.

As a log progresses to class 5, the amount of small animal activity within it increases. Tree squirrels stash their cones inside logs from late class 4 through class 5. Shrews feed within class 5 logs, and red-backed voles begin to glean fungi from log interiors. There is also an increase in feeding activity of small animals alongside and under class 5 logs which corresponds to an increase in the invertebrate fauna.

Class 5 logs are used for reproduction in essentially the same way as are class 4 logs. The main difference is that more subterranean burrows extend up into the rotten wood of class 5 logs.

In addition to cover, feeding, and reproduction, vertebrates use logs in other ways. Logs in classes 1 through 3 serve as lookout posts for animals, such as mantled ground squirrels, yellow pine chipmunks (Gordon 1943, Maser and Gashwiler 1978), Columbian ground squirrels, and yellow-bellied marmots. Ruffed grouse also use them as drumming sites, and western fence lizards use them for sunning. Logs which fall across streams or small canyons serve as bridges for bobcats, marten, flying squirrels, deer mice, and jumping mice (Maser, unpublished, see "References Cited"). Both deer and elk bed down on the upslope side of logs. In addition, logs that are partly submerged in water are important as preening sites for waterfowl, sunning areas for turtles, and feeding and resting sites for muskrats, mink, and river otter.

Logs in classes 4 and 5 become dusting sites for blue, ruffed, and Franklin's grouse and for other birds. Deer and elk use class 5 logs as sites for bedding down.

Hollow logs, regardless of class, are important as cover and denning sites for a variety of larger animals, such as snowshoe hares, bushy-tailed woodrats (Maser and Gashwiler 1978, Maser and Franklin 1974), weasels (Hall 1951), skunks, raccoons, and black bears (Poelker and Hartwell 1973). Some animals, such as chickarees and red squirrels, use hollow logs for storing their winter food supplies.

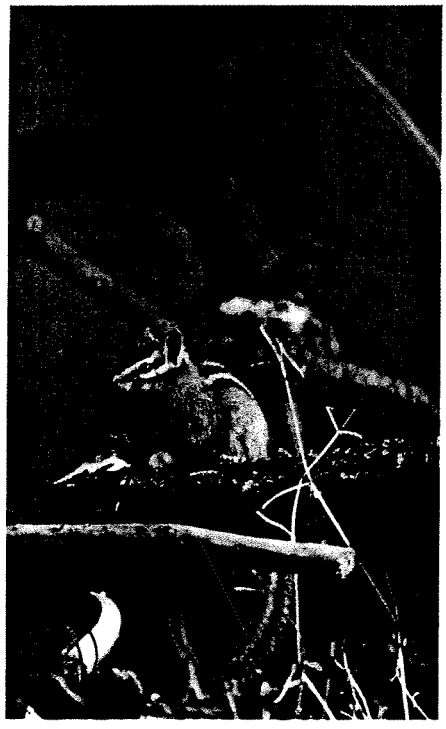
The size and location of a hollow area within a log determine which species can use it as a site for rearing young. For example, small hollows created by decayed limbs are used by house wrens, mountain bluebirds, and western bluebirds. Larger hollows within the trunk are used by bushy-tailed woodrats (Maser and Gashwiler 1978), skunks, and weasels (Hall 1951). Logs whose hollow ends extend over streams are occasionally used as nesting sites by dippers. Generally speaking, only logs in classes 1 through 3 serve as sites for cavity nesters.

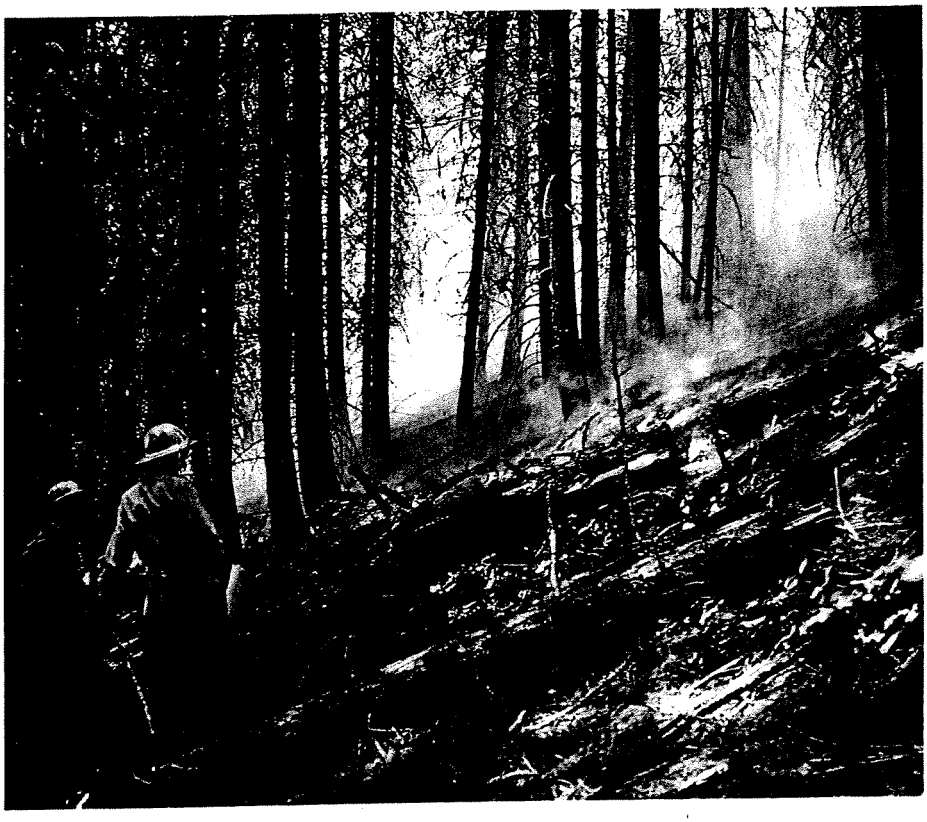
Logs that are partly submerged in water are important as physical links between aquatic and terrestrial habitats.

Management of Logs as Wildlife Habitat

The management of woody debris in forests will be an ongoing process as long as society requires products from these lands (Benson and Johnston 1976, Ruth and Harris 1975). The need for ecologically sound forest management increases with the demand for products and amenities (U.S. Laws, Statutes, etc., Public Law 93-378; Cramer 1974). Management decisions that affect dead and down woody materials range from the creation of debris by logging to destruction of woody material by slash burning. All such management actions have positive impacts on some species of wildlife and negative impacts on others. The manipulation of logs in the forest environment, therefore, is management of wildlife habitat and habitat components.

Logs in classes 1 through 3 serve as lookout posts for animals such as this yellow pine chipmunk.





Fire dramatically affects the physical properties of woody material and its use by wildlife.

The decision to manage woody debris, the intensity of management, and the technique selected are all dependent on the resource management objectives for the site. For example, if the decision is to reduce the fire hazard in a clearcut, then maximum reduction of woody debris may be the primary objective. On the other hand, if timber production is the primary objective and mycorrhizal fungi are necessary for tree survival and growth, then it may be necessary to leave a suitable number of logs on the ground. They will provide habitat for the small mammals that distribute fungal spores throughout the environment (Harley 1969; Ho and Trappe 1973; Marks and Kozlowski 1973; Marx 1973; Maser et al. 1978; Melin and Nilsson 1957; U.S. Laws, Statutes, etc. Public Law 94-588; Slankis 1973; Trappe and Fogel 1977; USDA Forest Service 1974; Wright 1971; Zak 1964).

Cover provided by logs has been associated with animal damage to tree seedlings (Hooven 1969, Mitchell 1950), and disposal of woody debris has been suggested as a means of controlling "problem" rodents in some stands (Krauch 1945). Research results, however, indicate that the presence of woody debris does not necessarily increase the occurrence or severity of animal damage to forest regeneration (Dimock 1974). Furthermore, the protection that woody debris provides to tree seedlings often outweighs the negative effects of increasing habitat for problem animals. According to Dimock (1974, p. 0-14):

> . . . animal damage will generally be less in residue situations that remain untreated; and residue treatments will likely result in increased levels of animal damage to forest regeneration.

Deer, elk, and cattle are also affected by the amount of woody debris left in a clearcut, shelterwood, or a precommercially thinned stand. The amount, distribution, and height of woody debris affect the use that deer and elk (Lyon 1976, Swanson 1970, Reynolds 1966b) and cattle (Garrison and Smith 1974) make of clearcuts.

The techniques used to treat woody debris depend on the management objectives for the site and are as varied and dynamic as the technology used for management of forest ecosystems. Only those methods that have the greatest potential impact on wildlife habitat values are discussed. They include land-use planning, manual and mechanical manipulation, use of chemicals, and prescribed fire.

Land-Use Planning

Management of woody debris for wildlife habitat begins with good land-use planning (U.S. Laws, Statutes, etc. Public Law 86-517; U.S. Laws, Statutes, etc. Public Law 91-190). During the land-use planning process, resource priorities—ecological, silvicultural, wildlife habitat, and fuel management objectives—are identified for individual forest sites. This process should include identification and management of woody debris, particularly logs, as wildlife habitat. When this is done, other ecological benefits, such as nutrient cycling, will also be realized.

Manual and Mechanical Manipulation

Manual manipulation of woody debris is an option, especially if suitable labor is available. The following methods can be used: (1) marking declining trees and snags to be left as logs for the future, (2) felling live trees and snags to create logs, (3) girdling live trees to create snags which will later become logs, (4) lopping and scattering logging slash or other woody debris, (5) hand-piling slash for later burning or to improve its location or distribution, and (6) preparing sites for treatment with prescribed burning—for example, by isolating snags and logs to be retained during the fire.

Mechanical manipulation of woody debris is perhaps the most widely used technique (Seidel 1974), particularly if used in conjunction with prescribed burning. Mechanical treatment often includes: (1) pushing over small trees with a bulldozer; (2) removing, piling, and redistributing woody debris with bulldozers, rubber-tired skidders, or cable-equipped machinery; (3) smashing woody debris and grinding it into the soil with bulldozers and brushblades; and (4) chipping woody debris and either redistributing it over the site or removing it.

Chemicals

Herbicides and pesticides are widely used to manipulate forest vegetation to accomplish silvicultural objectives (Newton 1977, Newton and Norgren 1977). Many uses of chemicals result in the creation of large amounts of standing dead woody material. Brush and sometimes trees lose their leaves, die, and become candidates for addition to the material on the forest floor.

When the use of chemicals is considered, their impact on the forest environment must be evaluated. Although chemicals may achieve the desired management objective, they can also have negative side effects. Specific hazards range from negligible (Montgomery and Norris 1970; Bollen et al. 1970, 1977) to acute poisoning (Norris 1974).

Prescribed Burning

Prescribed burning is gaining wider acceptance and is being used with increasing frequency to manipulate woody debris in the managed forest. Management goals of retaining uncharred snags and down logs are more difficult to realize, however, when prescribed burning is chosen over other types of manipulation.

Prescribed fire is used to achieve many different but often complementary management objectives, including reduction of wildfire hazards, site preparation, control of plant species composition and community structure, and meeting visual management goals. Prescribed burning techniques can be modified to reduce fuels and at the same time conserve logs that are valuable to wildlife and to the developing stand. Several variables affect the degree to which fuels are consumed—moisture content and arrangement of fuel, firing technique, weather, and fire history of the area. Each of these must be evaluated to select the prescription that will best achieve management objectives.

Fire specialists frequently want to remove as much fuel as possible from a site to obtain maximum reduction of fire hazard. Fuel consumption which eliminates large logs probably contributes little to hazard reduction since the greatest potential for the ignition and spread of fire is among the fine fuels. Although large-diameter fuels add to the total fuel load of a site, their fire-hazard potential depends greatly on the presence of fine fuels.

Fire specialists use a classification system for fuel size classes that is based on timelag. Timelag is the period of time it takes for a fuel to lose 63 percent of the moisture content it will eventually lose if exposed to constant lower humidity conditions (table 25). Thus, a fuel particle starting at 30 percent moisture content and exposed to low humidities, such that it would eventually be in equilibrium at 10 percent moisture content, would lose 63 percent of that moisture in 1 timelag period. If the period is 1 hour, the fuel is in the 1-hour timelag class (table 25). If the period is 15 hours, the fuel is in the 10-hour timelag class.

Fire specialists in the West have found that a successful prescribed fire—one that prepared a site for regeneration and reduced fire hazard—consumed roundwood material up to approximately 15 centimeters (6 in) in diameter (Beaufait 1966). Swanson (1974) reported 31-percent consumption of large fuels (1,000 hour timelag and larger) when burning was done under young stands of coastal Douglas-fir, and Beaufait et al. (1975) reported average large fuel consumption of 55 to 60 percent on two blocks of 73 plots during burning of clearcut larch and fir slash. Such rates of consumption should leave more than adequate large fuels for wildlife habitat.

The consumption of large fuels can be controlled by conditions set in the prescription for the burn, but it is still often about 60 percent. Using data of Beaufait et al. (1975) and Bevins (1976), Martin [1976] presented

Logs used by wildlife can be preserved most easily if burning is done after periods of extended precipitation. It is important to leave adequate large logs for wildlife habitat.

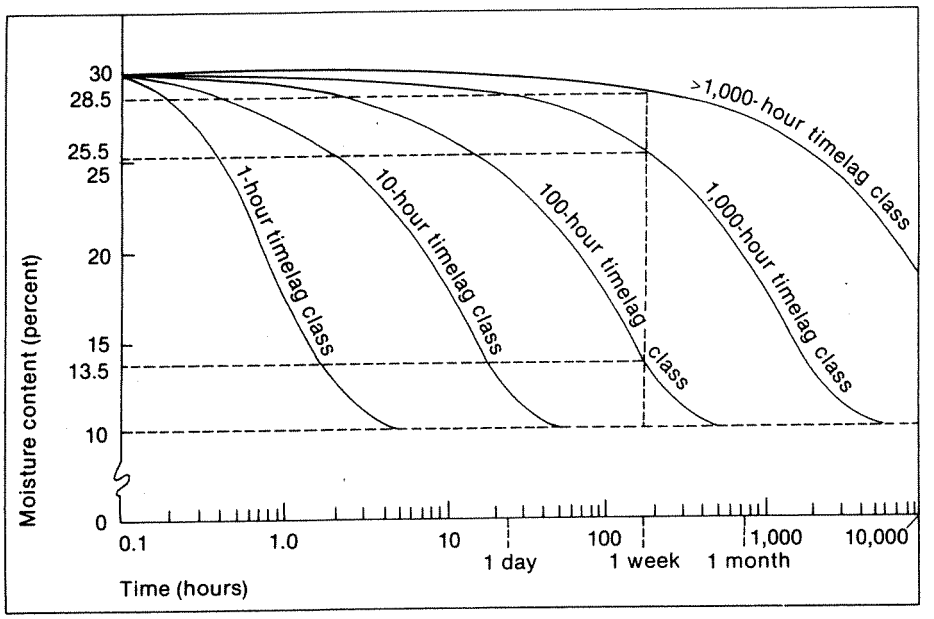
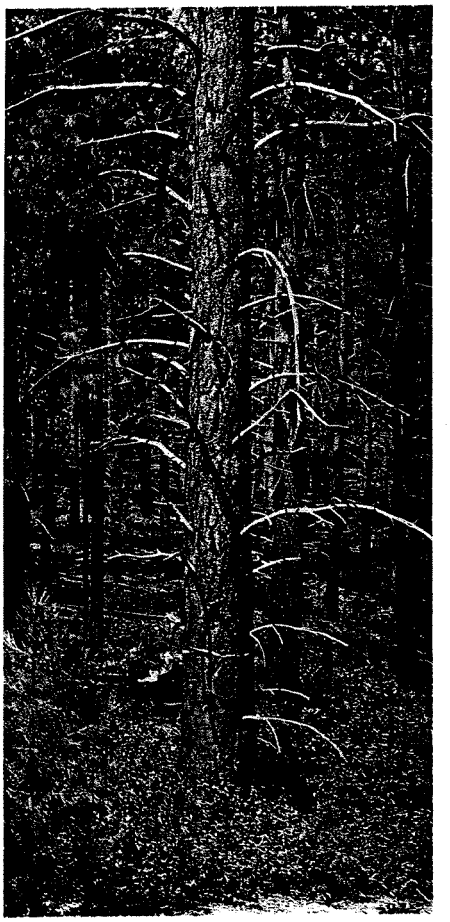


Figure 51. Theoretical drying rates for fuels of different size or timelag class if humidity changed rapidly from 30 percent (100-percent relative humidity) to 10 percent (45-percent relative humidity). Horizontal scale is logarithmic.



The best time to retain logs and snags while burning under a timber overstory is in the spring before moisture from winter precipitation has been lost. Application of fire retardant will protect the logs or snags from burning.

a review of the fuel consumption process resulting from prescribed slash burning and suggested appropriate prescriptions. Hedin and Turner (1977), however, found that on one old-growth hemlock clearcut only 26 percent of the woody debris greater than 7.5 centimeters (3 in) in diameter was consumed by the slash burn. Other useful information may be found in a recent summary paper which contains information from throughout the United States on the effects of fire on fuels (Martin et al. [n.d.], unpublished, see "References Cited").

There are techniques, however, that can be used in the application of broadcast burning in clearcuts to preserve a desirable number of downed logs for wildlife use. For example, wildlife logs can be preserved most easily if prescriptions call for burning after precipitation has occured over an extended period (Martin and Dell 1978).

Figure 51 illustrates the way forest fuels might dry out following heavy precipitation. Assume that all dead fuels are at 30 percent moisture content; when humidity drops all fuels will eventually decline to 10-percent moisture content. The 63 percent, or two-thirds, drop in moisture content may be read on figure 51 for any timelag class of fuel. For example, read the horizontal scale at the 100-hour point. Proceed vertically to the 100-hour timelag curve and read the left-hand scale. The moisture content for the fuel is 17.4 percent. The fuel has thus lost 12.6 percent of its moisture content, or 63 percent of the difference between 30 and 10 percent in its 100-hour timelag period.

A prescribed burn is planned one week after precipitation ends, or when snow melts completely. In order to obtain an estimate of the moisture content of the different fuel timelag classes, draw a vertical line at the 1 week mark (168 hours). Where the line intersects each fuel timelag class, draw a line horizontally to the left and read percent moisture content on the scale. The 1- and 10-hour timelag classes have already reached 10 percent and most of these fuels, which are important in carrying the fire, will be consumed. The 100-hour timelag fuels are at about 13.5 percent moisture content and probably half or more of these will be consumed by the fire. The larger fuels are still above 25 percent moisture content and will not burn well. Since the moisture content indicated is the average for the fuel, the outside of the logs in the 1,000- and >1,000-hour

timelag classes should be fairly dry while percent moisture content inside will still be around 30 percent. Only the outer layers of these large logs will burn off or char—which will leave material most useful as habitat for wildlife. Isolated, solid logs would probably remain almost intact, whereas decked logs would be almost completely consumed. Nevertheless, there is always a possibility that the behavior of the fire will not be totally predictable throughout the area of the burn. It may be wise, therefore, to leave two or three times the lowest desirable number of large logs isolated (i.e., those in the >1,000-hour timelag class) under the assumption that one-half to three-quarters of them will be charred or consumed.

Rotten logs (class 4) pick up moisture faster than sound logs. This means that a fire manager can plan a prescribed burn that will save rotten logs and burn solid ones—if he conducts the burn after sufficient precipitation has occurred. Logs will not usually pick up large amounts of moisture from precipitation of short duration. Thus, summer showers usually will not produce sufficient moisture in either rotten or solid logs to prevent their consumption by fire.

The best time to retain logs while burning under a timber overstory is in the spring before moisture from winter precipitation has been lost. Fine fuels will have dried out and will be responding to daily fluctuations in humidity. But intermediate (i.e., those in the 100- and 1,000-hour timelag classes) and larger size fuels will still be slightly wet and only partially consumed by the fire.

Logs to be left for wildlife may need special protection if they are not wet enough. Readily combustible fuels can be raked away from the logs or fire retardants applied around them. Soaker hoses can also be used on or around logs prior to burning to prevent ignition. Since prescribed burning must be done slowly in stands with heavy fuels, some of the crew can do this protective work while others are conducting the burn. Regardless of the technique used, the ecological impacts must be considered (Van Meter and Hardy 1975).

Fuel timelag class	Range of timelags	Definition
1-hour	0 to 2 hours	Dead herbaceous and woody fuels less than 0.6 centimeter (0.25 in) in diameter and the uppermost 0.6 centimeter (0.25 in) of needles and leaves on the forest floor
10-hour	2 to 20 hours	Dead fuels from 0.6 to 2.5 centimeters (0.25 to 1 in) in diameter and litter from 0.6 to 2.5 centimeters (0.25 to 1 in) below the surface of the forest floor (fuel moisture sticks 1.25 centimeters (0.5 in) in diameter are used to estimate moisture content of this fuel timelag class)
100-hour	20 to 200 hours	Dead fuels from 2.5 to 7.6 centimeters (1 to 3 in) in diameter and litter from 2.5 to 10.2 centimeters (1 to 4 in) below surface of the forest floor
1,000-hour	200 to 2,000 hours	Dead fuels from 7.6 to 20.3 centimeters (3 to 8 in) in diameter and litter 10.2 to 30.5 centimeters (4 to 12 in) below surface of forest floor
>1,000-hour	>2,000 hours	All dead fuels larger than 20.3 centimeters (8 in) in diameter or more than 30.5 centimeters (12 in) below surface of the forest floor (no fuel classes are defined beyond the 1,000-hour timelag class)

Table 25. Fuel classes used by fire management specialists (adapted from Deeming et al. 1978, Furman 1975). Fuel class is related to timelag, the time it takes for a fuel to lose 63 percent of the moisture content it will lose under a particular set of conditions

Snags left in clearcuts for cavity-nesting birds and mammals may eventually provide replacements for wildlife logs. Snags that are present during prescribed burning can catch fire, however, and be destroyed. Enough snags should be left to make sure that a sufficient number remain following the fire to meet wildlife goals.

Sparks from burning or smoldering snags can also scatter and cause unplanned spot fires. As a result, snags should be left well inside the clearcut, away from the edge and standing timber. Then if they catch fire they can be left to smolder and go out without danger of the fire spreading into standing timber.

Snags in timber stands may be protected during prescribed underburning by the same means described earlier to protect wildlife logs. Protecting snags is less work than protecting logs because only the area around the base of the snag must be treated. A snag is not apt to catch fire high above the ground if the flames are kept low. If it does catch fire in a hazardous location, it may be necessary to fell the snag to extinguish the fire. If a snag catches fire well within a large burn, it can be left until the later stages of mopup as the fire may burn itself out.

If a predetermined number of logs are to be left as wildlife habitat in areas to be prepared for fire prevention or control, it should be understood in the planning stage that they will not be uniformly distributed. For example, it may be desirable to leave some areas clear for human access or as fire lanes and fuel breaks. This can be compensated for by leaving a high density of fuels in other areas. By carefully planned use of equipment and/or prescribed burning, the manager can provide fuel-free areas and, at the same time, meet the log requirements for wildlife habitat.

Management Tips

Logs are considered to be more important as wildlife habitat than are other forms of woody debris since they are stable and persist longer in the environment (Brown 1970, Wagener and Offord 1972). Logs provide a wide range of habitat opportunities for wildlife. If there is a choice, logs should be saved in preference to other types of woody debris. In the absence of logs, some windrows, slash piles, and root wads should be kept to simulate log habitats.

To meet wildlife habitat needs, a manager should consider the following factors: (1) Species composition of the timber stand, (2) diameter of the trees, (3) density or number of stems per hectare (acre), (4) number and decomposition classes of logs on the forest floor, (5) number and condition of snags, and (6) speed with which a new stand of trees can become established and reach a diameter of 30 to 43 centimeters (13 to 17 in).

Logs serve many purposes for wildlife. Here a male blue grouse uses a log to stage his courtship display.

In many cases, it is possible to satisfy requirements for wildlife logs without sacrificing logs that have commercial value. An inventory of the species, decomposition classes, and the numbers and distribution of down logs prior to timber harvest will help managers determine the options available for meeting wildlife habitat requirements (Brown 1974b).

If snag management is an objective for a given stand, the snags will add to future log recruitment. On the other hand, if snag management is not an objective, the alternatives for meeting log requirements are proportionately decreased.

Different sites vary in their potential to produce trees; the higher the site potential, the sooner a new stand of timber of sufficient size will occupy the site and resume the role of log recruitment. From a manager's point of view, sites with high potential to grow trees provide more flexibility in meeting the log requirements for wildlife habitat because log recruitment on such sites begins proportionately earlier.

The species and size classes of the trees in a forest stand are indicators of the potential residence time of the logs that will be created if the stand is cut. Residence time is the number of years it takes a log of a given species and size to decompose and disintegrate. For example, the residence time of a rapidly decomposing tree species is less than that of a decay-resistant species; also, the greater the log diameter the longer its residence time. As a result, a manager has a greater number of alternatives in meeting log requirements for wildlife habitat in an uneven-aged, mixed-species stand, such as mixed conifer, than in an even-aged, single-species stand such as lodgepole pine. In a mixed-species stand a manager has a choice of species with varying degrees of decay resistance and a variety of potential stem diameters. In a stand with only one species, the choice is limited to stem diameter.

Management options are also affected by stand density or the number of stems per hectare (acre). A dense stand naturally produces more dead woody material than does an open stand. Since an open stand, such as ponderosa pine, has fewer stems per hectare (acre) than does a dense stand, such as mixed conifer, more careful planning will be required to meet log requirements for wildlife habitat in the open stand.

There is insufficient information at present for managers to know how many logs and how much woody material should be left for wildlife habitat. It is, therefore, prudent to maintain some of all natural habitats or conditions simulating them. These habitats are probably important, even if we do not fully understand how or why. In the Pacific Northwest, the USDA Forest Service has approached the problem by developing guidelines for management of woody debris (Pierovich et al. 1975). These guidelines have been adapted and are presented here as tips to help managers achieve specific objectives:

1. Woody debris (slash) should be retained for wildlife cover on 10 percent of the area clearcut (Dimock 1974, Garrison and Smith 1974, Pierovich et al. 1975).

2. Slash should be reduced to a depth of 20 centimeters (8 in) or less on at least 75 percent of an area with an established priority for livestock grazing. Untreated slash should be retained as wildlife habitat on 25 percent of the area (Pierovich et al. 1975).

3. Continuous concentrations of slash larger than 7.6 centimeters (3 in) in diameter or higher than 15.2 centimeters (6 in) above the soil should be avoided, because they restrict the travel of big game animals and livestock on frequently used trails (Dimock 1974, Garrison and Smith 1974, Pierovich et al. 1975).

4. A uniform 2.5-centimeter (1-in) thickness of wood chips has an adverse affect on the establishment of grass seeds, herbaceous plants, shrubs, and tree seedlings (Pierovich et al. 1975, Rothacher and Lopushinsky 1974). If the chips are mulched into the soil, the carbon-nitrogen ratio will reduce growth or kill vegetation (Garrison and Smith 1974). Chips should be scattered to a depth of less than 2.5 centimeters (1 in) (Pierovich et al. 1975).

5. Forced trailing—forcing big game animals and livestock to abandon established trails—because of windrowed materials should be limited to no more than 70 meters (230 ft) (Pierovich et al. 1975).

6. At least five uncharred class 1 or class 2 logs per hectare (two/acre) should be retained as wildlife habitat. Furthermore, all class 3, 4, and 5 logs, which have little or no commercial value but are acceptable as fuel loading, should be retained. For a maximum function as wildlife habitat, the logs should be at least 30 to 43 centimeters (12 to 17 in) in diameter at the large end and 6 meters (20 ft) or more in length. Preservation of logs in classes 3 and 4 may be easily accomplished in a manner consistent with big game, livestock, or other management objectives. Class 5 logs are so decomposed that their usefulness as habitat has been largely spent.

When slash is reduced to meet fuel management standards, logs are easier to save than other classes of dead and down material. Fortunately, this permits the most volatile woody material to be removed and reduces fire hazard while retaining the most important habitat component.

With modern machinery, logs can be easily moved around and positioned to provide maximum effectiveness as wildlife habitat. For example, a log can be moved away from a slash pile to be burned, placed along the contour of a slope, or abutted against the uphill side of a sound stump. The options are many; and with ingenuity on the part of the forester and wildlife biologist, adequate dead and down habitats can be maintained with minimum economic impact and without increasing the fire hazard.

7. Access to sources of water for both wildlife and livestock should be maintained (Pierovich et al. 1975).

8. The removal of natural, stable woody material, especially logs, may seriously damage the stream channel and the streamside riparian habitat. Such woody material provides excellent habitat for aquatic and amphibious wildlife and for many small terrestrial animals; it should be left in place when possible. Logs that are buried in the streambed frequently create small waterfalls and plunge pools which aerate the water and increase habitat diversity.

Massive accumulations of large woody material can act as barriers to fish passage and cause streambank erosion, thereby damaging the streamside riparian habitat (Brown 1974a, Pierovich et al. 1975). Such residues trap a significant amount of sediment and should be surveyed by competent stream ecologists and wildlife biologists before a decision is made to remove the woody material.

Logs securely anchored in the streambed frequently create small waterfalls and plunge pools which aerate the water and increase habitat diversity.

9. Unstable woody material may accumulate behind large obstructions in a stream and cause temporary damming. Under extreme flows, dams can break and severely damage the aquatic and streamside riparian habitats (Brown 1974a, Pierovich et al. 1975).

10. Under Federal law and many local pollution control laws, streams may not be used for solid waste disposal. Retention of adequate buffer strips will protect both water quality and riparian habitat. Directional and cable-assisted felling of trees and yarding away from streams will usually prevent logging debris from entering aquatic habitats (Brown 1974a, Pierovich et al. 1975).

11. Timing is a critical factor in remedial work to remove woody debris from streams. The best time is during the low water period. The optimum method is to lift wood out of the stream channel and place it well above the high-water level (Pierovich et al. 1975). Least desirable is any method that involves operating vehicular equipment within a stream channel (Burke 1965).

12. Unstable wood, such as logs or limbs more than 7.6 centimeters (3 in) in diameter and 1.5 meters (5 ft) in length, may divert water, causing streambank erosion and damage to streamside riparian habitat (Brown 1974a, Pierovich et al. 1975).

13. In contrast to unstable material, well-established logs are desirable. They provide habitat for aquatic, amphibious, and terrestrial wildlife and serve as pathways between aquatic and terrestrial habitats. Removal of such logs is detrimental to the habitat of small vertebrates dependent on the aquatic-terrestrial interface (Anderson et al. 1978, Swanson et al. 1976).

Management activities are not precluded just because the value of logs as wildlife habitat is recognized. But wildlife values should be considered in developing management objectives. A manager should be held accountable for the degree to which wildlife values, as well as silvicultural and fuel management goals, are considered (U.S. Laws, Statutes, etc. Public Law 91-190; U.S. Laws, Statutes, etc. Public Law 94-588).

7
Cliffs, Talus, and Caves

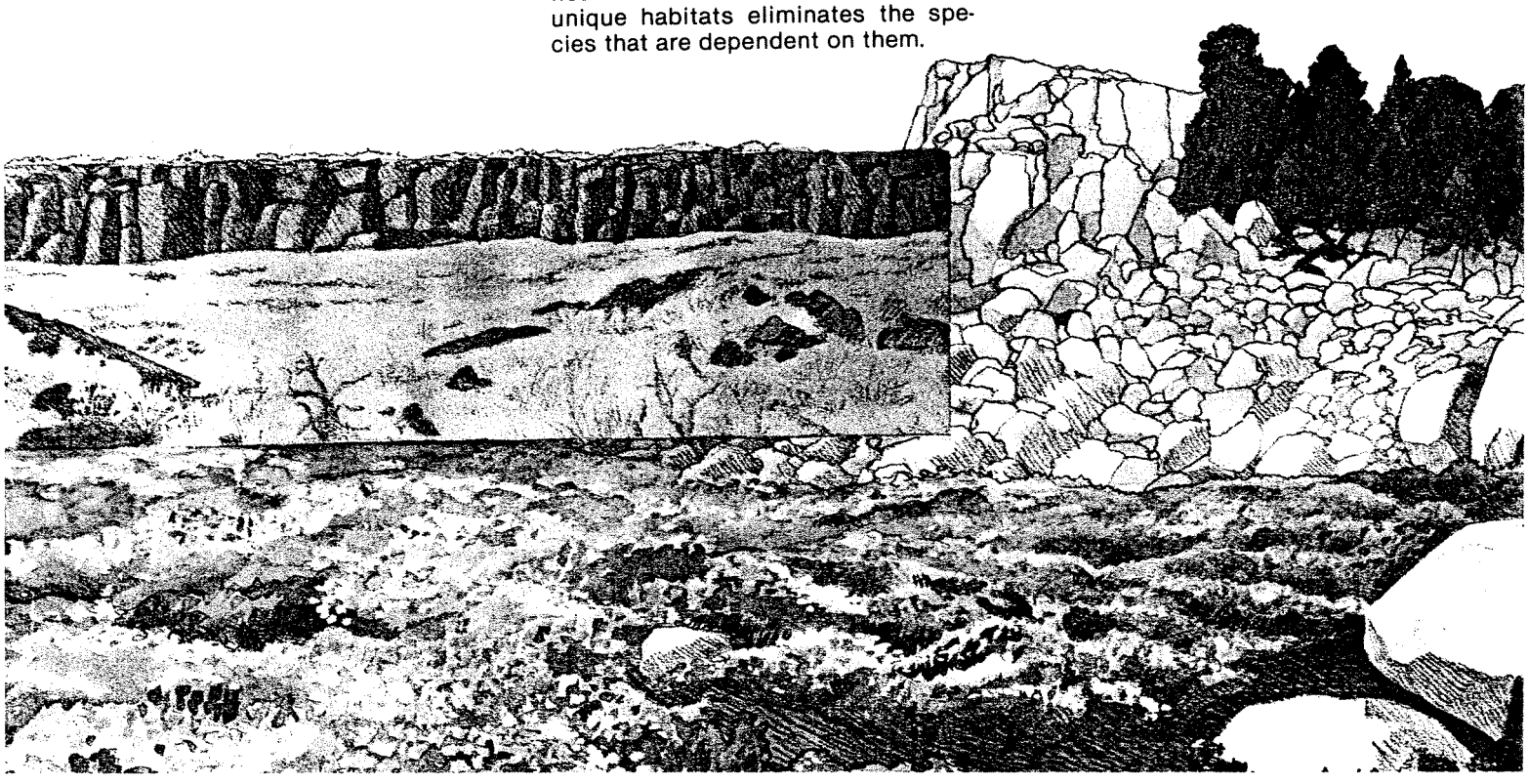
by
Chris Maser
Jon E. Rodiek
Jack Ward Thomas

Wildlife habitats in forest environments are associated with plant communities, but there are a few in which the plant community association is not obvious. These are called "unique habitats" and are created by geomorphic features. Although they may occur infrequently, unique habitats lend diversity to an environment otherwise largely dominated by plant communities, and in so doing, they play an important role in the enrichment of wildlife diversity.

Three types of unique habitats have been identified in the Blue Mountains—cliffs, talus, and caves. These features have abrupt, relatively stable edges, predictable airflow patterns (as along the face of a cliff), and provide relatively secure habitats for wildlife.

Unique habitats comprise a small part of the total land base and concentrate a variety of wildlife into relatively small areas. Each unique habitat has at least one species that cannot live elsewhere. Destruction of unique habitats eliminates the species that are dependent on them.

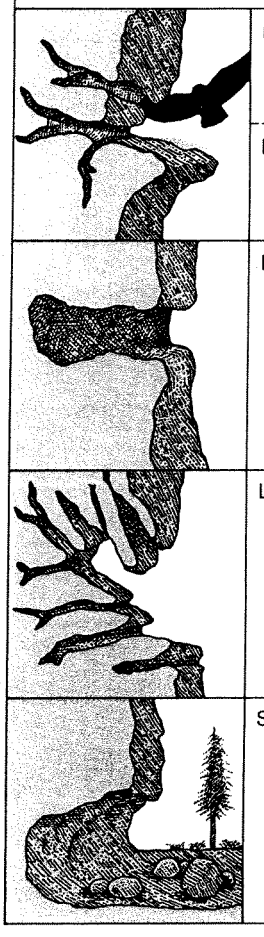
Unique habitats differ from the special habitats discussed earlier in one important respect. In nearly all cases, they cannot be artificially created, whereas special habitats can be. Once destroyed, they seldom can be replaced. An exception may be a manmade structure, such as an abandoned railroad tunnel, that incidentally serves some of the same purposes as does a natural geomorphic feature—in this case, a cave.



Cliffs

Cliffs are steep, vertical, or overhanging rock faces. Cliffs of igneous rock are more important as wildlife habitat than are those of sedimentary rock. Basalt and andesite cliffs have the necessary features, such as cracks, ledges, and occasionally deep caves (fig. 52), that provide habitat for many species of wildlife. Cliffs of sedimentary rock do not develop these features to the same degree because they are composed of softer, more easily eroded materials.

Cliffs provide physical protection for wildlife and concentrate a variety of reptiles, birds, and mammals into relatively small but stable environments. Most of the species that use cliffs obtain their food and water nearby. Essentially, the higher a cliff the more suitable the habitat it provides. With increasing height, there are more predictable upward-flowing warm air currents, or thermals, which provide conditions necessary for raptors (Craighead and Craighead 1969). Therefore, high cliffs adjacent to or within 0.4 kilometer (0.25 mi) of permanent water are by far the most important for those animals associated with them.



Feature	Wildlife	Uses
Fissures	Bats	Roosting Reproduction Hibernation
Ledges	Raptors	Roosting Nesting Perching
Deep cliff-face caves	Bats	Roosting Reproduction Hibernation
Loose slab rock	Swifts	Roosting Reproduction
Shallow caves	Lizards Snakes	Shelter Feeding Hibernation
	Mice Woodrats Coyotes Bobcats Pumas	Shelter Reproduction Nesting

Figure 52. Features of cliffs and their use by wildlife.

F Feeding only R Reproduction only ● Feeding and reproduction

Life form	Species	Orientation
	AMPHIBIANS	
2	Woodhouse toad	F
2	Pacific treefrog	F
	REPTILES	
5	western fence lizard	●
4	side-blotched lizard	●
3	western skink	F
5	striped whipsnake	F
5	gopher snake	F
5	night snake	F
5	western rattlesnake	F
	BIRDS	
3	Canada goose	R
4	turkey vulture	R
11	goshawk	F
12	red-tailed hawk	R
7	Swainson's hawk	F
4	ferruginous hawk	R
12	golden eagle	●
4	prairie falcon	●
4	peregrine	●
14	American kestrel	●
4	chukar	●
4	rock dove	R
14	barn owl	●
14	screech owl	●
12	great horned owl	●
15	burrowing owl	F
6	poorwill	F
6	common nighthawk	●
4	black swift	●
14	Vaux's swift	●
4	white-throated swift	●
4	Say's phoebe	●
7	gray flycatcher	F
4	barn swallow	●
4	cliff swallow	●
11	Steller's jay	F
7	black-billed magpie	F
4	common raven	●
10	Clark's nutcracker	F
3	dipper	R
4	canyon wren	●
4	rock wren	●
7	sage thrasher	F
14	western bluebird	F
14	mountain bluebird	F
6	Townsend's solitaire	●
7	loggerhead shrike	F
14	starling	●
4	gray-crowned rosy finch	●
4	black rosy finch	●
11	pine siskin	F
7	lesser goldfinch	F
7	green-tailed towhee	F
7	sage sparrow	F
	MAMMALS	
14	little brown myotis	●
14	California myotis	●
4	small-footed myotis	●
4	western pipistrelle	●
14	big brown bat	●
4	spotted bat	●
4	western big-eared bat	F
4	pallid bat	●
15	least chipmunk	●
15	yellow pine chipmunk	●
4	yellow-bellied marmot	●
15	Columbian ground squirrel	R
15	mantled ground squirrel	●
4	canyon mouse	●
15	deer mouse	●
4	pinyon mouse	●
4	bushy-tailed woodrat	●
6	porcupine	R
15	coyote	●
15	red fox	F
15	black bear	F
14	marten	F
14	fisher	F
15	short-tailed weasel	F
15	long-tailed weasel	●
5	wolverine	●
15	badger	F
15	spotted skunk	●
15	striped skunk	F
5	lynx	F
4	bobcat	●
4	mountain goat	●
4	big-horned sheep	●

Table 26. Wildlife that use cliffs for feeding and/or reproduction (source: appendix 14; all species listed)

Cliffs are essential to the survival of some raptorial birds and other species such as white-throated swifts (Peterson 1961), western pipistrelles (Cross 1965), pallid bats (Orr 1954), spotted bats (listed as threatened, U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife 1973), canyon mice, and pinyon mice (Bailey 1936) (table 26). They are very important as secure places for a variety of raptors to nest and rear their young (Bent 1961, Denton 1976, Gabrielson and Jewett 1970). Denton (1976, p. 16) wrote that:

> Nearly all nestings [of prairie falcons] occurred on basaltic rock formations (94 percent); in only two instances were sedimentary formations used. All cliffs were nearly vertical and most exhibited a fractured texture offering structures suitable for nest ledges.

Prairie falcons, for example, use high cliffs because they have predictable thermals and because their height provides security from ground-dwelling predators. Denton (1976), who studied prairie falcons in eastern Oregon, found that 64 percent of the falcons that were actively rearing young used cliffs that were between 7.6 and 30.5 meters (25 and 100 ft) in height. The prairie falcons had used the highest cliffs available, but only 43 percent of the total cliffs available had been used by nesting falcons. More than half the cliffs under 7.6 meters (25 ft) in height had not been used. If high cliffs had not been available, the population of prairie falcons might have been significantly reduced.

Other species also require high cliffs. In northeastern Oregon and southeastern Washington, for example, bats and swifts use cliffs that are more than 12.2 and 15.2 meters (40 and 50 ft) in height (Maser, unpublished, see "References Cited").

The great horned owl nests in trees or cliffs.

Talus

Talus is the accumulation of broken rocks at the base of cliffs or other steep slopes. The important structural components of talus include length, depth, width, type and size-class of the rock, and the age and stability of the formation. A large, deep, stable talus of basalt or andesite is much more important as wildlife habitat than is a small talus or one of sedimentary rock (fig. 53). The latter erodes easily and rapidly and provides few or no stable living spaces for wildlife.

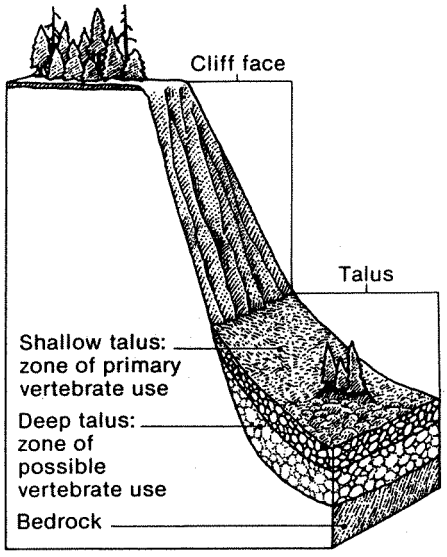


Figure 53. Talus is an accumulation of broken rocks at the base of a cliff.

This cliff face is an ideal nesting site for the common raven.

F Feeding only ● Feeding and reproduction

Life form	Species	Orientation
	AMPHIBIANS	
2	long-toed salamander	F
2	western toad	F
2	Woodhouse toad	F
2	Pacific treefrog	F
	REPTILES	
5	western fence lizard	●
4	side-blotched lizard	●
3	western skink	●
5	western whiptail	●
15	rubber boa	●
5	yellow-bellied racer	●
5	striped whipsnake	●
5	gopher snake	●
5	western terrestrial garter snake	●
5	night snake	●
5	western rattlesnake	●
	BIRDS	
4	turkey vulture	F
11	goshawk	F
12	red-tailed hawk	F
7	Swainson's hawk	F
4	ferruginous hawk	F
12	golden eagle	F
4	prairie falcon	F
4	peregrine	F
14	American kestrel	F
4	white-tailed ptarmigan	●
4	chukar	●
5	turkey	F
14	barn owl	F
14	screech owl	F
12	great horned owl	F
14	pygmy owl	F
15	burrowing owl	F
6	poorwill	F
6	common nighthawk	F
4	black swift	F
14	Vaux's swift	F
4	white-throated swift	F
4	Say's phoebe	●
7	gray flycatcher	F
4	cliff swallow	F
11	Steller's jay	F
7	black-billed magpie	F
4	common raven	F
4	canyon wren	●
4	rock wren	●
7	sage thrasher	F
14	western bluebird	F
14	mountain bluebird	F
7	loggerhead shrike	F
4	gray-crowned rosy finch	F
4	black rosy finch	F
11	pine siskin	F
7	lesser goldfinch	F
7	green-tailed towhee	F
7	sage sparrow	F
	MAMMALS	
15	vagrant shrew	●
14	little brown myotis	F
4	small-footed myotis	F
4	western pipistrelle	F
14	big brown bat	F
4	western big-eared bat	F
4	pika	●
15	mountain cottontail	●
15	least chipmunk	●
15	yellow pine chipmunk	●
4	yellow-bellied marmot	●
15	Columbian ground squirrel	●
15	mantled ground squirrel	●
15	Great Basin pocket mouse	●
15	western harvest mouse	●
4	canyon mouse	●
15	deer mouse	●
15	northern grasshopper mouse	●
4	bushy-tailed woodrat	●
15	mountain vole	●
15	sagebrush vole	●
15	coyote	F
15	red fox	F
15	black bear	F
14	marten	F
14	fisher	F
15	short-tailed weasel	F
15	long-tailed weasel	●
5	wolverine	F
15	badger	●
15	spotted skunk	F
15	striped skunk	F
5	lynx	F
4	bobcat	●
4	mountain goat	F
4	big-horned sheep	F

Table 27. Wildlife that use talus for feeding and/or reproduction (source: appendix 14; all species listed)

Talus concentrates vertebrate animals, such as frogs and toads, lizards, snakes, birds, and small mammals, into relatively small areas. The larger a talus, the more stable it is and the more opportunities it provides for wildlife habitat. A talus needs to be large enough to provide living space for a self-sustaining population of the species that is dependent on it. In the Blue Mountains, for example, the pika is the only animal known to be dependent on talus for its survival. Depth is important because animals move up and down inside a talus seeking the right conditions of temperature and humidity. Talus is especially important for the protection of some species during reproduction and hibernation. In addition, talus often supports an edge of herbaceous vegetation that is the food supply for species living within it, such as pikas, marmots, deer mice, and woodrats (Bailey 1936, Dalquest 1948, Krear 1965, Taylor and Shaw 1927) (table 27).

Krear (1965) found that the environment within a deep talus was more stable than it was on the surface (fig. 54). He also observed that snow rested on the larger rocks and formed a protective mantle under which the animals could readily move about.

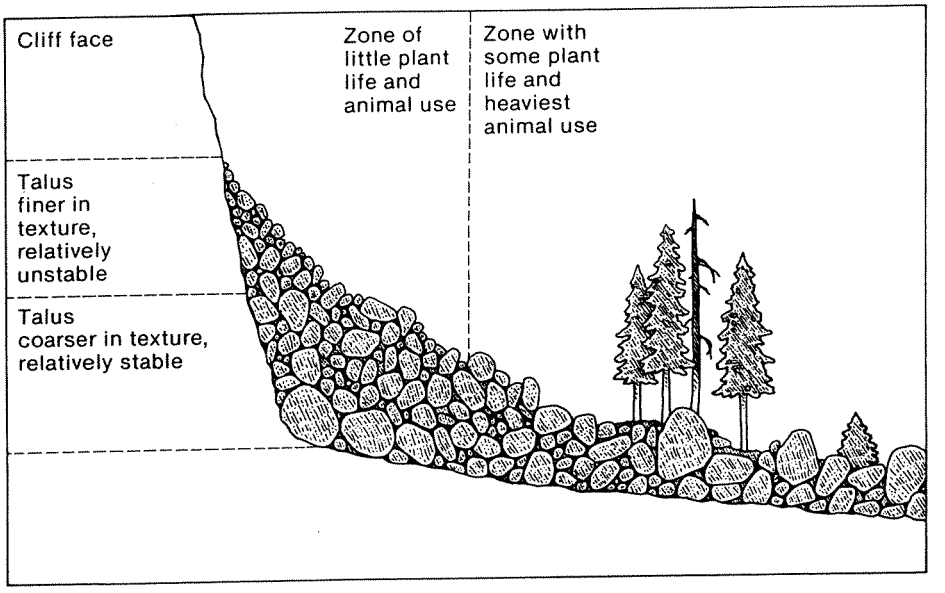
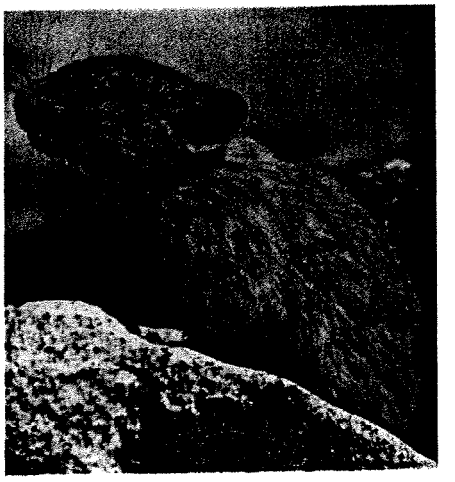


Figure 54. Features of talus and degree of wildlife use.



The turkey vulture commonly nests in crevices or caves in cliffs, or in hollow stumps or logs.

In the Blue Mountains, the pika is the only animal known to be totally dependent on talus for its survival.

Caves

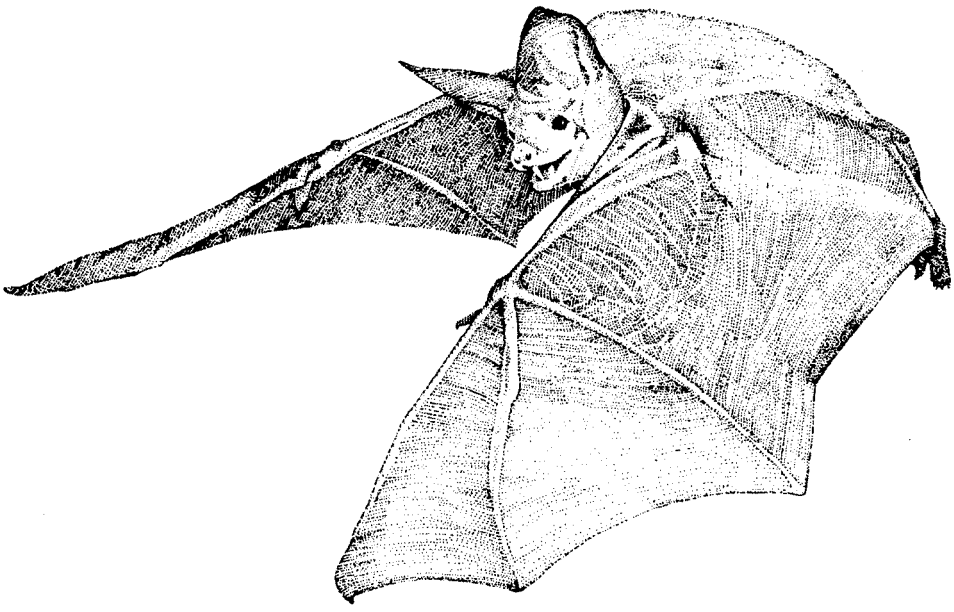
A cave is a natural underground chamber that is open to the surface. There are many types of caves. They may be shallow or deep and occur in igneous, metamorphic, or sedimentary rock formations. Regardless of type, they are important and unique habitats (fig. 55).

Caves provide shelter from extreme weather conditions, varying degrees of darkness, and solitude from the outside world. They also provide stable internal environments for wildlife and physical protection from predators (Barr 1967, Culver 1970, Harris 1970, Poulson and Culver 1969, Poulson and White 1969). Deep caves, for example, provide total darkness, complete solitude, a stable humidity and temperature regime, and almost complete protection from predators. Such caves are essential to the survival of some bats, primarily western big-eared bats, which breed, form their nursery colonies, and hibernate in them (Dalquest 1948, Pearson et al. 1952). Other bats use caves only as night roosts where they hang up periodically to rest and digest their food (Barbour and Davis 1969).

Deep caves are scarce in northeastern Oregon, but abandoned mineshafts and railroad tunnels occasionally provide the same specialized habitat as do natural caves (Barbour and Davis 1969). The more abundant shallow caves are used by deer mice, bushy-tailed woodrats (Bailey 1936), bobcats, coyotes, porcupines, and occasionally by bats, and other small mammals (Maser, unpublished, see "References Cited") (table 28). They are also used occasionally by owls (Peterson 1961) and other birds (fig. 55).

Table 28. Wildlife that use caves for feeding and/or reproduction (source: appendix 14; all species listed)

Cave-dwelling bats, such as the pallid bat, may be eliminated by human disturbance.



F Feeding only
R Reproduction only
● Feeding and reproduction

Life form	Species	Orientation
	BIRDS	
14	barn owl	R
14	screech owl	R
	MAMMALS	
14	California myotis	R
4	small-footed myotis	R
14	big brown bat	R
4	western big-eared bat	R
4	pallid bat	R
4	canyon mouse	R
15	deer mouse	●
4	pinyon mouse	R
4	bushy-tailed woodrat	R
6	porcupine	R
15	coyote	R
15	gray fox	R
14	marten	F
14	fisher	F
15	short-tailed weasel	R
15	long-tailed weasel	R
5	wolverine	R
15	spotted skunk	R
4	puma	R
4	bobcat	R

Management Considerations

Unique habitats occupy a very small percent of the total forest land base, yet they are disproportionately important as wildlife habitats. Each unique habitat has at least one animal that is highly adapted to it as a place in which to live. Each habitat also concentrates and supports a unique animal complex. Adjacent plant communities provide the source of food for the animals, and snags along the tops of cliffs are essential perches for raptors. Therefore, plant communities adjacent to these habitats should be stabilized as much as possible.

Unique habitats are fragile environments and little or nothing can be done to improve them. They seldom can be artificially created, but they can be easily destroyed with subsequent loss of critical wildlife habitat. Removal or alteration of a habitat normally eliminates the animal dependent on it. For instance, the use of a talus as a source of material for a roadbed could eliminate the pika.

Some animals can also be eliminated from an area simply through human disturbance such as travel over access roads or trails near their habitats, especially when they are actively rearing young. Cave-dwelling bats, for example, are very easily eliminated by cave exploration, artifact hunting, fire building, and vandalism (Bailey 1936, Graham 1966). It is wise, therefore, not to advertise the location of caves unless they are to be developed specifically for recreational use.

Cliffs, talus, and caves should be recognized as relatively rare, unique habitats (Vuilleumier 1973). Forest management activities involving alteration or disturbance of unique habitats should be carefully evaluated, and the sites should be inspected by wildlife experts during the planning process to insure their proper management.

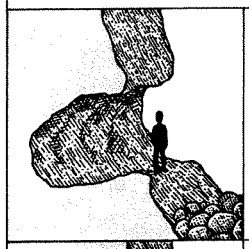
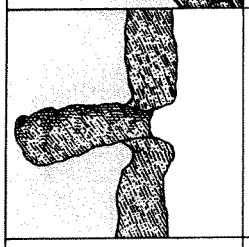
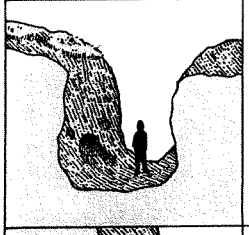
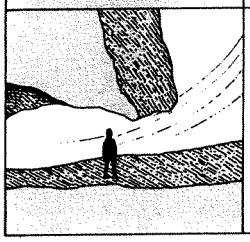
	Cave	Wildlife	Uses
	Shallow caves	Birds Mice Woodrats Coyotes Bobcats Pumas	Shelter Nesting Reproduction
	Cliff-face caves	Bats	Roosting Reproduction Hibernation
	Lava tubes	Bats	Roosting Reproduction Hibernation
		Mice Woodrats	Shelter Nesting Reproduction
	Abandoned mine shafts and railroad tunnels	Bats	Roosting Reproduction Hibernation
		Mice Woodrats	Shelter Nesting Reproduction

Figure 55. Types of caves and their use by wildlife.

8
Deer and Elk

by
Jack Ward Thomas
Hugh Black, Jr.
Richard J. Scherzinger
Richard J. Pedersen

The forest manager may choose to enhance habitats for many vertebrate species. But there are also situations where it is desirable to enhance habitat for a few selected or "featured" species. This chapter shows how habitat for deer and elk can be enhanced in the managed forest. Similar systems can be developed for other featured species.

Timber management practices in the Blue Mountains alter forest ecosystems faster and more profoundly than any of man's other activities. As forests are managed more intensively, there are increases in human activity and significant changes in the amount of cover and forage available for deer and elk. Every timber management decision has an effect on deer and elk populations.

Forest managers have historically taken little notice of the impacts of timber management practices on deer and elk. As a result, the consequences have been accidental rather than intentional. By considering both the short- and long-term effects of timber management decisions on deer and elk habitat, the forest manager can identify opportunities to reduce negative impacts or even to enhance habitat.

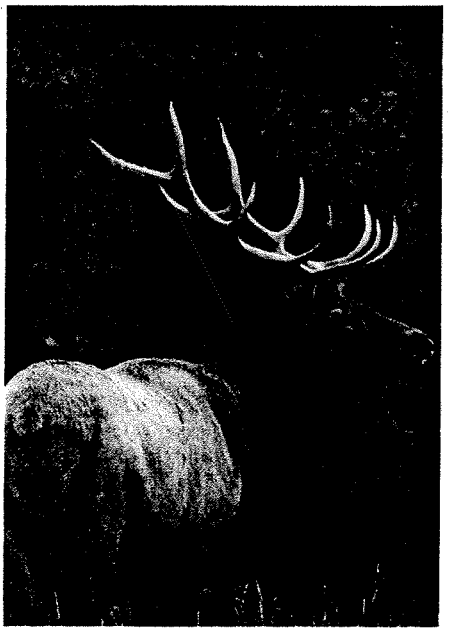
Unless action is taken to insure full management coordination, the results of timber management will become an either-or situation—good for either timber production or deer and elk production but not for both. This situation need not occur. There can be simultaneous production of timber and deer and elk from the same area.

Featured Species Management

This chapter provides a system for predicting the effects of alternative timber management plans on deer and elk. The system can be used for long-range planning or for evaluating the consequences of individual timber sales. The system does not make management recommendations; it merely displays models that predict the consequences of various timber management practices.

Nine assumptions provide the foundation for the system and take into account the interplay that occurs between timber management, deer and elk management, and people management:

1. Forage, water, and cover are the primary habitat factors that limit deer and elk populations.



The Rocky Mountain elk is an important big game species in the Blue Mountains.

2. The amount, type, and interspersion of forage, water, and cover can be controlled to achieve predictable results in deer and elk use.

3. In situations where the welfare of deer and elk must be considered, their habitat requirements will be of paramount importance in long-range planning and in layout of timber sales.

4. The management of deer and elk includes manipulation of habitat and human activities in the forest. The relationships presented here were developed to insure that the biological requirements of the species will be met. They are not designed to protect deer and elk during hunting seasons. Human activity can be managed and errors quickly rectified, but mistakes in habitat management may require decades to correct. On the other hand, uncontrolled human disturbance may negate what has been achieved through well-planned habitat management. Considerations relating to hunting and human disturbance can best be handled by hunting regulations or by management of public access.

5. Logging slash and dead and down material will be treated to achieve at least MM standards for fire protection (USDA Forest Service 1968). This is the amount and type of fuel that would allow a medium (M) rate of fire spread and would have medium (M) resistance to control based on tree cover and type, understory type and density, and the amount of dead material on the ground. If MM standards are not met, access by animals to logged areas will be severely hampered (Lyon 1976). In rare cases where long rows of slash occur, they should be broken at regular intervals to permit movement of deer and elk (Pierovich et al. 1975).

6. If the habitat of deer and elk on summer ranges (fig. 56) is optimized, then the capacity of the available winter range may be exceeded. Summer ranges tend to be more extensive than winter ranges and in heavier precipitation zones. As a result, there is more opportunity to increase forage and provide adequate cover. Many winter ranges have been lost and will continue to be lost because of developments for agriculture, roads, settlements, and intensive grazing of livestock.

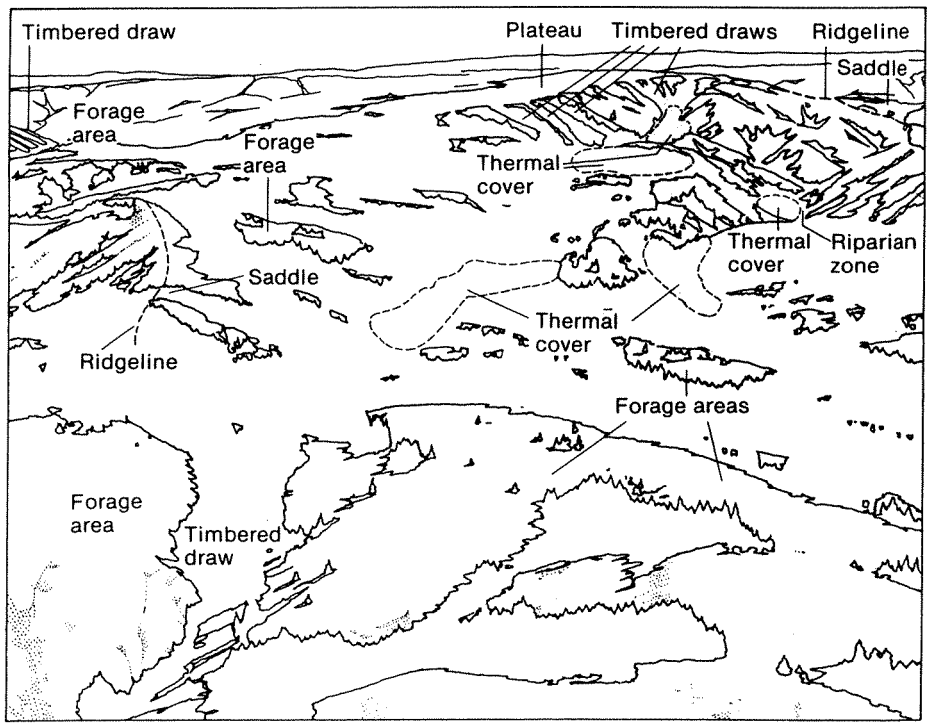


Figure 56. Habitat components of typical summer range in the Blue Mountains.

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
1	1		G4	5	0-35	All	20	7.6-16.8 (25-55)	K51	GB-49-11	•	Bunchgrass on shallow soil, gentle slopes
									K51	GB-49-12	•	Bunchgrass on deep soil, gentle slopes
									K51	GB-91-11	•	Bluegrass scabland
									K11	CP-G1-11	•	Ponderosa pine/wheatgrass
									K11	CP-G1-12	•	Ponderosa pine/fescue
5	3c				30-80	North, south	35	6.1-18.3 (20-60)	K51	GB-49-13	•	Bunchgrass on shallow soil, steep slopes
									K51	GB-49-14	•	Bunchgrass on deep soil, steep slopes
									K12	CD-S7-11	•	Ponderosa pine-Douglas-fir/ ninebark
									K14	CW-S2-11	•	White fir/big huckleberry
									*	SM-19		Ninebark shrubland
									K12	CD-G1-11		Ponderosa pine-Douglas-fir/ elk sedge
8		2a 2b	S2		30-80	All	85	13.7-24.4 (45-80)	K15	CE-S3-11	•	Subalpine fir/big huckleberry
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									K15	CE-S4-11		Subalpine fir/grouse huckleberry
									*	CL-S4-11		Lodgepole pine/grouse huckleberry
									K52	CA-G1-11		Subalpine fir-whitebark pine/sedge
12	5a 17a			1	0-30	All	75	13.7-23.2 (45-76)	K15	CE-S4-11	•	Subalpine fir/grouse huckleberry
									K15	CE-S3-11		Subalpine fir/big huckleberry
15	6a 15a 18a		G5	1	0-30	All	90	15.2-24.4 (50-80)	K15	CE-S4-11	•	Subalpine fir/grouse huckleberry
									*	CL-S4-11	•	Lodgepole pine/grouse huckleberry
									K14	CW-S8-11	•	White fir/grouse huckleberry
									K15	CE-S3-11		Subalpine fir/big huckleberry
									*	CL-S5-11		Lodgepole pine/big huckleberry
									*	CL-G2-11		Lodgepole pine/pinegrass-grouse huckleberry

See footnotes at end of appendix 25.

7. If forage is limiting on summer range and there is marked competition with livestock, big game animals should be given full consideration in allocation of forage. In some cases, deer and elk habitat may actually be improved by livestock grazing (Anderson and Scherzinger 1975).

8. Habitat suitability can be judged by the ratio of cover areas to forage areas and their size and arrangement in time and space.

9. Roads left open to vehicular traffic will adversely affect use of the area by elk and, to a lesser extent, by deer. Proper location and management of roads is an essential part of deer and elk habitat management.

Response of Deer and Elk to Land-Types

Deer and elk respond dramatically to some topographic features and to the arrangement and juxtaposition of different kinds of vegetation (fig. 56). These combinations of land features and vegetation are known as land-types. For example, during winter deer and elk prefer to use moderately steep south slopes rather than north slopes because temperatures are warmer and there is less snow. Stringer forest stands interspersed with grassland are also consistently used because they provide thermal cover and protected travel lanes. Under a single kind of silvicultural treatment, deer and elk will respond in different ways depending on the environmental setting, or land-type, in which the management action is applied.

Table 29. Descriptions of selected land-types on National Forests in the Blue Mountains (source: appendix 25)

There are 32 land-types in the Blue Mountains (appendix 25). Examples are shown in table 29. Land-types are combinations of land features and vegetation used to predict the way plant and animal populations will respond to timber harvest practices. The specific responses of deer and elk to land management alternatives based on these land-types should be considered appropriate only for the Blue Mountains.

Six kinds of information are needed for making sound land management decisions. Four of these, items 3, 4, 5, and 6, define the basic characteristics of land-types:

1. Current condition of the forest stand, such as species composition, volume per acre, acreage, tree size, and status of understory vegetation.

2. Current use of the area, such as presence of summer or winter range for elk, livestock grazing, timber sale activity, landscape foreground, proximity of fences and roads, the amount of travel over roads, or unique wildlife habitat sites.

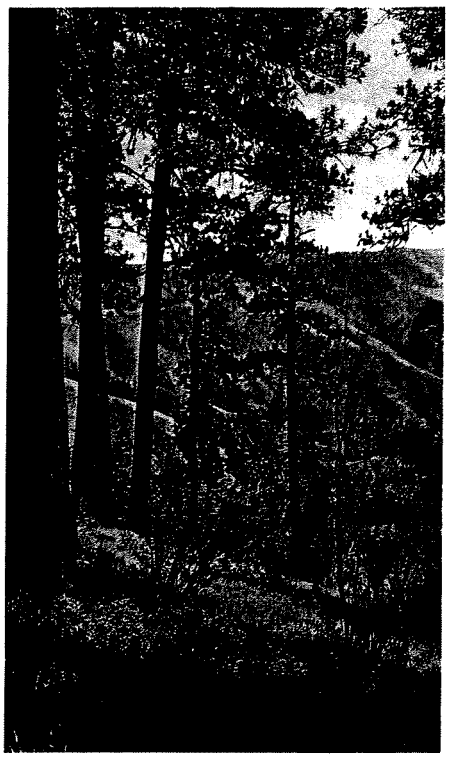
3. Site potential, including such information as habitat type, plant community type, or site type. Such characteristics of the vegetation will help in predicting response to treatment and potential for reforestation or revegetation.

4. Soil features, such as depth, stability, and susceptibility to compaction.

5. Topographic features, such as slope steepness and aspect, shape of the topography, and geologic stability.

6. Size and general shape of the area under consideration, its position on a slope, the type of adjacent vegetation, and available water.

As an example of how land-type information may be interpreted, consider land-type 1 (table 29) which occurs in the Umatilla, Wallowa-Whitman, and Ochoco National Forests. Slopes within this land-type are 35 percent or less, meaning that animals and motorized vehicles can easily use the area. This land-type can occur on any aspect. Only 20 percent of the type is in forest sites, and these are small and widely separated. The potential for producing cover for deer and elk is severely limited. The conditions in land-type 1 also tend to result in higher logging costs.



Primary winter range for elk in the Blue Mountains. Elk use trees on steep north slopes for thermal cover.

Area used (percent)

Potential use (percent)

100	90	80	70	60	50	40	30	20	10
90	81	72	63	54	45	36	27	18	9
80	72	64	56	48	40	32	24	16	8
70	63	56	49	42	35	28	21	14	7
60	54	48	42	36	30	24	18	12	6
50	45	40	35	30	25	20	15	10	5
40	36	32	28	24	20	16	12	8	4
30	27	24	21	18	15	12	9	6	3
20	18	16	14	12	10	8	6	4	2
10	9	8	7	6	5	4	3	2	1

Figure 57. Deer and elk make optimum use of their habitat when the maximum possible use occurs on the maximum possible area without deterioration of vegetation. The progressively darkening area indicates increasing realization of this goal.

Low elevations are found in land-type 1, which varies from 762 to 1 676 meters (2,500 to 5,500 ft). This means that the type tends to include deer and elk winter ranges or areas used intensively by these animals in the spring and fall. The major plant community types are bunchgrass types and scabland. The major forest type is ponderosa pine. Each plant community type is described by Hall (1973) according to its vegetative response to treatment, productivity, management opportunities, and limitations.

The bunchgrass and scabland of land-type 1 cannot provide adequate cover for deer and elk. Also, the stocking potential of climax ponderosa pine is too low to provide the crown closure needed for thermal cover. Hiding cover for deer and elk may be provided during early successional stages, but tree reproduction will stagnate quickly if not thinned widely enough. Thinning dramatically reduces the effectiveness of the stand as cover.

Land-type 8, on the other hand, occurs in the central Blue Mountains. Slopes vary from 30 to 80 percent. Such steep slopes indicate that vehicles will not be able to travel on most of the area and that livestock use will probably be restricted. This land-type can occur on any aspect. The type is 85 percent forested, indicating abundant cover and large contiguous forest stands. Elevations range from 1 372 to 2 438 meters (4,500 to 8,000 ft), indicating an upper-slope type. This is indicated by the dominance of subalpine fir and fire-successional lodgepole pine with an understory of huckleberry.

The information used to describe land-types can form the basis for a workable system to predict the effects of timber management on deer and elk. This is done by integrating appropriate combinations of descriptive factors relating to hiding cover, thermal cover, and cover-forage area ratios that create optimum habitat for deer and elk in the Blue Mountains. Appendices 26, 27, and 28 show deer and elk response to habitat changes that result from integration of these factors.

Optimum Habitat for Deer and Elk

Optimum deer and elk habitat is the amount and arrangement of cover and forage areas that result in the maximum possible proper use of the maximum possible area by the animals. This occurs when the greatest possible area is used and the vegetation is utilized to the maximum without deterioration (fig. 57).

The ratio of 40 percent of a landtype in cover to 60 percent in forage areas of proper size and arrangement approximates optimum habitat in the Blue Mountains. Information about the way deer and elk use cover and openings in relation to forest edge was used to calculate optimum habitat (Reynolds 1962, 1966a; Harper 1969). This ratio should be valid for use with any silvicultural treatment. The principles are considered applicable to both even-aged and uneven-aged silvicultural systems as described by the U.S. Department of Agriculture (USDA Forest Service 1973b).

Deer and elk require water, particularly on summer range (Schmidt-Nielsen and Schmidt-Nielsen 1952). Studies in Montana by Marcum (1975, 1976) indicate that elk make disproportionately heavier use of areas within 320 meters (1,050 ft) of water. Julander (1966) documented similar patterns for mule deer. Optimum habitat has potable water within 0.8 kilometer (0.5 mi) of any point (Mackie 1970). In one study on summer range in northeastern Oregon, elk displayed a highly disproportionate use of riparian habitat with potable water (Pedersen, unpublished, see "References Cited").

Hiding Cover

Optimum habitat for deer and elk requires hiding cover, perhaps because it gives the animals a sense of security. Hiding cover (fig. 58) is defined as vegetation capable of hiding 90 percent of a standing adult deer or elk from the view of a human at a distance equal to or less than 61 meters (200 ft). This is the distance at which the animal is essentially hidden. Because deer are smaller, the height and density of vegetation suitable for cover may be less than that required by elk. In fact, hiding cover suitable for elk will probably be more than adequate to meet the needs of mule deer in the managed forest.

Wet meadows provide water and forage for deer and elk on summer range.

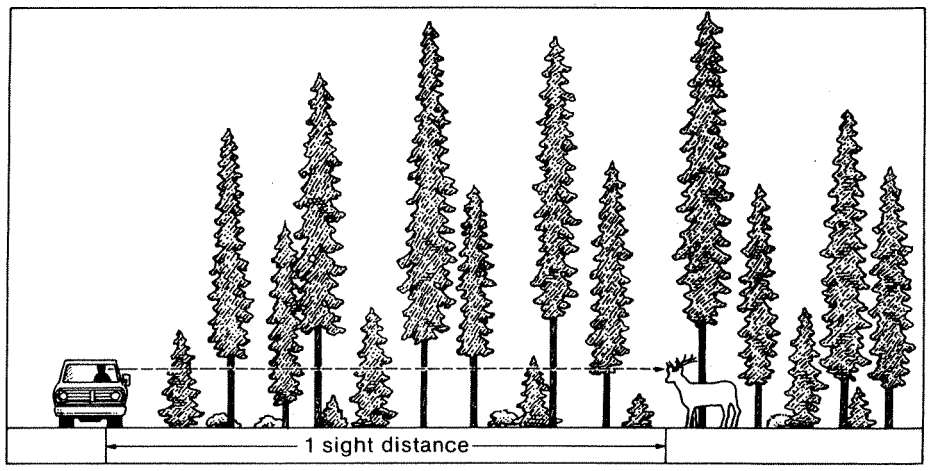


Figure 58. Sight distance is the distance at which 90 percent or more of a deer or elk is hidden from an observer. Hiding cover exists when 90 percent or more of a standing deer or elk is hidden at a distance of 61 meters (200 ft) or less.

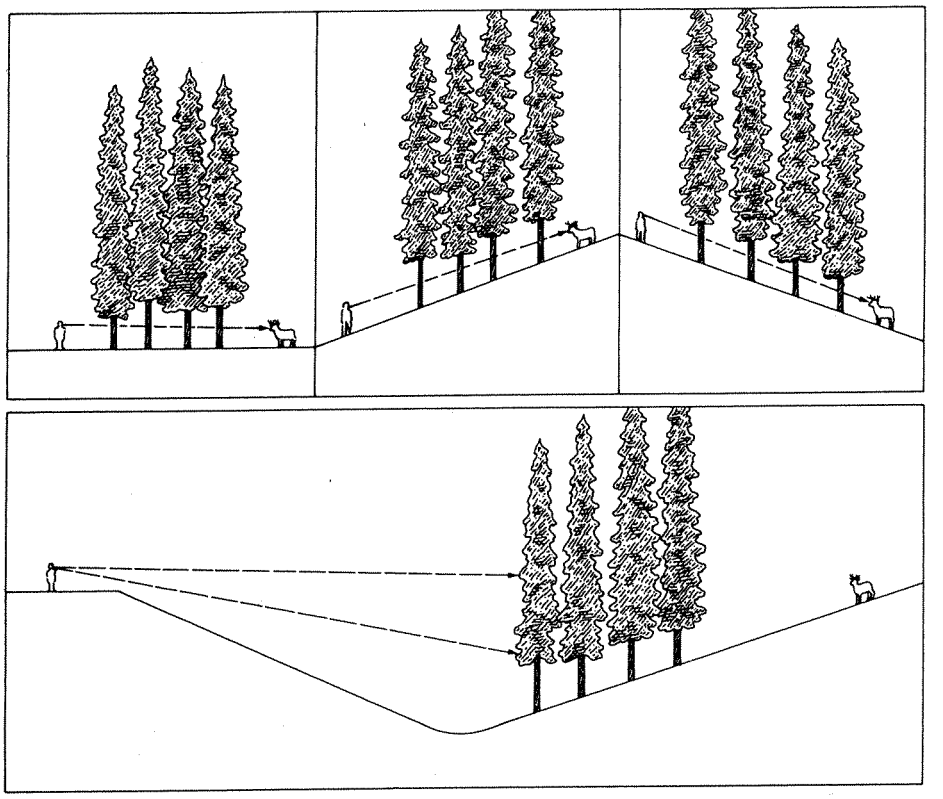


Figure 59. Topography influences the effectiveness of vegetation as hiding cover.

Physical barriers such as topographic differences or slash piles in logged areas have been omitted from these considerations because such factors introduce infinite variations. Topography has not been demonstrated to be a substitute for vegetative cover. Although topographic sight barriers between an animal and a potential predator may be significant, the animal may still use the area less than a comparable area with appropriate vegetative hiding cover.

Topography can have a marked impact, however, on the value of a particular type of vegetation for hiding cover (fig. 59). When the sight plane is parallel to the ground, only the trunks and lower limbs of trees contribute hiding cover; but when the angle of observation is elevated above the ground, the canopy becomes effective as cover. Thus, in sharply varied topography, tree canopies may supply effective cover if trunks and lower limbs do not meet hiding cover requirements. The angle of observation becomes especially important in canyons or timbered stringers. Careful attention should be given to this relationship when logging is planned in such areas.

Circular patches of hiding cover can vary between 183 and 366 meters (600 and 1,200 ft) in diameter and still meet the definition of optimum habitat (fig. 60). This is three to six maximum sight distances of 61 meters (200 ft) each. Such circular cover patches would vary from 2.6 to 10.5 hectares (6.42 to 25.95 acres) in size.

Reynolds (1966a) and Harper (1969) showed that most use by deer and elk occurred within 183 meters (600 ft) of the edge between cover and forage areas. Therefore, in a circular cover patch with a radius of 183 meters (600 ft), or a diameter of 366 meters (1,200 ft), there would be an interior area (zones 2 + 3 in fig. 60) of 4.7 hectares (11.61 acres) in which the animal would be hidden from view in any direction. At the same time, any spot within the entire area would be 183 meters (600 ft) or less from the edge between the cover patch and a forage area. Circular cover patches larger than this would have interior zones that, although serving as cover, would probably be used less.

A circular cover patch with a radius of 91.5 meters (300 ft) or a diameter of 183 meters (600 ft) would provide an interior zone of 0.3 hectare (0.74 acre) in which the animal would be hidden from view in all directions. Patches smaller than this are less likely to provide adequate cover for elk because elk move in relatively large social groups at certain times of the year.

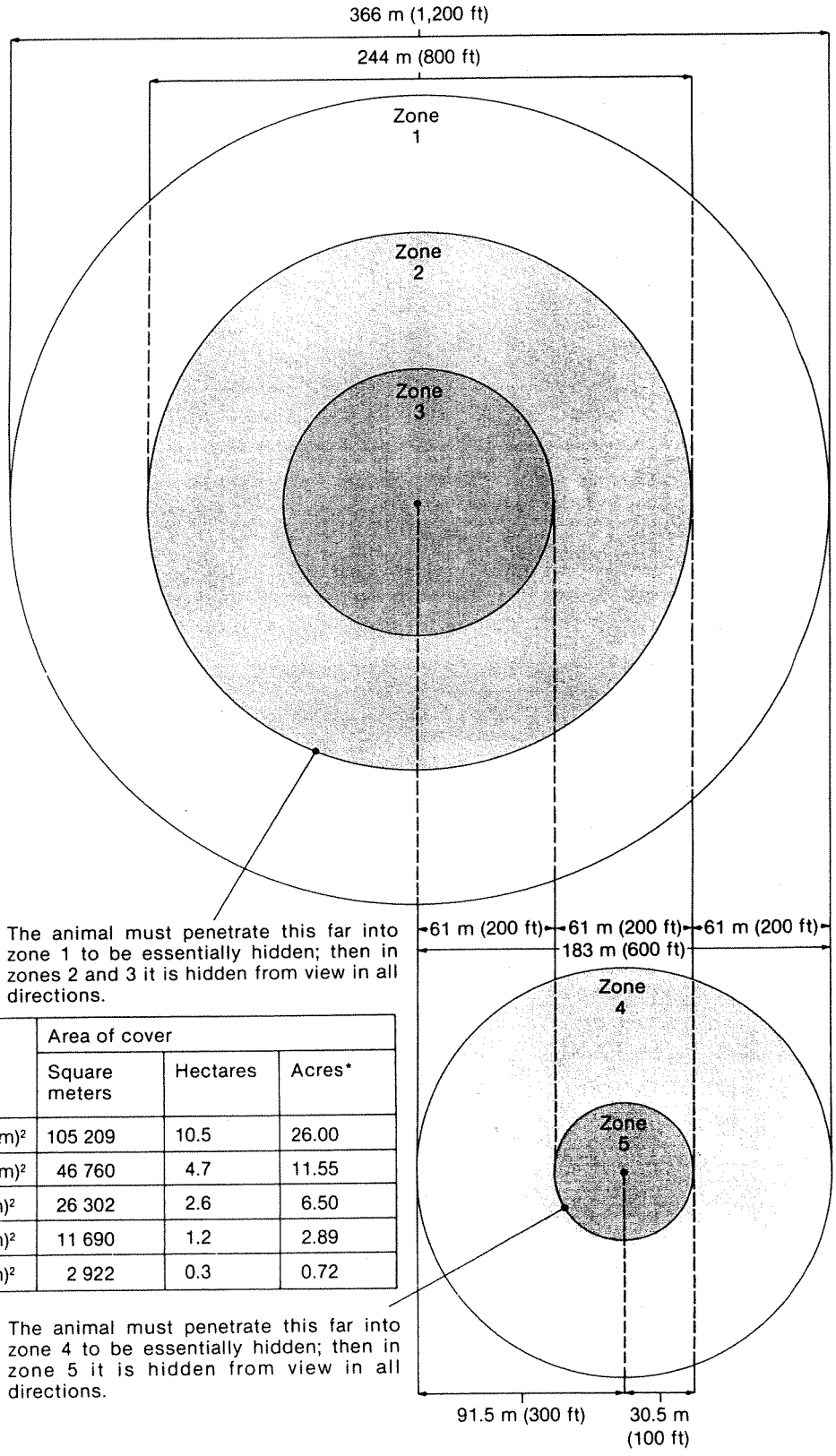
If the manager wants to enhance habitat for deer and elk and also increase diversity for many edge species, the edge perimeter of the cover patch can be increased by changing its configuration. The relative degree of edge produced by different shapes of stands can be determined by the formulas in chapter 4.

Figure 60. Patches of hiding cover can vary in diameter and still be of optimum size.

A circular cover patch with a diameter as large as 366 meters (1,200 ft), above right, could qualify as optimum. All zones within the area are heavily used by deer and elk. This allows maximum use of the maximum area. A larger patch would produce an interior zone of less than maximum use.

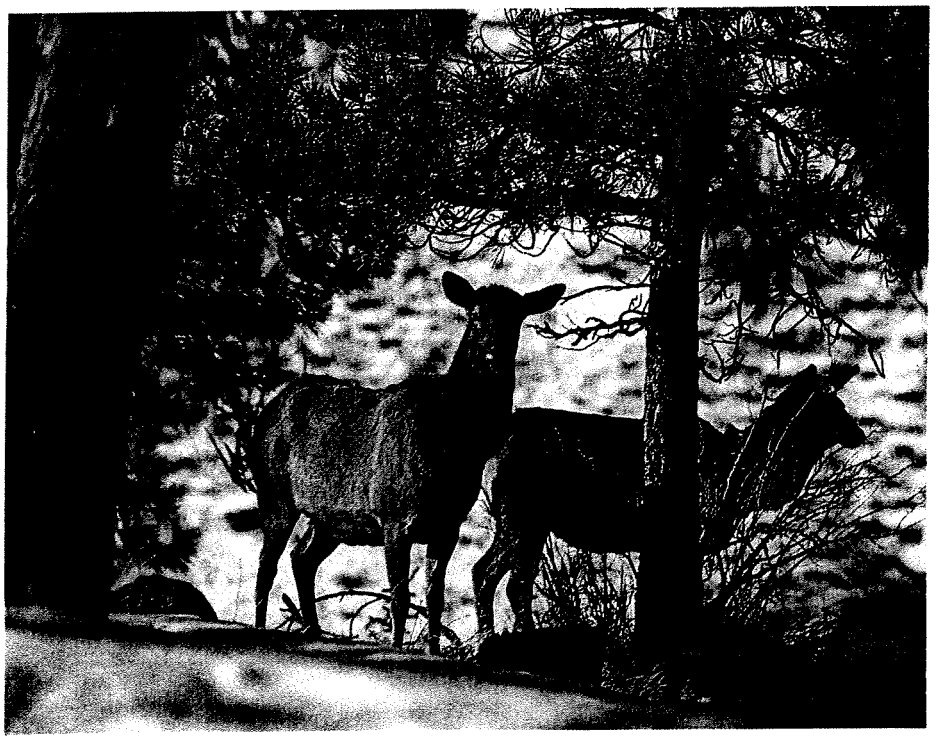
A circular cover patch with a diameter as small as 183 meters (600 ft), below, could qualify as optimum. All points in this patch are within the area heavily used by deer and elk and some effective hiding area remains. Smaller patches would have an interior hiding zone of inadequate size.

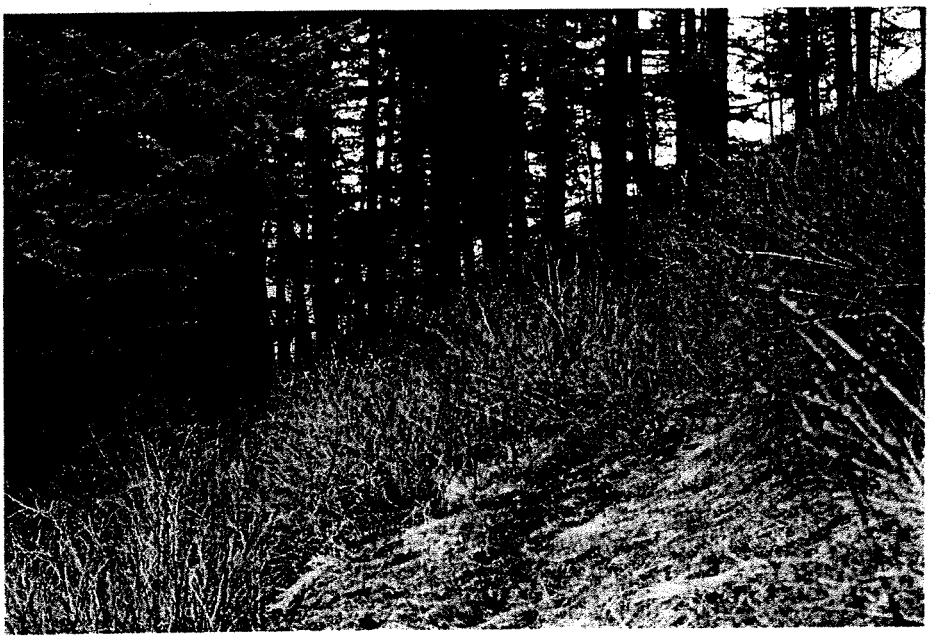
1 sight distance = 61 meters (200 ft).



Hiding cover zones	Radius		πr^2 = area	Area of cover		
	Meters	Feet		Square meters	Hectares	Acres*
1 + 2 + 3	183.0	600	(3.1416) (183.0 m)^2	105 209	10.5	26.00
2 + 3	122.0	400	(3.1416) (122.0 m)^2	46 760	4.7	11.55
4 + 5	91.5	300	(3.1416) (91.5 m)^2	26 302	2.6	6.50
3	61.0	200	(3.1416) (61.0 m)^2	11 690	1.2	2.89
5	30.5	100	(3.1416) (30.5 m)^2	2 922	0.3	0.72

*4 047 m^2 = 1 acre





Deer and elk use thermal cover to maintain body temperature.

Thermal Cover

Deer and elk are warm-blooded (homoiothermic) animals and must maintain a nearly constant body temperature. When food is digested, heat is produced and lost to the environment. This loss is accelerated when the animal's body temperature is greater than the ambient temperature. Conversely, heat is absorbed by the animal when the ambient temperature is greater than its body temperature.

A deer or elk can increase or decrease heat production by adjusting its physical activity and its metabolic rate (Moen 1973). Used together, these two heat production methods have their own limits of effectiveness. For example, increased physical activity requires greater body exposure which results in a higher rate of heat dissipation. This increases the metabolic rate and creates a tissue-oxygen deficit that reduces metabolic efficiency.

Deer and elk can conserve energy through behavioral response to appropriate stimuli. They attempt to position themselves, particularly when at rest, in the closest approximation of a thermal-neutral zone. This is the temperature range that does not trigger a metabolic response. Animals do this by selecting combinations of topography and vegetation that produce the best approximation of a thermal-neutral zone. Beall (1976, p. 97) described how:

> . . . elk react to changing ambient air temperature and solar and thermal radiation conditions by selecting bedding sites which enhance control of body temperature. As air temperature increased, elk moved to north slopes [which were cooler] during the day and to south slopes [which were warmer] at night. . . . In all cases of habitat selection under varying meteorological conditions a closer correlation was found with thermal and solar radiation intensities than with ambient air temperatures.

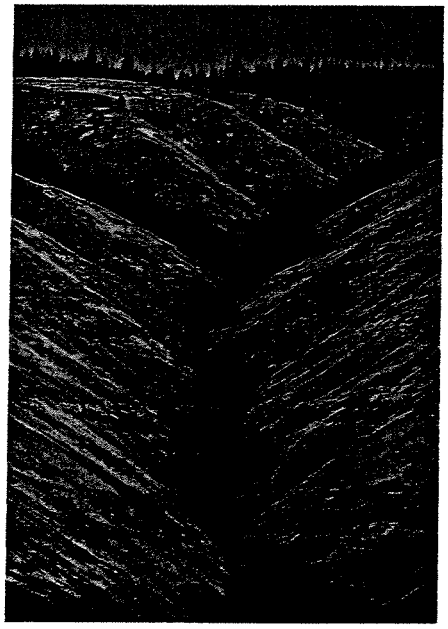
Cover used by deer or elk to assist in maintaining homoiothermy is called thermal cover (Black et al. 1976). The cover selected may vary with windspeed, cloud cover, relative humidity, time of day, and season. Although deer and elk may not always find perfect cover conditions, the presence of thermal cover will enable them to move to a location that is as close as possible to a thermal-neutral zone.

The variety of temperature regimes provided by thermal cover creates a range of opportunities for deer and elk to conserve energy. They can select appropriate cover to suit the thermoregulatory requirements of the moment (Beall 1974, McEwan and Whitehead 1970). The effect of thermal cover on summer air temperatures has been graphically demonstrated by Edgerton and McConnell (1976) for mixed conifer stands in the Blue Mountains (fig. 61). Closed canopy stands were warmer at midnight and cooler at midday than open areas or stands with open canopies.

By using thermal cover, deer and elk can reduce their radiational heat loss at night when ambient temperatures are apt to be less than body temperature. Thermal cover reduces insolation to the body during midday when air temperature in the open is likely to exceed body temperature.

Several characteristics associated with the structure of forest stands should be taken into account. During the day, the forest canopy creates an umbrella effect that prevents incoming radiation from adding heat energy to the airmass under the canopy during the day. At night it helps reduce the animal's radiational heat loss to the open sky. Tree trunks and low ground vegetation reduce air movement which protects the animal from the chill factor associated with low temperature and increasing windspeed (Moen 1973, Ozoga and Gysel 1972). This is particularly important for thermal cover on spring-fall and winter ranges.

On most summer ranges, there is relatively little low ground vegetation under thermal cover. At midday during hot summer months, air movement in such stands may be an important factor that helps keep the animal cool. This air movement at ground level under dense-canopied stands, with little understory impediment to such movement, was called "secondary wind maxima" by Shaw (1977, p. 520) who explained the phenomenon.



Timbered stringers along travel lanes provide hiding cover and sometimes thermal cover for deer and elk.

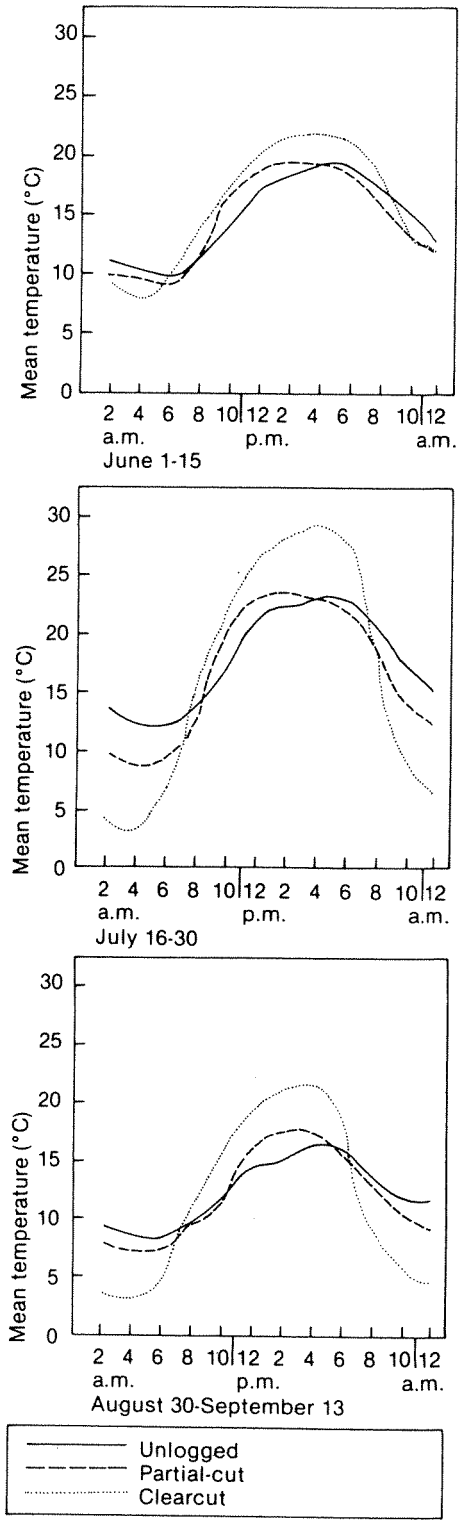
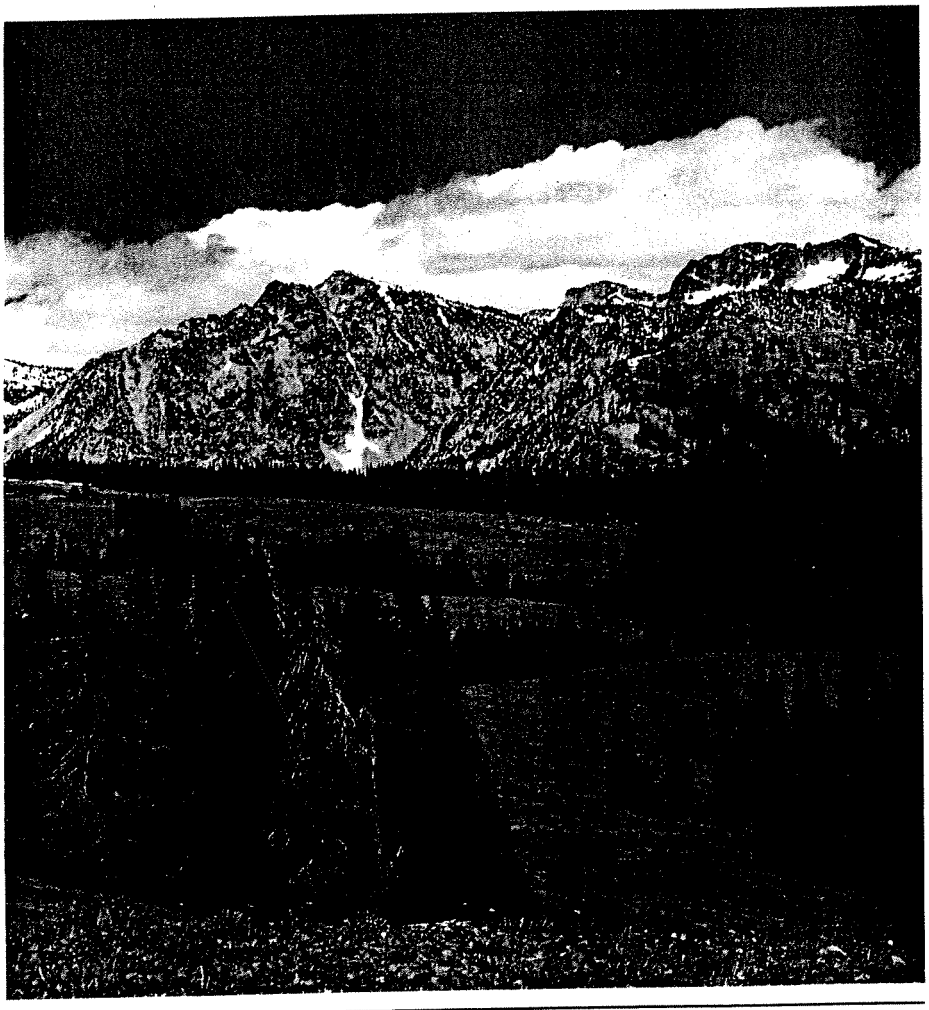


Figure 61. Ambient air temperature profiles for unlogged, partial-cut, and clearcut mixed conifer forests in northeastern Oregon (adapted from Edgerton and McConnell 1976).



Thermal cover for deer on summer and spring-fall range in the Blue Mountains.

Thermal Cover for Elk

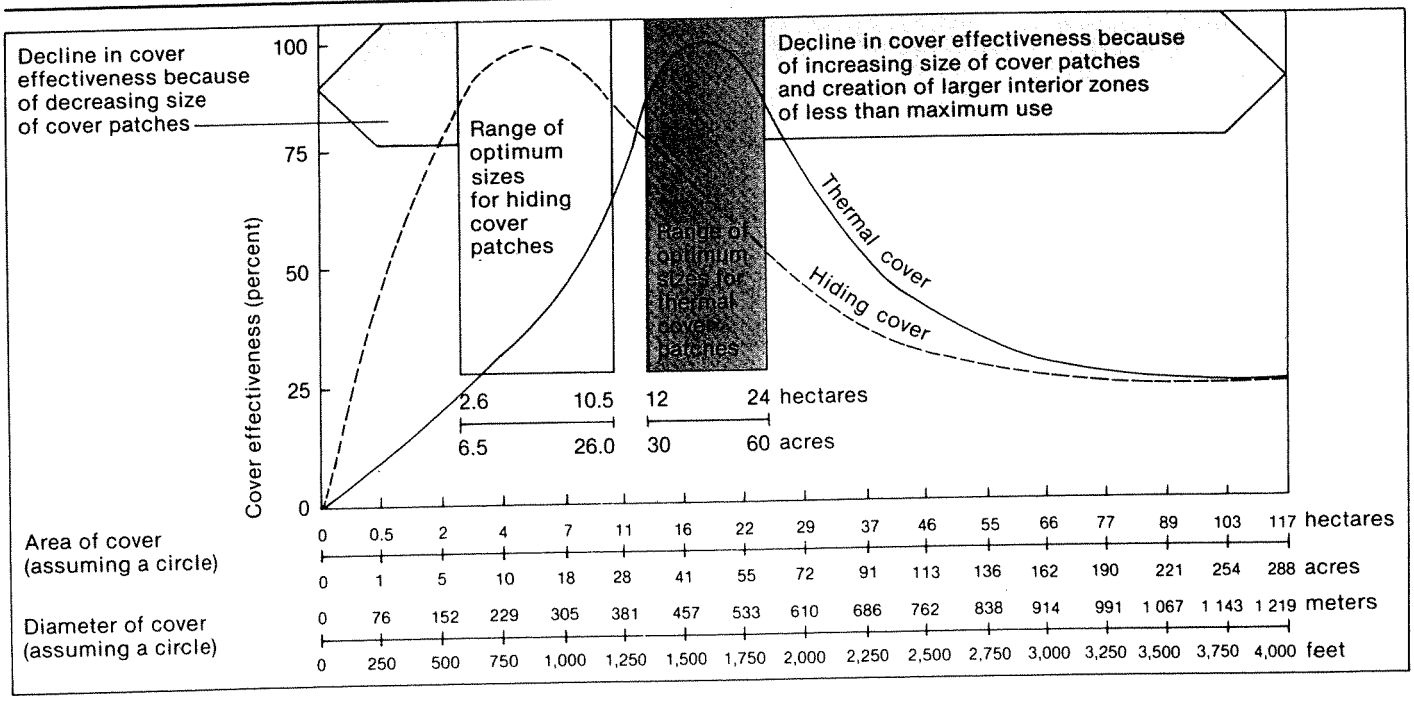
In the Blue Mountains, thermal cover for elk on summer range is defined as any stand of coniferous trees 12 meters (40 ft) or more tall, with an average canopy closure exceeding 70 percent. This definition is based on 7 years of observations of radio-collared elk (Pedersen, unpublished, see "References Cited").

The optimum size of stands for elk thermal cover (fig. 62) on summer and spring-fall ranges is estimated to be 12 to 24 hectares (30 to 60 acres). Stands that are larger or smaller will be effective to varying degrees but will probably not be used to their full potential. Areas less than 12 hectares (30 acres) do not provide the necessary internal stand conditions to accommodate the herd behavior of elk. The interior of thermal cover areas larger than 24 hectares (60 acres) would probably be underutilized (Reynolds 1966a).

Thermal cover areas lose effectiveness faster as they get smaller than when they increase in size (fig. 62). Although it is obviously better for stands to be too large than too small, any kind of overstory provides some thermal cover.

The cover requirements of deer and elk on winter range must be considered more carefully than for summer range. Animals distributed over thousands of square kilometers at high elevation in spring, summer, and fall are forced by increasing snow depths to travel downslope as

Figure 62. Effectiveness of various sizes of hiding and thermal cover areas on summer and spring-fall ranges in the Blue Mountains. The range of optimum sizes for patches of hiding cover are derived from figure 60.



winter sets in. They move down through spring-fall ranges and by midwinter are concentrated into smaller, more restricted areas at lower elevation. Consequently, the number of animals per unit area is much greater than on summer and spring-fall ranges.

But any cover is better than no cover. Deer and elk on many winter ranges in the Blue Mountains use thermal cover below the 70-percent canopy closure level (fig. 63). For example, where ponderosa pine stands are used for thermal cover, it is especially rare to find canopy closures approaching 70 percent. Logging may also reduce closure below 70 percent. In either case, thermal cover drops below the optimum level. Further reductions would force the animals to expend more energy to maintain homoiothermy and should be viewed as detrimental (fig. 62).

In the Blue Mountains, multistoried stands are generally considered better for thermal cover than single-storied stands because they are ecologically more stable. Multistoried stands are often composed of several tree species of various ages which provide some protection against catastrophic loss, such as insect outbreaks or fire. If only single-storied stands are considered, dense stands with low canopies are better than widely spaced stands with high canopies (fig. 64).

Most of the winter ranges in the Blue Mountains are at lower elevations where forested areas are interwoven with openings. In such cases forest cover may be less than optimum, and existing cover is frequently the key to determining how animals will use the areas.

Winter ranges are more sensitive to land management decisions than are summer and spring-fall ranges because of their scarcity and higher intensity of use. This chapter gives criteria for management considerations on summer and spring-fall ranges in the Blue Mountains. It is inappropriate to do the same for winter ranges because the consequences of error could be greatly magnified. Each winter range is different in its vegetative mosaic and the way it is used by the animals. The manager should study winter ranges carefully before deciding if and how to alter cover—particularly thermal cover.

Thermal Cover for Deer

Small evergreen trees and shrubs are used by deer for thermal cover on winter range. On summer and spring-fall ranges deciduous trees and shrubs are used (Loveless 1964). The thermal cover requirements of deer on summer and spring-fall ranges include saplings or shrubs, either evergreen or deciduous, at least 1.5 meters (5 ft) tall, with 75 percent or more crown closure. These requirements may also be met if the forest stand is of at least pole size or larger and has a crown closure of 60 percent or more. The thermal cover requirements of deer on winter range are the same as those on summer and spring-fall range, except that all thermal cover must be evergreen and developed at least to the pole-sapling stage.

The optimum size of deer thermal cover areas is estimated to be 0.8 to 2 hectares (2 to 5 acres) with a minimum width of 91.5 meters (300 ft). Deer can use smaller cover patches than elk because their social groups are generally smaller. If optimum thermal cover for elk is provided, the requirements for deer will be more than adequately met (fig. 62).

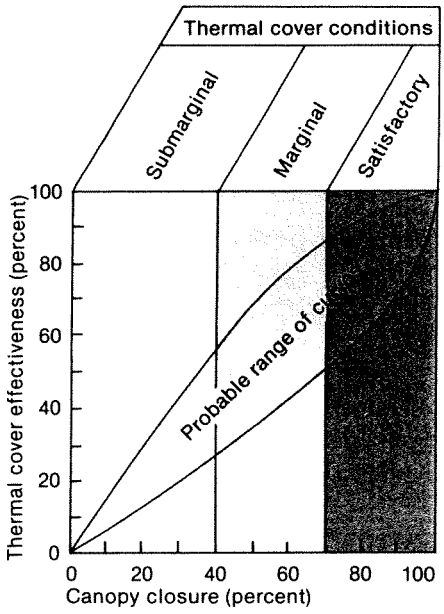


Figure 63. Relationship of canopy closure to effectiveness of thermal cover for deer and elk.

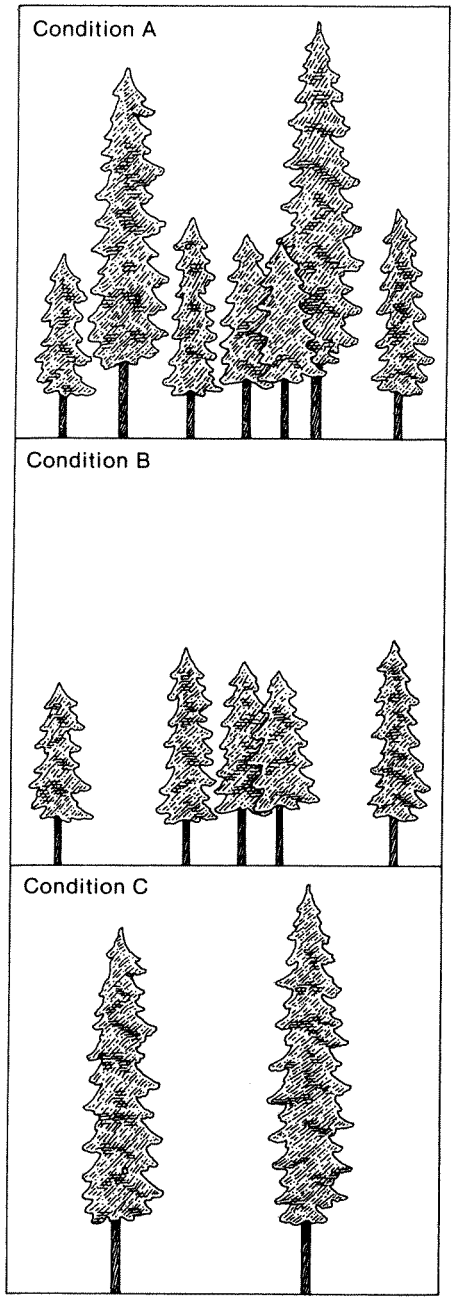
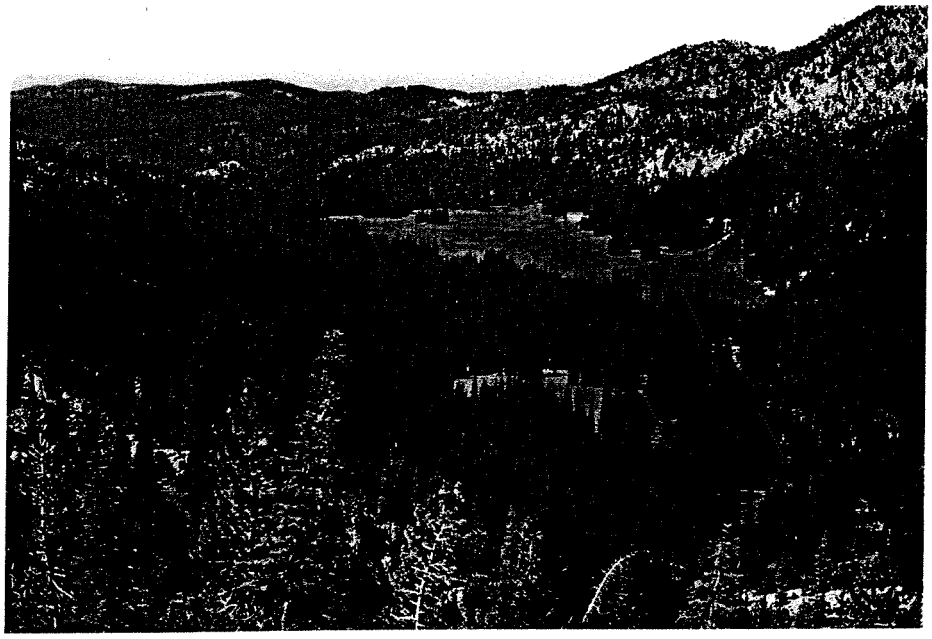
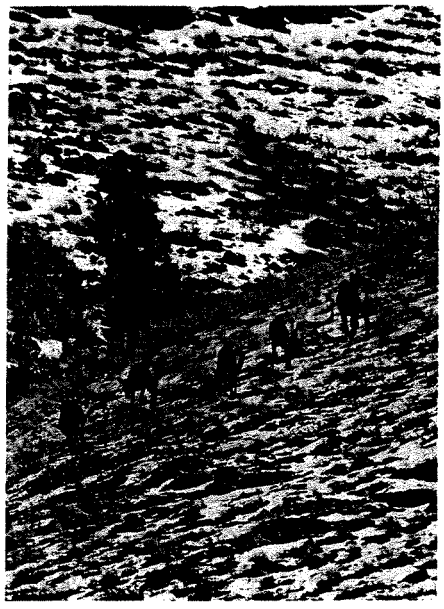


Figure 64. Stand structure is important where thermal cover is critical on winter range. For example, condition A is preferable to B and C, and B is preferable to C.





Forage areas for elk. Above: summer range. Below: winter range.

Forage Areas

Forage for both deer and elk is produced to some degree in all forest environments. Cover areas also produce forage, but in lesser quantity and often of lower quality. Optimum forage areas are basically different from optimum cover areas. Note in figure 65 that the yield of grasses, forbs, and shrubs is directly related to the percent of canopy closure in a pine forest (McConnell and Smith 1965, 1970; Skovlin et al. 1976; Irwin 1976).

Forage areas include all natural and manmade openings and forest stands that do not qualify as either hiding or thermal cover. In the Blue Mountains natural openings may result from shallow soils or sites that are either too dry or too wet for growing trees.

Deer and elk have been reported to use manmade openings in the forest more than natural openings (Reynolds 1966a). Work by Hershey and Leege (1976) in Idaho indicated that clearcuts were not more heavily used by elk than would be expected from the percent of the area clearcut. In Montana, Marcum (1976) recorded that elk actually avoided clearcuts. In Wyoming, Davis (1977) found significant use of clearcuts by deer and elk but more use in natural openings and burned areas. Information from the Blue Mountains indicates that elk readily use clearcuts, especially in late summer and early fall (Pedersen, unpublished, see "References Cited").

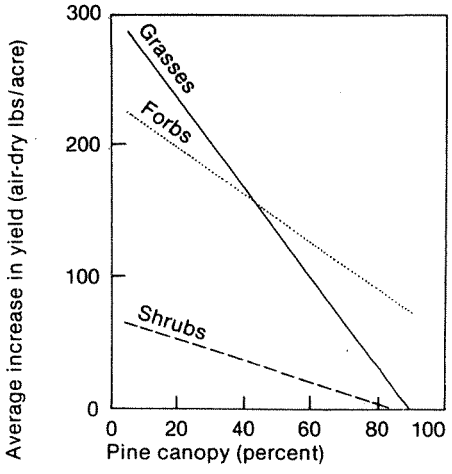


Figure 65. Relationship between percent of canopy closure and amount of grass, forb, and shrub vegetation in a ponderosa pine stand in eastern Washington (McConnell and Smith 1970).

For maximum use by deer and elk, forage areas should have no point farther than 183 meters (600 ft) from the edge of cover (fig. 66); use becomes insignificant beyond that point (fig. 67) (Reynolds 1962, 1966a; Harper 1969; Kirsch 1962; Hershey and Leege 1976). This allows circular forage areas of up to 366 meters (1,200 ft) wide, or 10.5 hectares (26 acres), to qualify as an optimum habitat arrangement (fig. 67). For summer ranges in Montana, Lyon (1976) suggested that openings of from 4 to 16 hectares (10 to 40 acres) would be acceptable to elk if slash were adequately cleaned up after logging.

Responses to Altered Cover-Forage Area Ratios

Forest land managers in the Blue Mountains needed a relatively simple system to help predict the response of deer and elk to forest management practices. The predictive mechanism selected was the changing cover-forage area ratios produced by timber management activities and the potential response of deer and elk to such changes.

Deer and elk are quite mobile and, unfortunately, no one has been able to develop detailed information on their response to changing cover-forage area ratios. In the absence of such data, information was generated by soliciting estimates from 15 wildlife biologists knowledgeable about deer and elk habitat requirements in the Blue Mountains. This approach was a modification of the "Delphi Technique" (Helmer-Hirschberg and Rescher 1960, Gordon and Helmer-Hirschberg 1964). Estimates were based on: (1) information about the way deer and elk use habitat in relation to forest-opening edges, and (2) the definition of optimum habitat as the maximum proper use over the maximum possible area.

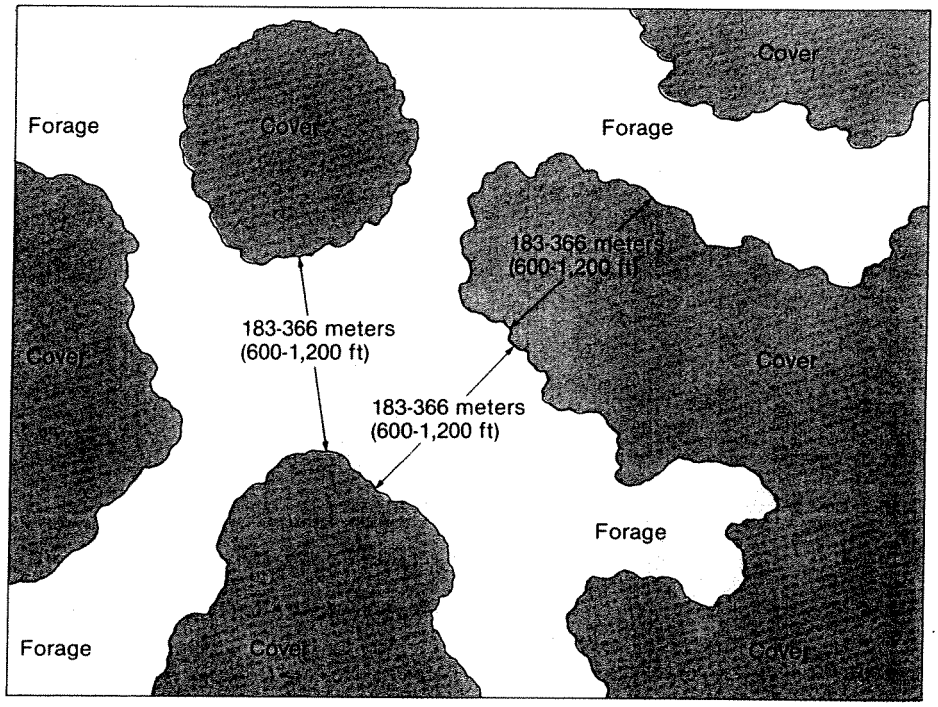


Figure 66. Cover patches properly spaced to obtain maximum possible use of the maximum area by deer and elk.

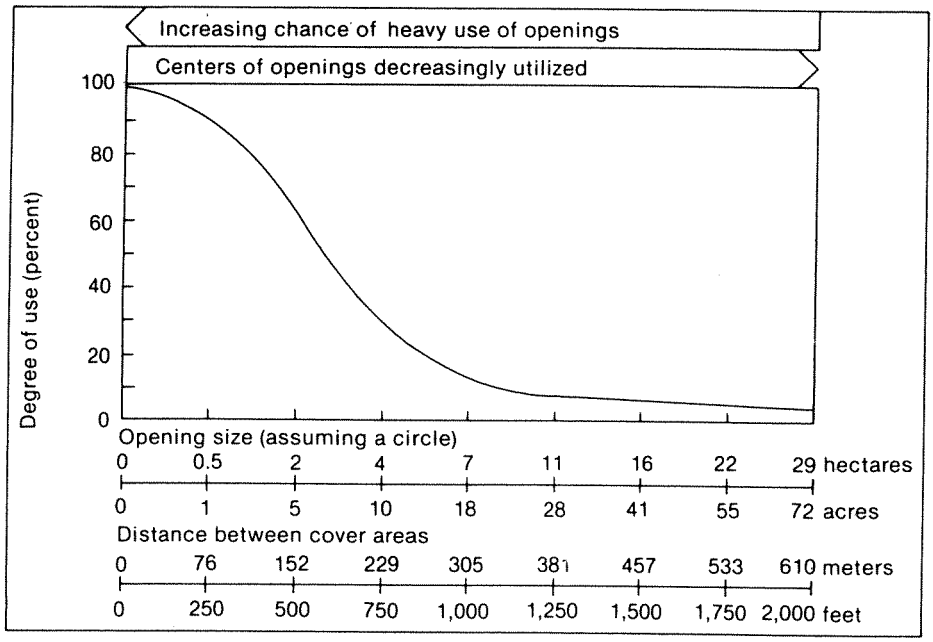


Figure 67. Relationship between the size of forage openings and use by deer and elk (based on data from Harper 1969 and Reynolds 1962, 1966a).

Land-type number	Land-type identification codes used by each National Forest[1]: Umatilla	Malheur	Wallowa-Whitman	Ochoco	1 Percent of land-type in forest sites (potential cover)	2 % of land-type in cover to achieve the optimum cover-forage area ratio[2]	3 % increase in potential use attainable by reducing cover to 40% of the land-type[2]	4 % of land-type in cover to produce potential use equal to that when all forest sites are in cover[2]	5 % of land-type in cover to produce potential use 33% less than that when all forest sites are in cover[2]	6 % of land-type in cover to produce potential use 66% less than that when all forest sites are in cover[2]	7	8 Remarks
5	3c				35	35	NA	35	28	21		Hiding cover of primary importance
12	5a,17a			1	75	40	0	40	30	15		
15	6a,15a, 18a		G5	1	90	40	300	18	14	9		

See footnotes at end of appendix 26.

Table 30. Elk use related to cover-forage area ratios on selected land-types on National Forests in the Blue Mountains (source: appendix 26)

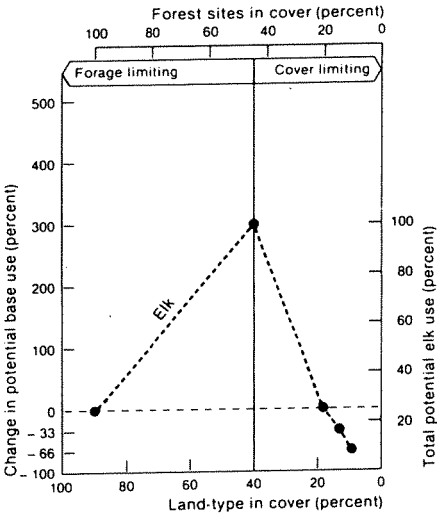


Figure 68. Relationship of elk use in land-type 15 to changes in cover-forage area ratios. In this case, cover in the land-type is above 40 percent and there is potential for increased use. Creation of openings increases use until cover becomes limiting. After that, use declines rapidly with further cutting (source: appendix 28). The points plotted are from table 30.

The biologists were given standard aerial photographs and colored aerial obliques of the land-types and asked to judge deer and elk response to various cover-forage area ratios. The data for table 30 and appendices 26 and 27 were derived in this manner. The same information is displayed in graphic form in appendix 28.

In the process of deriving these data, the biologists assumed the following: (1) a ratio of 40 percent of the land in cover to 60 percent in forage areas produces optimum habitat, (2) all forest sites are potential cover, (3) water is not a limiting factor, (4) cover and forage areas approximate optimum size, and (5) arrangement of cover and forage areas is nearly optimum.

Because the amount of each land-type in potential cover (forest sites) is different, each land-type has a different range of potential cover-forage area ratios. The graphs in figures 68, 69, and 70 indicate opportunities for elk to respond to changes in cover-forage area ratios. Similar "opportunity curves" are provided in appendix 28 for deer and elk on all the land-types. The points plotted on those graphs were derived from appendices 26 and 27.

When changes occur in cover-forage area ratios by land-type, elk may demonstrate three kinds of response. If cover is above 40 percent, there is potential for increased use (fig. 68) or there may be no potential for increased use (fig. 69). If cover is below 40 percent, there is no potential for increased use (fig. 70).

Cover Over 40 Percent – Potential for Increased Use

The first response occurs where forest sites exceed the optimum 40 percent of the land-type and reductions in cover will increase potential for elk use until cover becomes limiting. Consider the information for elk use of land-type 15 (table 30). Column 2 shows that 90 percent of the total area in land-type 15 is in forest sites or potential cover. Column 3 indicates that 40 percent of the land-type should be retained in cover to achieve an optimum cover-forage area ratio for elk. Column 4 indicates that a 300-percent increase in potential elk use, over that which exists when all forest sites are in cover (base use), would result from reducing cover from 90 percent to 40 percent of the land-type. Column 5 shows that cover could be reduced to 18 percent and still have the same potential for elk use as when all forest sites are in cover (as in column 2). Column 6 indicates that retaining 14 percent of the land-type in cover would produce a reduction in elk use equal to 33 percent of base use. Column 7 shows the same relationship as that in column 6, but for a 66-percent reduction. Use rates below the 66-percent reduction level indicate only incidental or intermittent use of the land-type.

Figure 68 (constructed from the data points in table 30) shows the potential response of elk to alteration in cover-forage area ratios. Predicted changes in potential elk use have been considered as a percent change in the anticipated base use. This is the scale on the left side of figure 68. The base use potential is the use expected when all potential cover sites meet the definition of cover.

It is probably more useful for managers to consider these changes in terms of changes within the total range of potential elk use. This can be determined from the scale on the right side of figure 68 which shows the percent change in total potential elk use. This scale can be used to evaluate the impact of various management alternatives.

As an example, consider that planning is underway for an area composed of land-type 15. Previous activity has reduced the total area of the land-type in cover to 80 percent. Locate 80 percent on the bottom scale in figure 68 and find that point on the response curve. Then draw a line from this point across to the right-hand scale. This is approximately 39 percent of the total potential elk use. A management decision is being considered that will reduce the percent of the total area of the land-type in cover to 60 percent. Proper size and spacing of cover and forage areas will be maintained. Locate the point on the response curve that corresponds to 60 percent on the bottom scale and read across to the right-hand scale. This is approximately 70 percent of the total potential elk use. The management action contemplated should increase the potential elk use from 39 to 70 percent—an improvement of 31 percent.

Cover Over 40 Percent—No Potential for Increased Use

The second type of response is shown in figure 69. The percent of the land-type in forest sites exceeds the optimum 40 percent, but reducing cover to 40 percent does not cause either an increase or a decrease in potential elk use. In this case forage is not limiting. When cover drops below 40 percent, cover becomes limiting and use drops.

For example, consider the data for land-type 12 in table 30. Column 2 shows 75 percent of the land-type is in forest sites or potential cover. Column 3 indicates that 40 percent of the land-type must be retained in cover to achieve an optimum cover-forage area ratio for elk. Column 4 shows that no increase in use can be attained by reducing cover from 75 percent to 40 percent of the land-type; that is, forage is not limiting and the cover-forage area ratio is optimum anywhere in that range. Column 5 indicates that 40 percent of the land-type must be retained in cover to obtain use equal to that when all forest sites are in cover. Columns 6 and 7 show, respectively, that retention of 30 and 15 percent of the land-type in cover will reduce base use by 33 and 66 percent.

Again, the percent of the total potential elk use corresponding to any possible cover-forage area ratio may be determined from the scale on the right side of figure 69. The change in potential elk use caused by changes in cover-forage area ratios may be determined by taking the difference between the points on the response curve.

Cover Below 40 Percent—No Potential for Increased Use

The third response is shown in figure 70. In this case any removal of cover is expected to cause a decline in potential use. But silvicultural practices can take place in such areas without reducing long-term elk use provided they do not reduce the area meeting the definition of cover. Usually, this kind of response results from the amount of forest sites in the land-type where cover is below the optimum 40-percent level.

For example, consider the data for land-type 5 in table 30. Column 2 shows that 35 percent of the total area in the land-type is in forest sites and is, therefore, potential cover. Column 3 indicates that the entire 35 percent must remain in cover to get the highest potential elk use because potential cover is below the 40 percent required for optimum habitat. Additional cover cannot be removed without making the situation worse. As a result, column 4 is not applicable because cover is already below the optimum level. Column 5 shows the percent of the land-type that must be retained in cover to equal the potential elk use when all forest sites are in cover. In this case all 35 percent must be retained. Columns 6 and 7 show, respectively, that 28 and 21 percent of the land-type must be retained in cover to produce reductions in base use levels of 33 and 66 percent of the potential base use.

The percent of total potential elk use that corresponds to any possible cover-forage area ratio may be determined from the scale on the right side of figure 70 as in the previous examples. Again, the change in potential elk use may be determined by taking the difference between the points on the response curve.

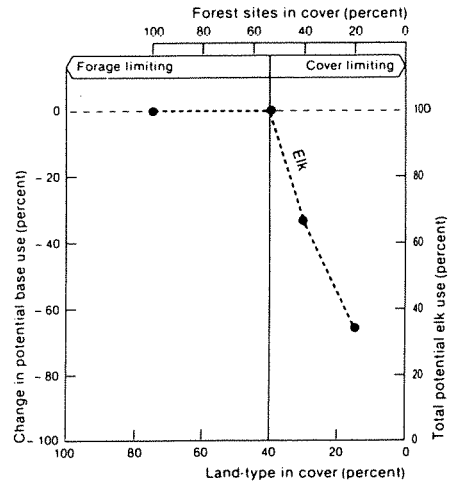


Figure 69. Relationship of elk use in land-type 12 to changes in cover-forage area ratios. In this case cover in the land-type is above 40 percent but there is no potential for increased elk use. Reduction in cover to 40 percent causes no change in use but reduction below 40 percent causes a rapid decline in use (source: appendix 28). The points plotted are from table 30.

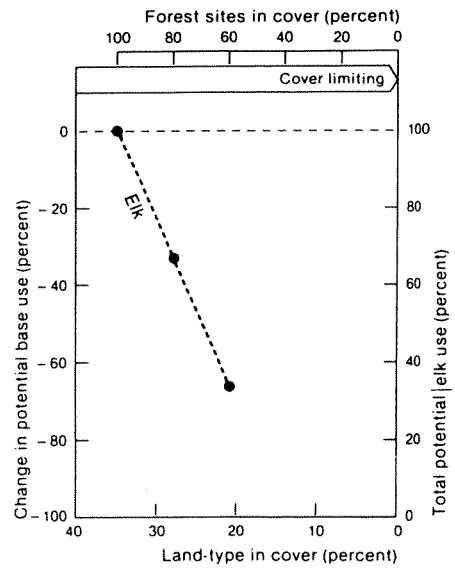


Figure 70. Relationship of elk use in land-type 5 to changes in cover-forage area ratios. In this case, cover in the land-type is below 40 percent and there is no potential for increased elk use. Further reductions in cover cause a rapid decline in potential use (source: appendix 28). The points plotted are from table 30.

Optimum calving habitat for elk (above) contains forage areas, hiding cover, and thermal cover.

Fawns have the best chance for survival when born in good fawning habitat.

Calving and Fawning Areas

Optimum calving habitat for elk contains forage areas, hiding cover, and thermal cover within forest stands. Hiding cover usually contains shrubs or downed logs that provide security for the newborn calves. Calving habitat is usually located on spring-fall range where slopes are gentle—usually less than 15 percent. Such slopes permit the cow to move about easily immediately before and after giving birth. Calving areas are often located on a bench in generally steep topography. In such habitat, succulent forage is available for the lactating cows, and water is usually found within 305 meters (1,000 ft).

Of course, not all areas with these characteristics are active calving grounds. Potential calving areas should be examined in late June for evidence of use. The value of calving areas is not yet fully known and it is not now possible to determine how habitat alterations of these areas will affect elk populations. This information is from descriptions of elk calving areas in Montana (Johnson 1951, Rush 1932) and Idaho (Roberts 1974, Davis 1970, Phillips (unpublished, 1966, see "References Cited"), Rust 1946, Young and Robinette 1939).

Optimum fawning habitat for deer includes low shrubs or small trees from 0.6 to 1.8 meters (2 to 6 ft) tall under a tree overstory of approximately 50-percent crown closure. These areas serve as "headquarters" for does and fawns during the critical period of parturition and the early weeks of life for the newborn. Fawning habitats tend to be relatively small and contain sufficient succulent forage to enable the does to produce milk (Einarsen 1956). The areas are usually located on slopes of less than 15 percent, where vegetation is succulent and plentiful in June, and where potable water is available within 183 meters (600 ft). The estimated optimum size of a deer fawning area is 0.4 to 2 hectares (1 to 5 acres). Areas that have these characteristics should be examined to determine if they are being used for fawning.

Optimum Mix of Types of Cover

On summer and spring-fall ranges the optimum mix of types of cover for elk is approximately 20-percent hiding cover, 10-percent thermal cover, 10-percent hiding or thermal cover, and 60-percent forage areas (fig. 71). Areas that qualify as either hiding or thermal cover should be counted in the more limited type. For example, if 5 percent is hiding cover, 20 percent thermal cover, and 10 percent either hiding or thermal cover, then the 10 percent should be classed as hiding cover because it is the more limited type. On winter ranges, however, the discretionary balance should always be assigned to thermal cover.

The amount of cover and forage areas for deer on summer and spring-fall ranges should be approximately 20-percent hiding cover; 10-percent thermal cover; 5-percent fawning cover; 5-percent hiding, thermal, or fawning cover; and 60-percent forage areas (fig. 72).

On ranges that are not used for fawning, the 5 percent in fawning cover may be added to either hiding or thermal cover. In such cases, optimum cover would be composed of 20- to 30-percent hiding cover and 10- to 20-percent thermal cover. On winter ranges the discretionary balance should be allocated to thermal cover. If the requirements of elk are met, deer will be adequately cared for if they occupy the same range. These distributions of cover types are not nearly as restrictive as they appear since many areas will qualify as both hiding and thermal cover.

Habitat for deer and elk should contain an optimum mix of thermal and hiding cover and forage areas.

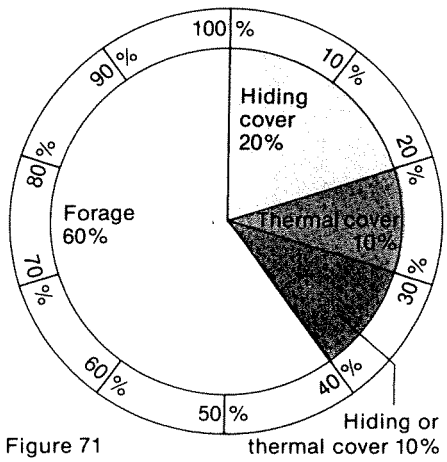


Figure 71

Figure 71. Optimum mix of cover and forage areas for elk.

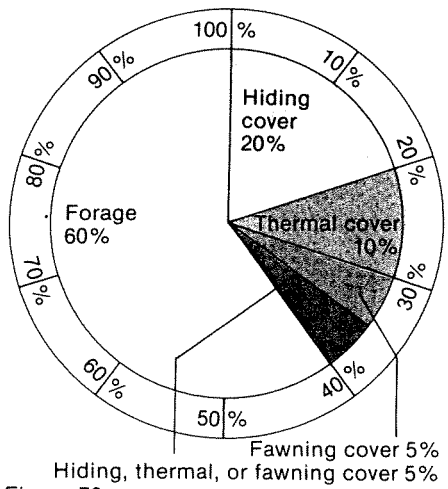


Figure 72

Figure 72. Optimum mix of cover and forage areas for deer.

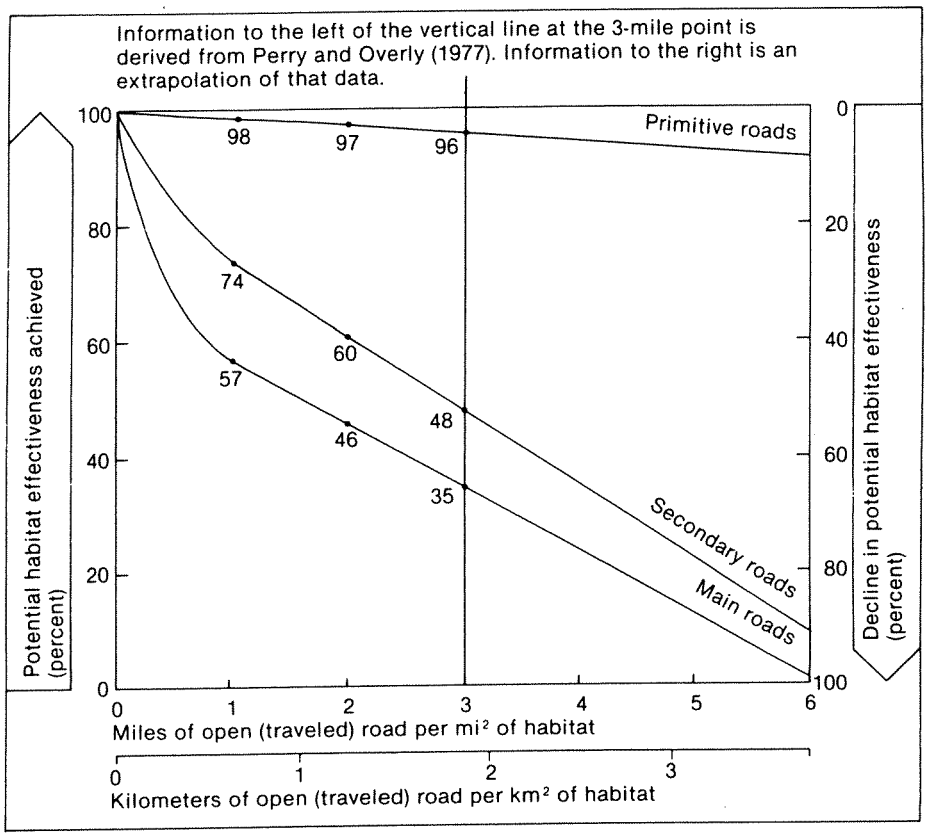
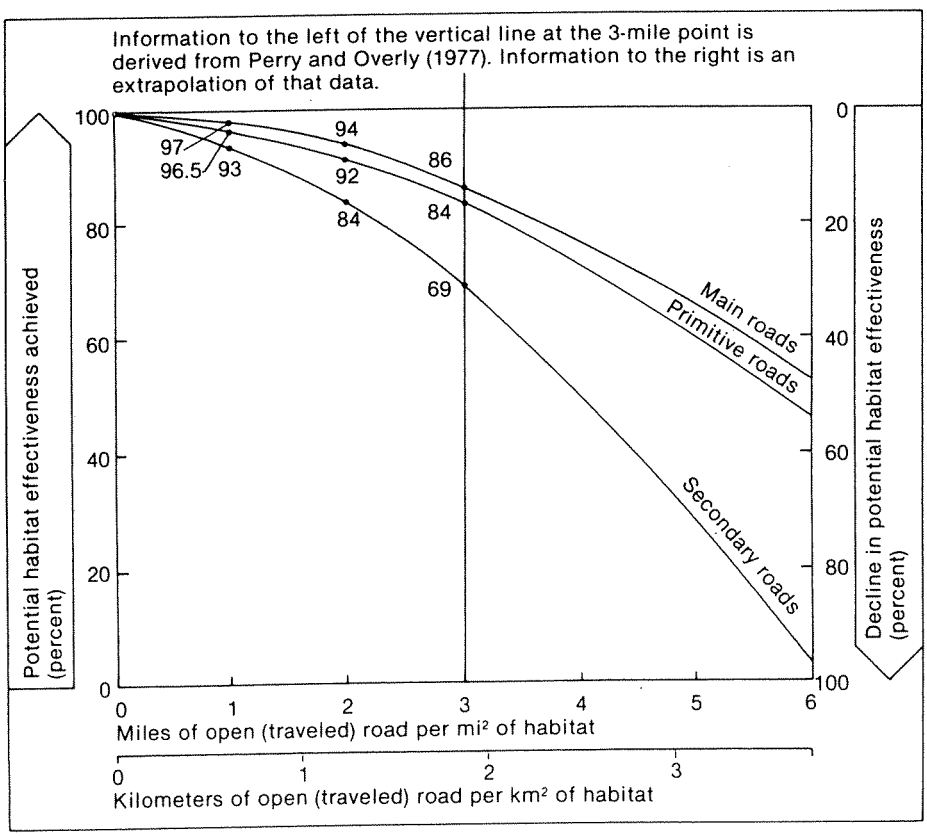


Figure 73. Impact of traveled roads on the potential effectiveness of summer elk habitat (adapted from Perry and Overly 1977).



Roads and Habitat Effectiveness

The effectiveness of deer and elk habitat in obtaining optimum use of the maximum area is adversely influenced by the presence of roads that are open to vehicular traffic (Leege 1976, Thiessen 1976, Perry and Overly 1977). This effect is markedly influenced by the type of road, its location, and degree of use (Perry and Overly 1977). Researchers have reported decreased use of areas adjacent to roads for distances ranging from 0.4 to 0.8 kilometer (0.25 to 0.50 mi) (Perry and Overly 1977, Ward 1976).

Data presented by Perry and Overly (1977, p. 14b) for the northern Blue Mountains were used to develop an estimate of the effectiveness of deer and elk habitat associated with varying densities of roads of three types (figs. 73 and 74). They classified roads into three groups (p. 7):

> 1) Main roads-one and one-half lanes wide or more, improved, good condition, main route of travel, constant maintenance; 2) Secondary roads-one and one-half lanes, somewhat improved, good to fair condition, irregular maintenance; and 3) Primitive roads-one lane, unimproved, fair to poor condition, seldom or never maintained. Main roads were gravel with an oil base; both secondary and primitive [roads] were either gravel and/or dirt. Traffic volume was highest on main roads and became less with decreasing road quality.

Figure 74. Impact of traveled roads on the potential effectiveness of summer deer habitat (adapted from Perry and Overly 1977).

The elk habitat values displayed in figures 68, 69, and 70 and appendix 28 should be modified by the factors that can be derived from figure 73. When impacts of various types of roads on habitat effectiveness are considered, the values derived from figure 73 are considered additive. For example, an area of habitat has 0.62 kilometer of open (traveled) main road per square kilometer of habitat (the same road density as 1 mile of road per square mile). This causes an approximate decline of 43 percent in habitat effectiveness. There is 0.62 kilometer of open secondary road per square kilometer (the same road density as 1 mile of road per square mile of habitat). This causes an approximate 26-percent decline in habitat effectiveness. There are no open primitive roads. The result is a decrease in habitat effectiveness of approximately 69 percent (43% + 26% + 0% = 69%).

These relationships should be used only to evaluate the impact of open roads on summer range. The principle is similar for winter ranges, but these ranges are especially important and deer and elk use is quite specific for each range. Winter ranges should be evaluated individually and more carefully than summer ranges.

Similar information on the effect of roads on mule deer use of forested habitats is shown in figure 74. This display was also derived from Perry and Overly's (1977) data. The material can be used in the same manner as described earlier for elk in evaluating habitat conditions for mule deer.

Silvicultural Options

Each time the forest manager chooses a silvicultural option, a decision is made that directly concerns the welfare of deer and elk. Accomplishing two management goals is more difficult than dealing with one. The more options available to the decisionmaker, the better the chances of achieving several goals simultaneously—a decided advantage in a management situation where objectives and the "rules of the game" are subject to frequent change.

The biological needs of deer and elk can be met under a variety of timber stand rotation ages and intensities of management. But attention must be paid to how these animals respond to changes in cover-forage area ratios. This is discussed in chapter 9.

Figure 75 suggests a way to display the emphasis on deer and elk welfare in timber management. Note that the more closely activities are confined to the center of the zone of permitted operation, the closer the manager comes to maintaining the optimum 40-percent cover-forage area ratio. By setting constraints, the manager establishes a policy about the degree of emphasis on deer and elk production. The narrower the limits, the greater the emphasis. The wider the limits, the lower the emphasis.

So far, the premise has been that the cover-forage area ratio can be used to coordinate timber management with deer and elk management. But there are a number of other ways to enhance habitat or minimize adverse impacts on deer and elk. These are shown in figure 76. Some can be accomplished only at the expense of timber production. Others are essentially "free." The forest manager should remember that the extent to which they are followed will result in the eventual labeling of an area as either carefully managed or carelessly managed so far as deer and elk are concerned.

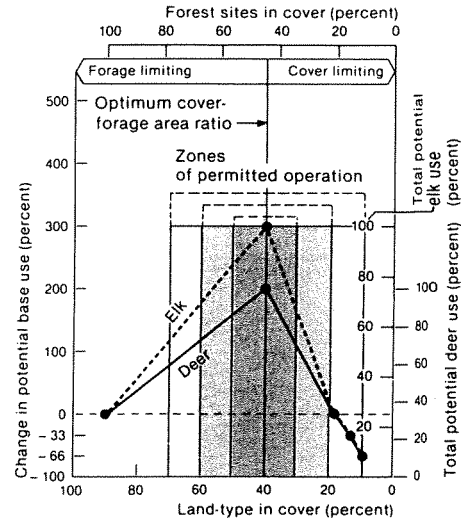


Figure 75. Emphasis on deer and elk management can be illustrated by defining acceptable limits on cover-forage area ratios. The narrower the zone of permitted operation, the greater the emphasis on deer and elk production. The wider the limits, the lower the emphasis. The yield curve for deer and elk in land-type 15 is used as an example (source: appendix 28).

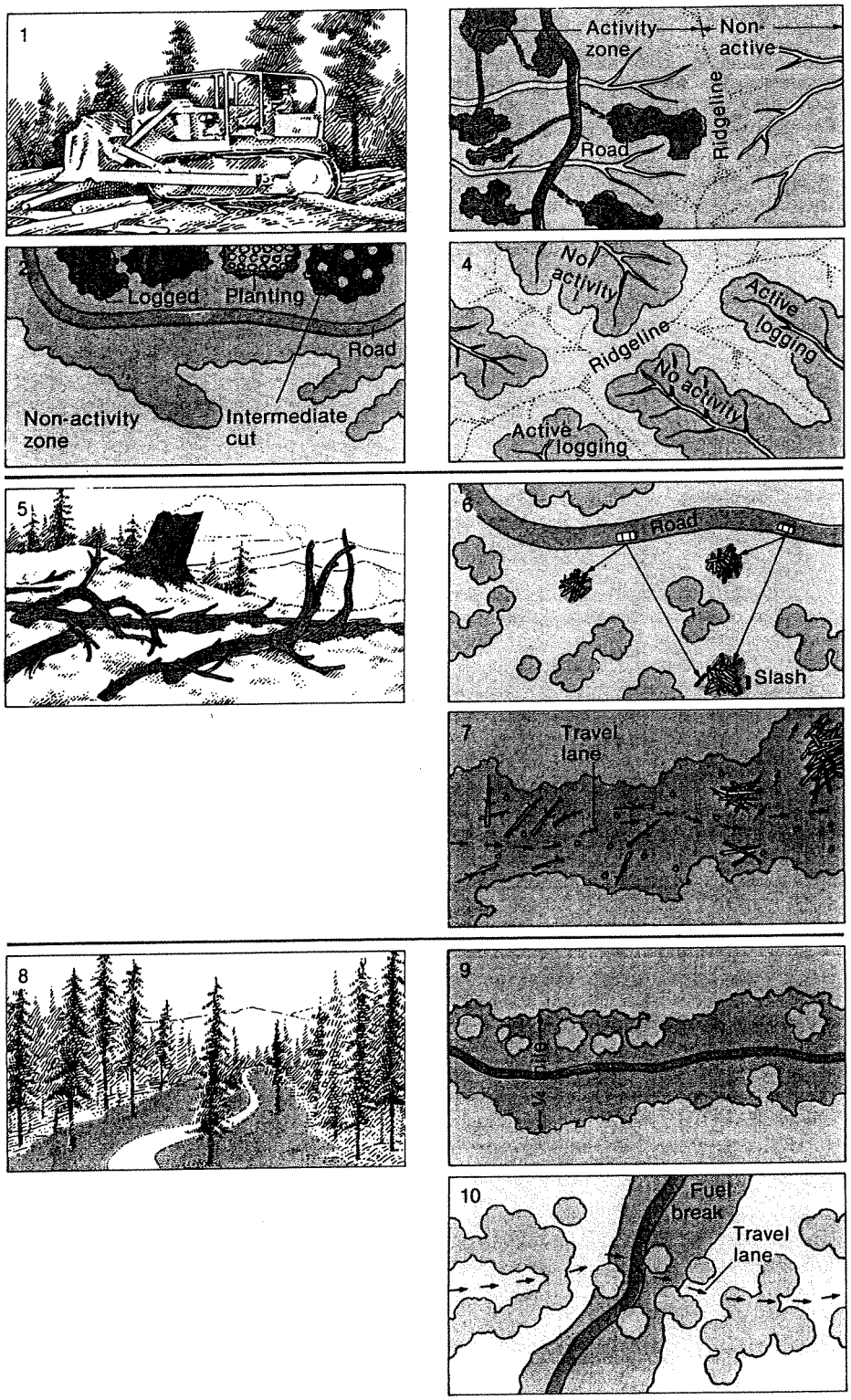


Figure 76. Ways to minimize the adverse impacts of timber management operations on habitat for deer and elk.

Timber Management Operations

1. Timber management operations are a dramatic source of disturbance to deer and elk, particularly elk.

2. Concentrate management activities within the smallest possible area and the shortest possible period of time (Hershey and Leege 1976, Ward 1976). The more severe the disturbance, the more important this becomes.

3. Maintain non-activity zones adjacent to zones of concentrated activity (Montana Cooperative Elk-Logging Study 1975).

4. Confine timber operations to a single drainage at a time. Do not log adjacent drainages simultaneously; disturbance seems to be reduced by ridgelines (Lyon 1975, Ward 1976).

Slash Treatment

5-6. Slash can be windrowed or piled to break long sight distances and provide cover in critical areas.

7. Logging slash or dead and down material can affect the way elk use an area (Wallmo 1969). Depths of more than 0.61 meter (2 ft) decrease use of both timber stands and clearcuts (Lyon 1975, 1976). Reduction of dead and down material to MM standards (USDA Forest Service 1968) will minimize the problem.

Shaded or Other Fuel Breaks

8. Fuel breaks in forest cover may be necessary as part of fire management operations. They are considered forage areas, as they do not meet the definition of cover.

9. Adverse impacts of shaded or other fuel breaks can be minimized by keeping sight distances to less than 0.4 kilometer (0.25 mi).

10. Careful attention should be paid to the place where travel lanes cross fuel breaks. Fuel breaks should be as narrow as possible and still meet fire control objectives.

Cover

The definition of optimum cover as 40 percent of the total area is based on an average need. More cover may be needed in critical areas. Winter ranges, for example, must be considered individually and only after determining how the animals use each area.

Careful long-range planning is essential to maintain the right cover-forage area ratios and to maintain the correct size, shape, and arrangement of cover and forage areas.

Cover is used most heavily when adjacent to wet areas such as meadows, streams, and springs (Montana Cooperative Elk-Logging Study 1975).

Cover is less used when adjacent to, or bisected by, traveled roads (Perry and Overly 1977, Ward 1976).

Travel Lanes

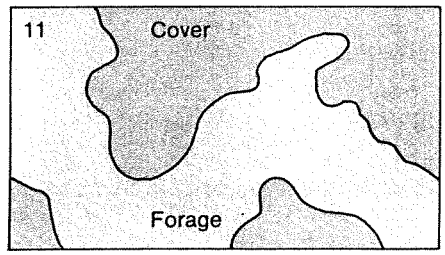
14. Travel lanes conceal deer and elk moving across areas that lack cover. Timbered "stringers" across otherwise open slopes are one example.

15. Cover within known travel routes should be maintained.

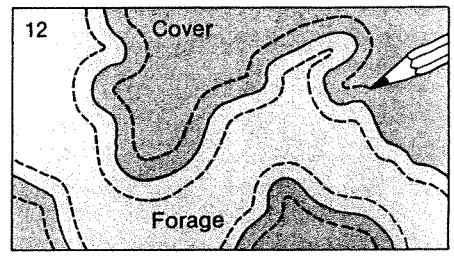
16-17. Prime locations for travel lanes are: (1) areas of least topographic resistance to deer and elk movement such as saddles and gaps, bands around ridges, and stream courses; (2) seeps, springs, and riparian zones; and (3) cover areas in locations that are generally deficient in cover.

18. The size, shape, and distribution of travel lanes should be considered. One primary need is for continuous or relatively continuous cover between timbered drainages. Non-continuous patches of cover separated by 91 meters (300 ft) or less often serve as travel lanes.

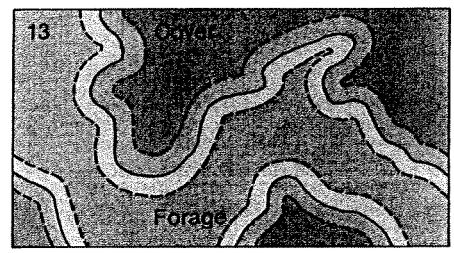
How to Determine Deviation from Optimum Cover-Forage Area Arrangement:



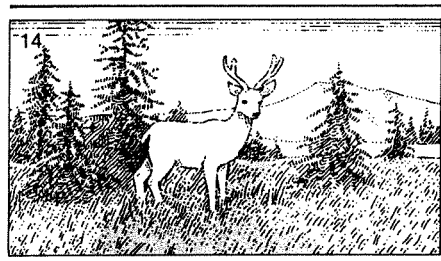
11. The situation—a mixture of forage and cover areas.

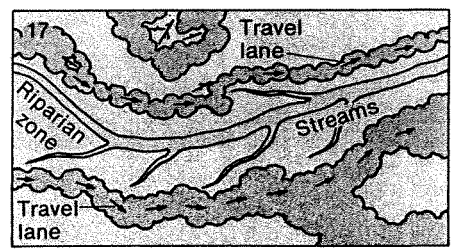


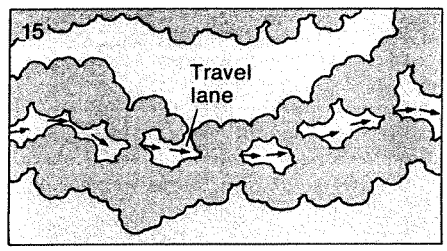
12. Delineate the zone of primary use by drawing dotted lines 183 meters (600 ft) on both sides of the cover edge.

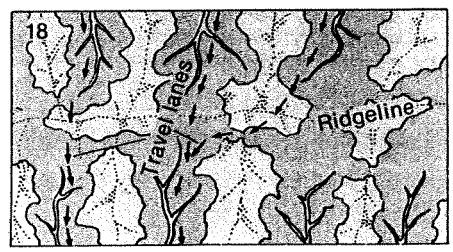


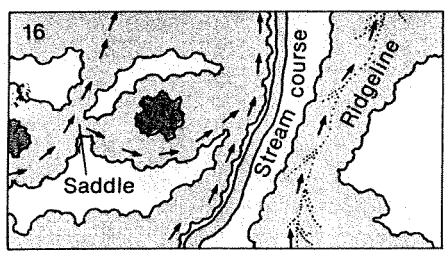
13. Shade all areas greater than 183 meters (600 ft) from the cover edge. These are cover and forage areas of less than maximum use; they may be enhanced by creating new cover in the forage areas and new forage in the cover areas.

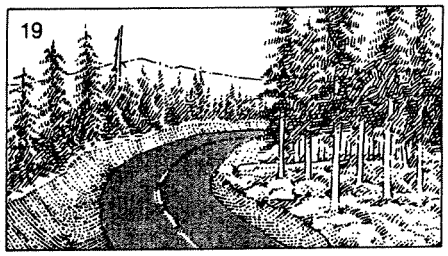


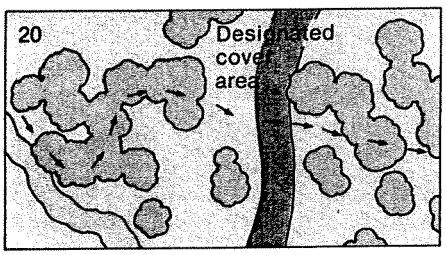


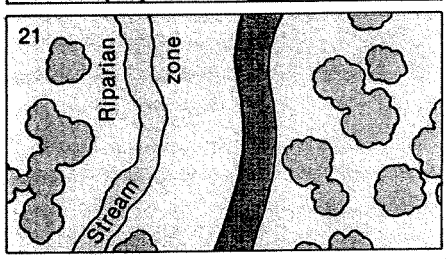


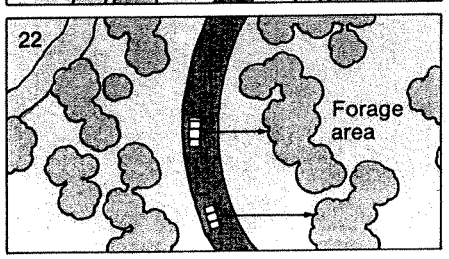


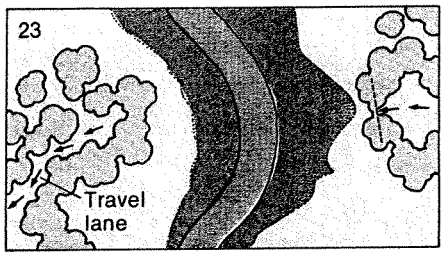


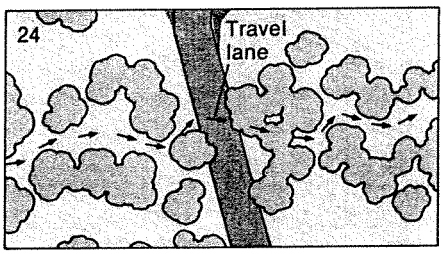


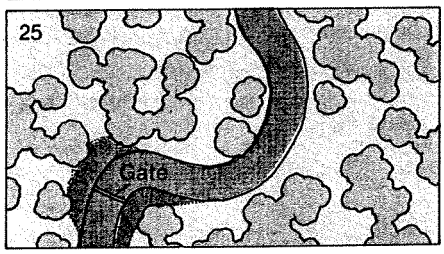


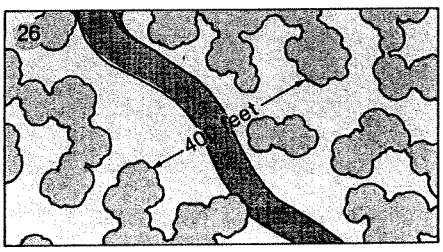


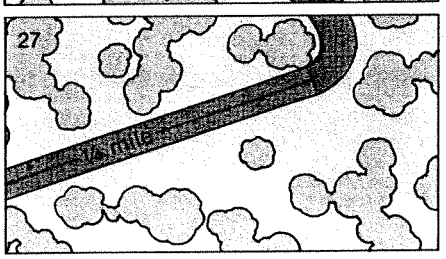












Roads

19-20. Roads reduce the effectiveness of areas for cover.

21. Riparian zones are the most heavily used habitat. Roads that traverse riparian zones reduce use of this important habitat by deer and elk.

22. Insure the usability of forage areas—meadows, clearcuts, and other openings—by screening them from main roads with vegetation or topography (Ward 1976).

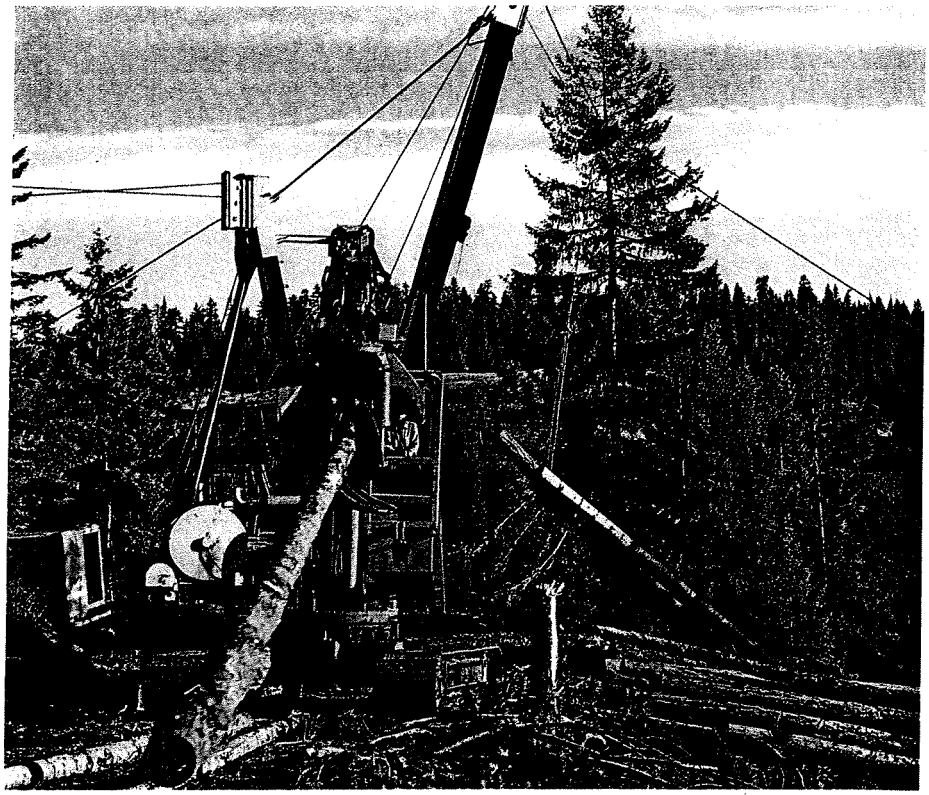
23. Cuts and fills near roads should not block travel routes for deer and elk.

24. Where roads cut across areas managed for deer and elk travel routes, a minimum right-of-way or crossing distance should be planned (Montana Cooperative Elk-Logging Study 1975).

25. Roads should be laid out to facilitate closure with gates. It may become necessary to close a road in order to protect elk and deer from harassment or insure quality hunting (Coggins 1976, Perry and Overly 1977).

26. Maintain roadside vegetation as hiding cover wherever possible (Ward 1976). Where silvicultural operations occur in such areas, care should be taken not to open the areas to more than two maximum sight distances (122 meters or 400 feet). This reduces disturbance to deer and elk and makes it more difficult to hunt them from roads.

27. Avoid locating straight stretches of road of more than 0.4 kilometer (0.25 mi) in forested sites. This will increase the cover value for deer and elk and reduce hunting from roads (Montana Cooperative Elk-Logging Study 1975). Roads should be held to a minimum in areas managed for deer and elk. As many roads as possible should be closed (Perry and Overly 1977, Thiessen 1976).

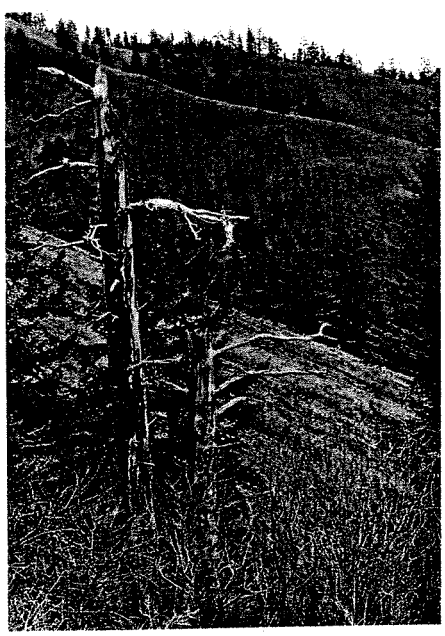


Timber management practices in the Blue Mountains alter forest ecosystems more than any of man's other activities.

Slash treatment can affect use of an area by deer and elk. If properly planned, slash piles can break long sight distances and provide hiding cover.

9
Silvicultural Options

by
Frederick C. Hall
Jack Ward Thomas



Pileated woodpeckers require large snags.

Long before the coming of man to the Blue Mountains, the forests were under a type of management—a natural regulation in which many types of forest conditions were created. Lightning fires periodically devastated portions of the forest. Insects attacked and killed trees or groups of trees. Disease took its toll, and storms created areas of blowdown. The result was a variety, or diversity, of conditions that covered the gamut of successional stages: areas recently cleared by wildfire, grass-forb and shrub-seedling successional stages, even-aged sapling and pole stands, mature trees, and some areas of old growth containing large, old-trees, standing dead trees, and dead and down trees on the forest floor.

Over the ages, wildlife species evolved and adapted to these various conditions. As a result, each type of stand structure provides for a particular set of species adapted to exploit the niches provided by the habitat for purposes of feeding and reproduction. Each habitat is ideally suited to meet the needs of these species.

To the forest manager, however, the natural conditions described are far from ideal. Some stands were established with intermediate stocking and eventually developed into mature, merchantable sawtimber. But some burned areas remained unstocked for many years. Other stands became minimally stocked. Still others were overstocked, and growth rates declined. Silvicultural manipulation is essential to optimize production of timber in such stands (Hawley and Smith 1954).

Silviculture is the science and art of cultivating forest crops, more particularly the theory and practice of controlling the establishment, composition, and growth of forests (Ford-Robertson 1971). It is the means by which different stand structures are created. Wildlife respond to the structure of a forest perhaps more than to any other single factor (Hooper and Crawford 1969). As a result, forest management activities have a significant impact on wildlife. The challenge is to meet both timber and wildlife management objectives.

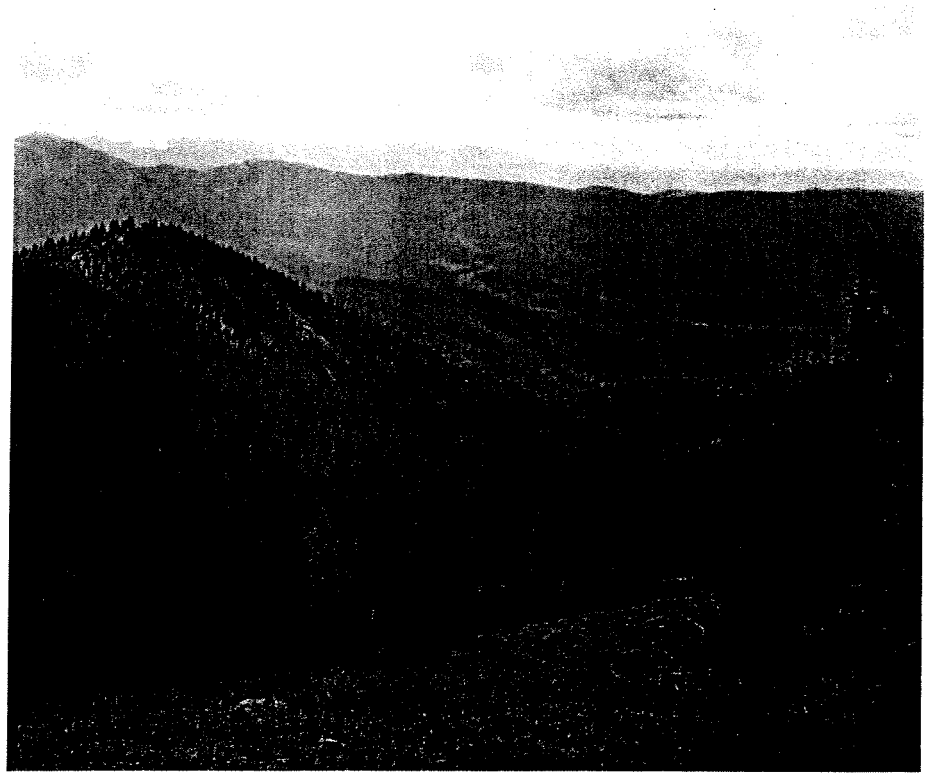
A forest manager can follow three options in formulating wildlife objectives for the managed forest: featured species management, management for species richness, or a combination of the two approaches. Regardless of the option selected, the forest vegetation must be manipulated in a manner that will provide the necessary habitat conditions. That would be complex enough. But the silviculturist must also manipulate the forest to maintain an acceptable and sustained flow of wood products to national and world markets.

The process of simultaneously achieving wildlife and wood production goals is based on manipulation of several variables: (1) scheduling of silvicultural treatments, (2) arrangements of stands in time and space, (3) stand condition, (4) size of treatment area, and (5) land-type.

Timing of silvicultural treatment allows flexibility in creating or maintaining a particular stand condition. Use of this variable has the potential to exact the highest costs in terms of wood production. Any silvicultural treatment to enhance wildlife habitat that either accelerates or delays harvest beyond culmination of mean annual increment will result in a loss of timber production.

The arrangement of stands in time and space can be accomplished by the timing of silvicultural treatments, particularly regeneration cuts. This arrangement is critical to assure appropriate juxtaposition of habitats for species that require two or more types. The degree of contrast of the edges where two stands join and the species richness of the associated ecotone can also be controlled by appropriate arrangement of stands.

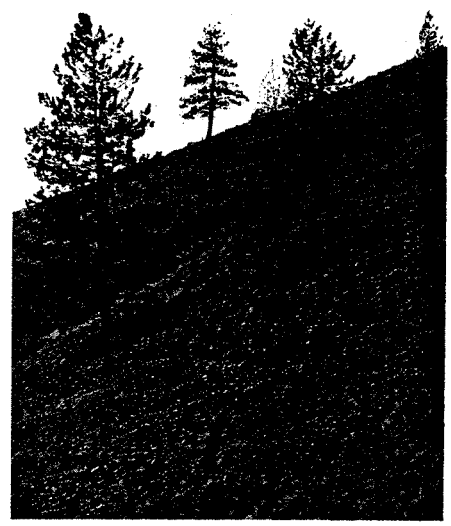
Stand condition describes the many attributes of the stand, including the presence of disease or insects, number of dead and dying trees, stand structure (one, two, or three canopy layers), stand size (average tree height and diameter), and species composition. Stand condition can be greatly influenced by the regeneration technique (natural or planted), treatment of shrubs and grasses, selection of tree species to be favored in thinning, extent or intensity of thinning, kind of thinning (from above, below, or both), and the silvicultural system employed (even-aged or uneven-aged).

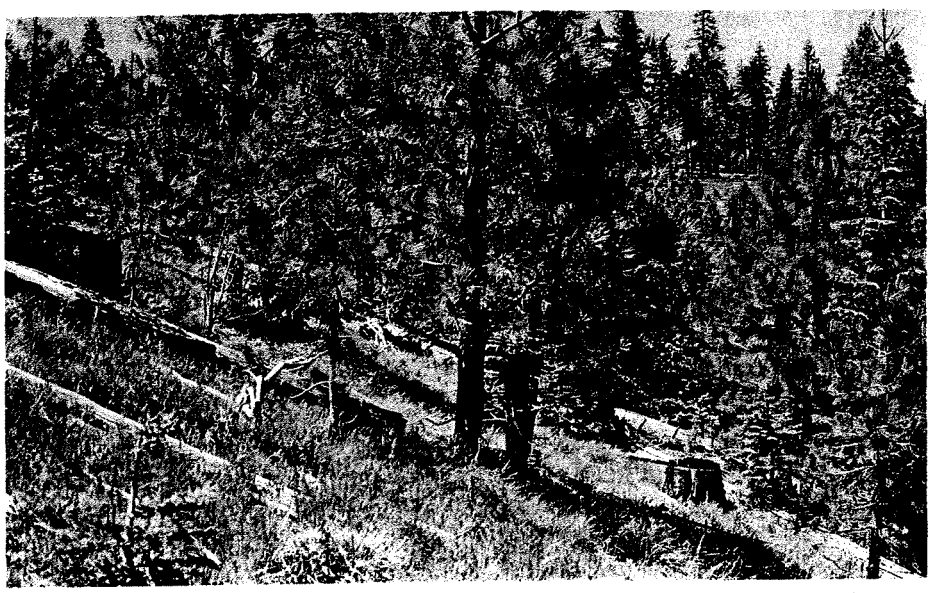


The size of the area to be silviculturally treated is subject to manipulation in the managed forest. This is usually controlled by the size of the regeneration unit. Consideration must also be given to the land-type. Land-types that are completely forested can be greatly enhanced in terms of wildlife diversity by silvicultural treatment. But wildlife diversity in areas that are only partially forested can be reduced by treatments such as regeneration cutting.

There are many possible combinations of timber and wildlife objectives and silvicultural options that can be used in managing forest communities in the Blue Mountains. It is impossible to develop a set of prescriptions that will fit every situation. The purpose of this chapter is to show how the silviculturist can meet timber and wildlife goals under two courses of wildlife management—featured species management and management for species richness.

Elk fare best where forage areas and suitable forested sites for hiding and thermal cover are properly arranged.





A clearcut planted with 200 trees per acre. Fifteen years later, the same clearcut provides both hiding cover and forage for deer and elk.

Treatment Scheduling

In this first example, the objective is to meet wood production goals in a mixed conifer forest in the Blue Mountains and at the same time emphasize the prime habitats for Rocky Mountain elk and pileated woodpeckers. These two species were selected because their habitat requirements are very different, thereby demonstrating that even widely varying objectives can be achieved by innovative and flexible application of silvicultural treatments. The following discussion shows how the silviculturist can use the primary manipulative factors (scheduling of silvicultural treatments, management of stands in time and space, production of desirable stand conditions, selection of appropriate treatment area size, and consideration of land-type) to provide habitat for two featured species and still maintain high timber production.

Optimum habitat for elk requires that 60 percent of the land area be in clearcuts or open forest where there is abundant forage and that 40 percent of the land area be in hiding and thermal cover (Black et al. 1976). Optimum habitat for pileated woodpeckers in a mixed conifer forest requires old-growth stands of two or more stories with total forest canopy exceeding 70 percent, large trees for nesting, and heart rotted snags (Bull 1975). Obviously, the optimum habitat for both elk and pileated woodpeckers cannot be met on every acre. But balanced habitat conditions can be provided over a large area to maintain viable populations of both elk and pileated woodpeckers and other species in the same life forms.

Optimum Habitat for Elk

On midelevation summer ranges in the Blue Mountains, the optimum habitat for elk is approximately 40 percent in cover (20 percent hiding cover, 10 percent thermal cover, 10 percent either hiding or thermal cover) and 60 percent in forage areas. Forage areas can be clearcuts, open timber stands, or natural openings. Patches of forage areas should be less than 366 meters (1,200 ft) wide to provide for the maximum use of the maximum area by elk (Black et al. 1976).

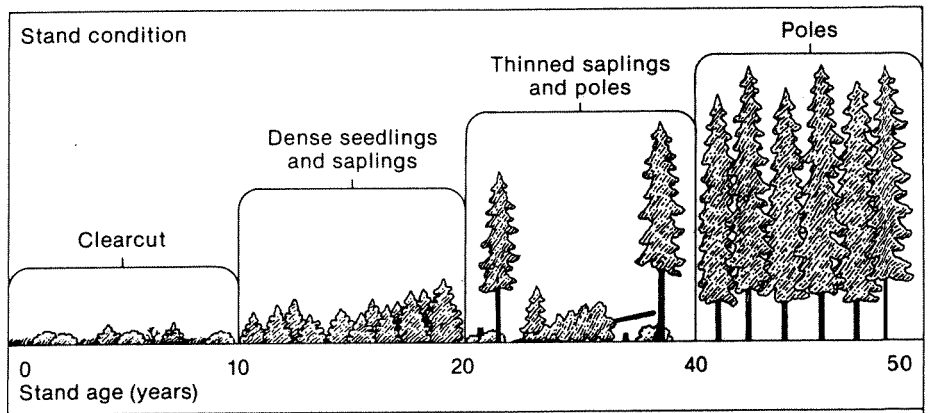
Requirements for elk hiding cover are met by stands dense enough to hide 90 percent of a standing adult elk from an observer at 61 meters (200 ft) or less. Understory shrubs, low branches, and very dense trees provide good hiding cover. Requirements for thermal cover are best met in stands where dominant trees are more than 12 meters (40 ft) high with a crown closure exceeding 70 percent (Black et al. 1976).

Featured Species Management

Scheduling of silvicultural treatment is the primary means by which elk habitat can be altered. The following examples show how to obtain an appropriate cover-forage area ratio and create optimum hiding and thermal cover for elk during a rotation of 50 years and a rotation of 140 years. These rotations are the shortest and longest rotations feasible for optimizing habitat. The silviculturalist can choose any rotation within these limits.

In the first stage of the rotation (fig. 77), clearcutting creates forage areas for elk. Abundant, highly nutritious browse plants grow in full sunlight—a distinct contrast to the former old-growth forest (Hedrick et al. 1968, Young et al. 1967). Optimum establishment of 1,236 trees per hectare (500/acre) will result in hiding cover about 10 years later, when trees are 2 to 3 meters (6 to 10 ft) tall. This cover condition will last until stand age 20 when half the trees should be removed in a precommercial thinning, leaving the most vigorous individuals to become crop trees. At this point, however, hiding cover is destroyed and a different kind of forage area is created (Hedrick et al. 1968, McConnell and Smith 1970, Young et al. 1967).

By age 40, a rapidly growing stand should be 12 meters (40 ft) tall with approximately 70 percent crown closure and should provide optimum thermal cover for elk. If the regeneration cut is made at age 50, the stand will provide thermal cover for 10 years. Thus, during the 50-year rotation, the stand has provided 30 years as a forage area, 10 years in hiding cover, and 10 years in thermal cover, or optimum elk habitat of 40-percent cover (20 percent hiding and 20 percent thermal) and 60-percent forage areas.

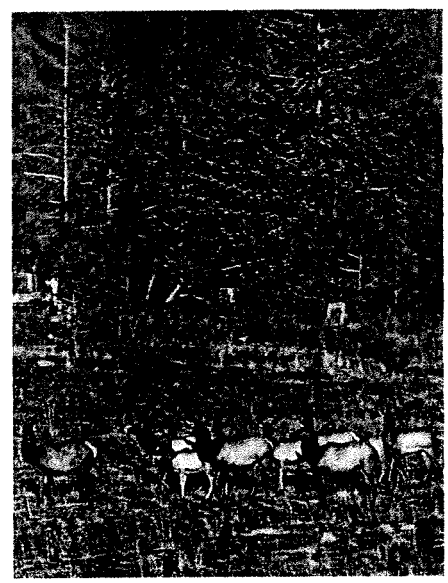


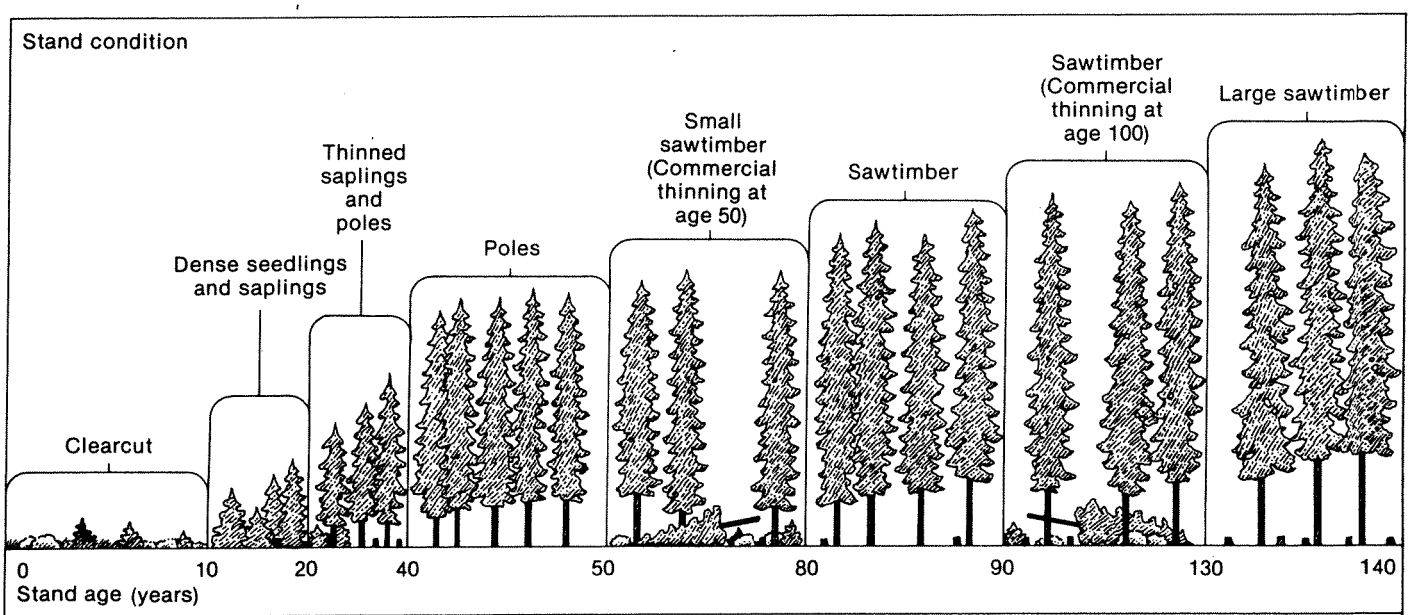
Habitat for elk			
Forage area Forage is abundant.	Hiding cover Sight distance is less than 61 meters (200 ft) from age 10 to 20 or 20 percent of the rotation.	Forage area Half the trees are thinned at stand age 20 to select the best crop trees. The area now becomes a forage area and hiding cover is destroyed.	Thermal cover As the trees grow, crowns close and tree height reaches at least 12 meters (40 ft). Thermal cover is provided for 10 years or 20 percent of the rotation.

Figure 77. A 50-year rotation designed to optimize habitat for elk.

Stand Size and Arrangement

Habitat is optimum, however, only if treatment areas are well distributed throughout the landscape and the treatments are properly synchronized to insure that hiding and thermal cover and forage areas exist in proper amounts and in proper arrangement at all times. The distance across cover areas and clearcut areas should be less than 366 meters (1,200 ft) to insure maximum use of the maximum area. For example, the 50-year rotation might be applied to 50-hectare (120-acre) blocks in which a clearcut would occupy 10 hectares (25 acres); hiding cover, 10 hectares (25 acres); a thinned block, 20 hectares (50 acres); and thermal cover, 10 hectares (25 acres). In this way, various habitat conditions can be provided over very large areas.





Habitat for elk						
Forage area Forage is abundant	Hiding cover Sight distance is less than 61 meters (200 ft) from age 10 to 20 years or 7 percent of the rotation. One-quarter of the trees are thinned at stand age 20 to encourage growth but maintain hiding cover for 30 years or 20 percent of the rotation.	Thermal cover As the trees grow, crowns close and tree height reaches at least 12 meters (40 ft). Thermal cover is provided for 10 years or 7 percent of the rotation.	Forage area About 30 percent of the trees are removed in a commercial thinning. Thermal cover is destroyed and the area is now a forage area.	Thermal cover Tree crown cover is now over 70 percent. Thermal cover is provided for another 10 years or 7 percent of the rotation.	Forage area A second thinning removes another 30 percent of the trees, destroys thermal cover, and creates a forage area.	Thermal cover Thermal cover is restored the last 10 years prior to regeneration cut. Three 10-year periods of thermal cover amount to 30 years or 20 percent of the rotation.

Figure 78. A 140-year rotation designed to optimize habitat for elk.

Stand Condition

In the Blue Mountains, 50 years is about the shortest rotation in mixed conifer stands that will provide optimum hiding and thermal cover for elk. This minimum rotation age results primarily from the requirement for thermal cover. To qualify as thermal cover, trees must be at least 12 meters (40 ft) tall. Douglas-fir and white fir stands have a site index of about 24 meters (80 ft) at age 100 or 15 meters (50 ft) at age 50. This means trees will be about 12 meters (40 ft) tall at age 40.

Maximum rotation length results from the requirements for hiding cover (fig. 78). In forests of the Blue Mountains, a rotation of 140 years seems to be a reasonable maximum length to provide optimum hiding cover. Beyond that age, the trees

have been thinned, either naturally or silviculturally, and no longer provide adequate hiding cover.

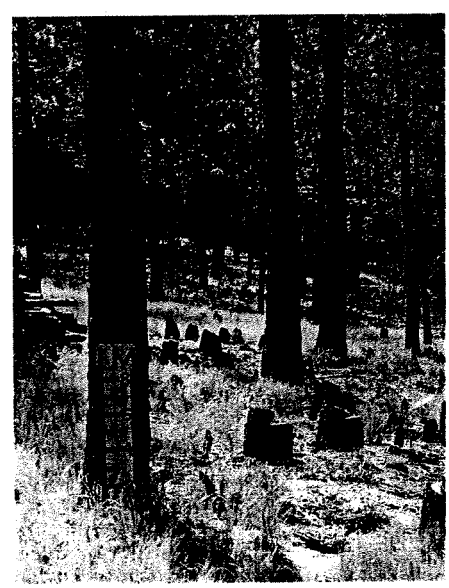
If a stand is commercially thinned instead of regenerated at age 50, it would produce forage for 20 to 30 years and attain thermal cover status again by age 80 (Garrison 1960; Hedrick et al. 1968, 1969; Young et al. 1967). If a second thinning is delayed until the trees are 90 years old, 10 years of thermal cover will be provided. The stand will provide forage for 20 to 30 years and then attain thermal cover again by age 130, providing another 10 years of thermal cover before the stand is regenerated at age 140. In this way, 30 years of thermal cover provide the 21 percent of the stand's life that is optimum for elk. With proper arrangement of such stands in time and space, the appropriate cover-forage area ratios can be maintained at all times.

But only 10 years of hiding cover has been provided—7 percent of the 140-year rotation. For optimum habitat, dense stand conditions must be maintained for 30 years after regeneration or from stand age 10 to 40. This could be accomplished by altering the silvicultural prescription so that precommercial thinning takes only 25 to 30 percent of the trees instead of the 50 percent required to maximize tree growth. In this way, hiding cover will be maintained by a stand stocking density too high for optimum tree growth—and some timber production is traded off for optimum elk habitat. Then, either commercial thinning will have to be delayed from age 50 to about age 70 or smaller diameter trees must be harvested at age 50. For example, precommercial thinning to provide 10 years of hiding cover should create an average stand d.b.h. of 22 centimeters (9 in) at stand age 50, whereas thinning to provide 30 years of hiding cover would produce trees of only 15-centimeter (6-in) d.b.h.

Thus, stands managed for longer rotations must provide hiding cover for longer periods than stands managed strictly to maximize wood production: 20 years for 100-year rotations, 30 years for 140-year rotations, and 40 years for 200-year rotations. Again, a 140-year rotation seems a reasonable maximum length to provide optimum elk habitat in the Blue Mountains.

The silviculturist has much flexibility in providing for optimum elk habitat—any rotation length between 50 and 140 years. The manager can do this and still provide timber products through intensive management. The only real constraint is the silvicultural skill of the forester. How should a 50-year-old, mixed conifer stand of Douglas-fir and white fir be marked for thinning so it can provide thermal cover by age 80? How many trees should be removed in precommercial thinning to maintain hiding cover to age 40? And how many trees should be planted to attain hiding cover by age 10? Only professional judgment and field experience can provide answers to these questions.

A stagnated, unthinned stand of ponderosa pine is hiding cover for elk (above); the same stand 10 years after thinning (below) is a forage area.



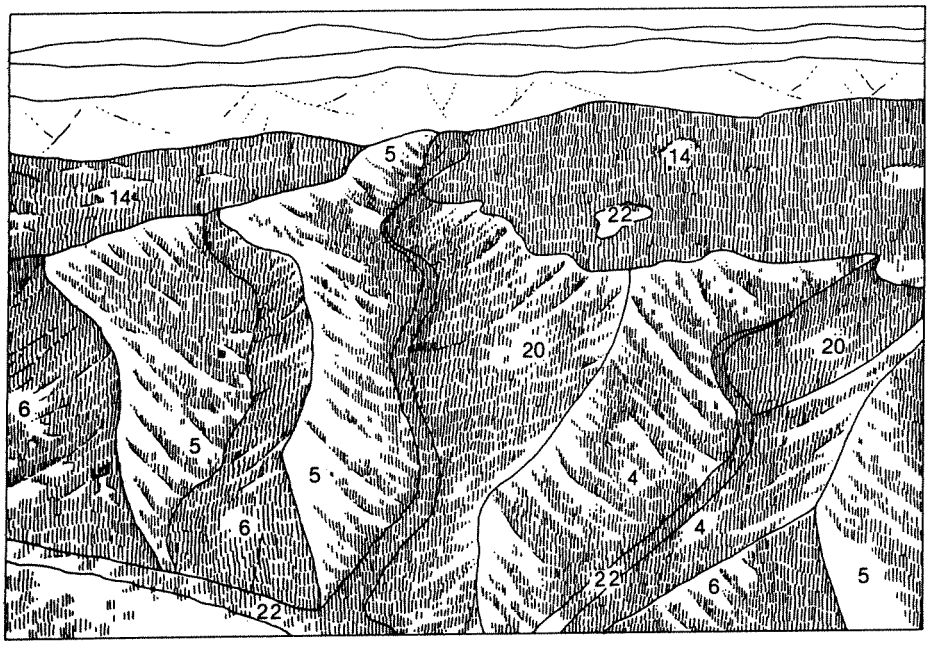


Figure 79. Some land-types in the Blue Mountains. Type 14 is dominated by white fir, has slopes less than 30 percent, and is 100 percent forested. Type 5 is white fir, has slopes over 30 percent, and is 35 percent forested. Type 4 is dominated by white fir, has slopes over 30 percent, and is 60 percent forested.

Land-type number	Land-type codes used by each National Forest[1]: Umatilla	Malheur	Wallowa-Whitman	Ochoco	% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
4	3		S4	2	30-80	All	60	6.1-19.5 (20-64)	K12	CD-S7-11	•	Ponderosa pine-Douglas-fir/ninebark
									K14	CW-S2-11	•	White fir/big huckleberry
									K51	GB-49-13	•	Bunchgrass on shallow soil, steep slopes
									K51	GB-49-14	•	Bunchgrass on deep soil, steep slopes
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
									K14	CW-G1-11		Mixed conifer/pinegrass, residual soil
5	3c				30-80	North, south	35	6.1-18.3 (20-60)	K51	GB-49-13	•	Bunchgrass on shallow soil, steep slopes
									K51	GB-49-14	•	Bunchgrass on deep soil, steep slopes
									K12	CD-S7-11	•	Ponderosa pine-Douglas-fir/ninebark
									K14	CW-S2-11	•	White fir/big huckleberry
									-	SM-19		Ninebark shrubland
									K12	CD-G1-11		Ponderosa pine-Douglas-fir/elk sedge
14	6 11b 18	3a 3b		1	0-70	All	100	10.7-21.3 (35-70)	K14	CW-G1-12	•	Mixed conifer/pinegrass, ash soil
									K14	CW-S2-11	•	White fir/big huckleberry
									K14	CW-F3-11	•	White fir/twinflower-forb
									K14	CW-S8-11		White fir/grouse huckleberry

See appendix 25 for footnotes.

Table 31. Descriptions of selected land-types in the Blue Mountains (source: appendix 25)

Silvicultural Options and Land-Type

The land-type is a general description of the area in which the stands to be managed occur. The descriptions, singly and in combination, give the silviculturist information needed to develop an acceptable management scheme.

A land-type categorizes an area that will produce a similar and predictable response to land management activities—particularly those related to silvicultural treatment of forest stands (fig. 79). The land-type classification scheme used by the USDA Forest Service in the Blue Mountains is described in appendix 25. Land-types 4, 5, and 14 are used as examples (table 31). The primary factor distinguishing these particular land-types is the percent of area that is forested. Land-type 14 is totally forested, whereas type 5 is only 35 percent forested and type 4 is 60 percent forested. Figures 80, 81, and 82 show anticipated changes in potential elk habitat related to treatment of land-types 4, 5, and 14.

The response curves in figures 80, 81, and 82 show what is likely to happen to habitat and its potential to support elk when a forested land-type is silviculturally treated. The response curves can be used to evaluate the impact of a timber sale on elk habitat or to schedule the type and amount of treatment to attain desired elk habitat. Trade-offs between cover and forage areas are the key to evaluating elk welfare.

In an undisturbed condition, land-type 14 (fig. 80) is characterized by mature white fir plant communities with some mature lodgepole pine plant communities. These plant communities have 80- to 120-percent crown closure (overstory plus understory) and produce little forage. Thus, land-type 14 is poorly balanced as elk habitat because of an extreme lack of forage areas. If all stands are more than 50 to 80 years old, the land-type is predominately in thermal cover condition and is deficient in both hiding cover and forage areas.

Under such conditions, the carrying capacity of summer range for elk is estimated to be only 18 percent of full potential under optimum habitat conditions. As silvicultural treatments, such as regeneration cutting and commercial thinning, are applied, forage areas and hiding cover are created. This makes the land-type more attractive to elk because the balance of forage and hiding cover is improved. It is theoretically possible to produce a 500-percent increase in the ability of land-type 14 to support elk during the summer by providing forage areas through cutting. This improvement requires that the stands are of the proper size and arrangement and that the treatments produce a balance of approximately 20-percent hiding cover, 20-percent thermal cover, and 60-percent forage areas. This is a more than fivefold increase in potential carrying capacity (18 to 100 percent of potential). Additional treatments that reduce cover below the optimum 40 percent will also reduce the ability of the area to support elk.

For land-type 14, the response curve shows predicted potential elk use increasing until 40 percent of the land-type is in cover. Potential elk use then declines rapidly as cover becomes the limiting factor. Potential carrying capacity drops to the pretreatment level of 18 percent when 20 percent of the land-type is in cover. Carrying capacity is reduced to 13 percent when 15 percent of the land-type is in cover. A reduction to 6 percent carrying capacity occurs when 10 percent of the land-type is in cover.

Only 60 percent of land-type 4 is forested. The structure, topographic orientation, and distribution or arrangement of forest sites make the natural vegetation mosaic of land-type 4 nearly optimum for elk (fig. 79). In an undisturbed condition, the land-type is dominated by mature white fir/big huckleberry and ponderosa pine-Douglas-fir/ninebark community types with natural bunchgrass openings. Crown closure (understory plus overstory) in mature forest stands ranges from 70 to 120 percent. The interior of these stands provides thermal cover, and stand perimeters —with branches low to the ground— furnish hiding cover. The forested areas tend to be long, narrow stringers associated with both intermittent and perennial streams and interspersed with natural bunchgrass openings or forage areas.

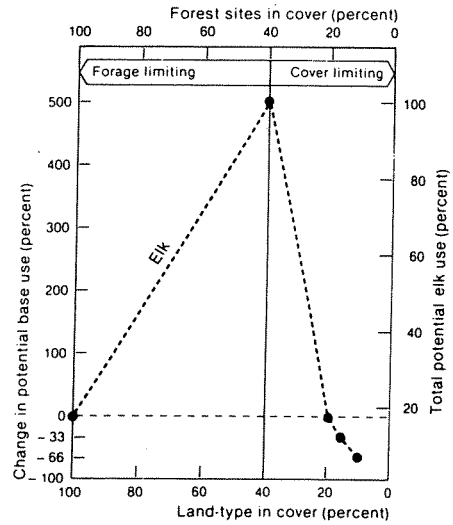


Figure 80. Relationship of elk cover to forage area requirements in land-type 14 (source: appendix 28).

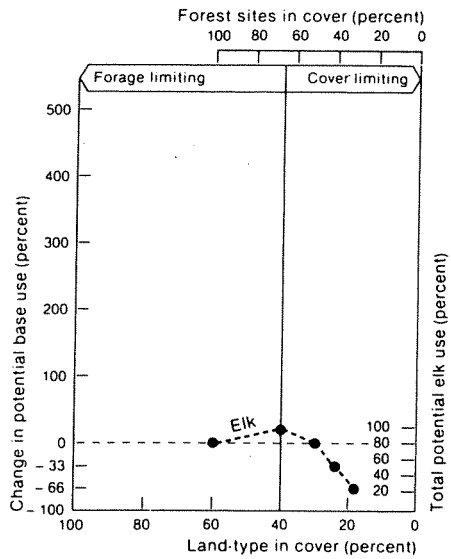


Figure 81. Relationship of elk cover to forage area requirements in land-type 4 (source: appendix 28).

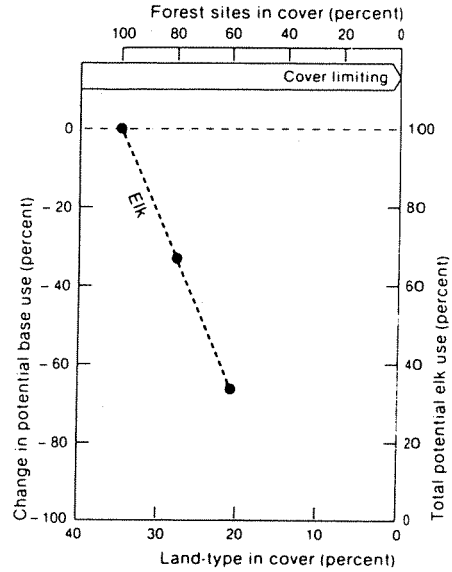
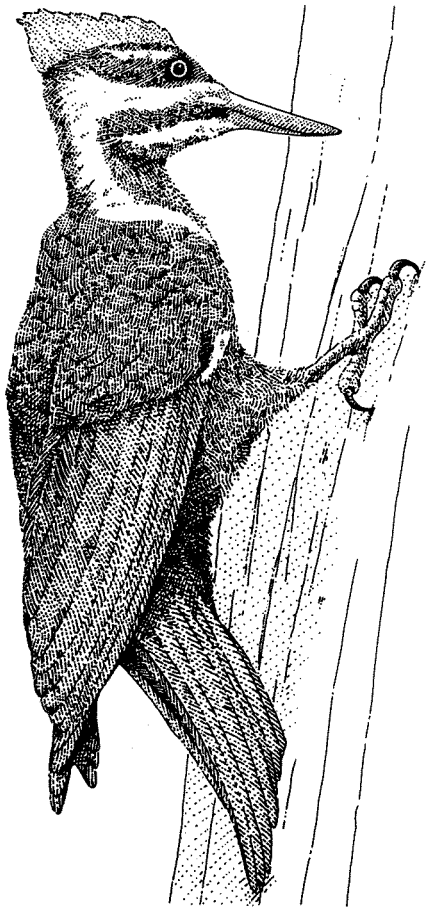


Figure 82. Relationship of elk cover to forage area requirements in land-type 5 (source: appendix 28).



The pileated woodpecker needs trees and logs with heart rot as suitable feeding substrates.

The opportunities for increasing potential elk use through silvicultural treatment in land-type 4 are severely limited. Figure 81 shows the percent of the land-type in forest sites and the percent of these forested sites in cover. The potential elk-use response curve for land-type 4 starts with 60 percent of the land-type in cover. This means that 100 percent of the forested sites are providing cover. As silvicultural treatments are applied, some additional forage areas are created. Potential elk capacity, however, increases from 80 to 100 percent as optimum habitat conditions are reached.

When optimum conditions are reached (60 percent of the land-type in forage areas and 40 percent in cover), 68 percent of the forested sites in land-type 4 are in hiding and thermal cover condition. In contrast, in land-type 14, only 40 percent of the forested sites had to be retained in cover to produce optimum habitat conditions. This means the selection of the type of silvicultural treatment, the size and location of treatment, intensity of cut, and scheduling of treatment are far more critical if potential elk use is to be maximized in land-type 4. In other words, the more completely forested land-types provide considerably greater flexibility when habitats are manipulated for elk production.

The potential for elk use in land-type 4 drops to pretreatment levels (80 percent) when 30 percent of the land-type is in cover. A reduction in potential elk carrying capacity to 50 percent occurs when the portion of the land-type in cover reaches 24 percent. A reduction to 20 percent of potential carrying capacity occurs when the portion of the land-type in cover drops to 18 percent.

Land-type 5 is only 35 percent in cover and, therefore, suboptimal for elk habitat. The land-type is composed primarily of bunchgrass types with mature white fir/big huckleberry and ponderosa pine–Douglas-fir/ninebark plant communities. Thermal cover is provided by stands more than 40 years old, and hiding cover is provided by low branches at the edge of the stand. Light to moderate precommercial thinning, leaving 370 trees per hectare (150/acre), will maintain hiding cover and permit the managed stands to attain thermal cover conditions earlier than would be expected in unmanaged stands. In older stands, a light commercial thinning is silviculturally desirable to enhance wood production, and the resulting stand structure will provide thermal cover. Such thinnings tend to maintain a healthier stand, less subject to deterioration from disease or loss of trees from competition. Stands which have deteriorated to the point that they provide neither hiding or thermal cover nor good forage areas should be regenerated and replaced with more vigorous stands. This will provide more management flexibility to meet both wood production and elk habitat goals.

But note the trade-offs implied in figure 82. Any silvicultural treatment which decreases the amount of cover in land-type 5 will have a detrimental effect on elk because cover is already limiting. Potential elk use is reduced to 66 percent when 28 percent of the land-type is in cover; a further reduction to 33 percent is expected when 21 percent of the land-type is in cover.

The situation in land-type 5 does not preclude timber harvest or silvicultural treatment. A decision may be made to accept the losses in potential elk use, or an uneven-aged timber management system may be adopted, in order to maintain most forested areas in cover while providing some wood products. At some point, it may become necessary to regenerate deteriorated stands to return them to cover condition. In other words, silvicultural treatment is not precluded when the objective is to provide optimum elk habitat, but constraints, in terms of wildlife, are severe in such land-types.

These examples have been given to make a point—that the scheduling and selection of silvicultural treatments that influence elk habitat must be prescribed on an individual basis—for each land-type. In the three examples, each land-type is dominated by white fir plant community types, yet the impacts of silvicultural treatment on elk habitat differ dramatically because of the difference in the mixture of timber cover and natural openings in the stands. For example, regenerating 20 percent of the forest area within the land-types discussed here can give results that range from doubling of potential elk use in land-type 14 to a one-third reduction in land-type 5.

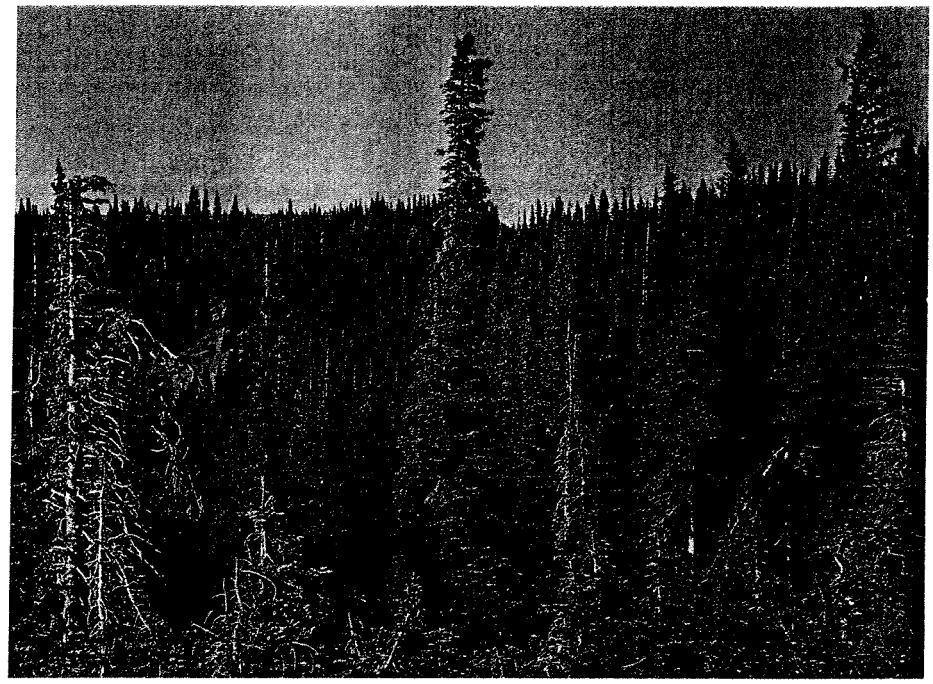
Optimum Habitat for Pileated Woodpeckers

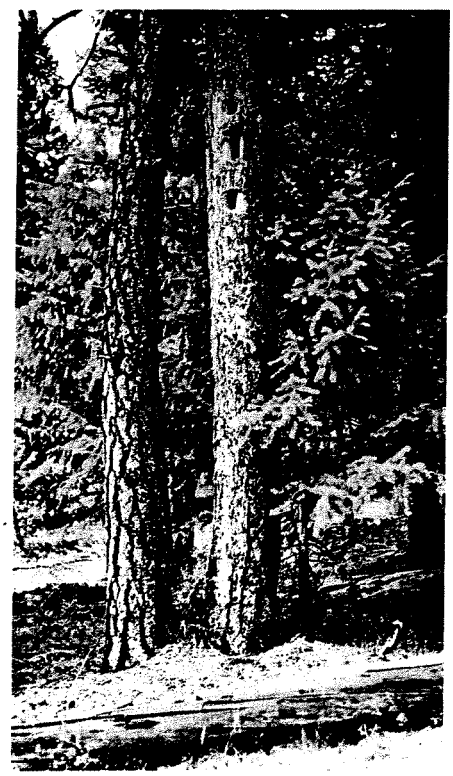
The optimum habitat for pileated woodpeckers is roughly synonymous with old-growth forest. Old growth provides the habitat structure necessary for both nesting and feeding (Bull 1975).

Pileated woodpeckers are large birds and require dead trees that are at least 38 centimeters (16 in) in diameter at the point where the cavity is excavated—usually at least 9.5 meters (31 ft) above the ground. Suitable nest trees must be more than 50.8 centimeters (20 in) in d.b.h. Pileated woodpeckers also prefer to nest in two-storied timber stands with a crown closure of approximately 70 percent, including both overstory and understory (Bull 1975). All these conditions are commonly found in old-growth stands.

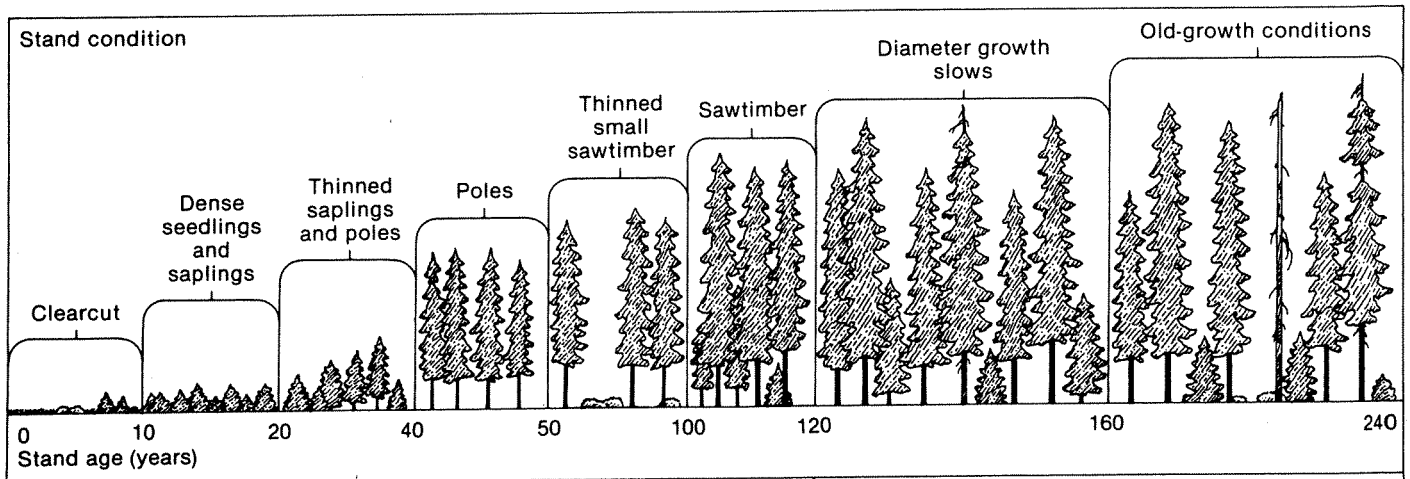
The primary food of pileated woodpeckers is carpenter ants and their larvae (Martin et al. 1951, Bull 1975). Since carpenter ants are usually found in trees and logs with heart rot, pileated woodpeckers need such trees and logs as suitable feeding substrates (Bull 1975; Bull [n.d.], unpublished, see "References Cited"). Heart rot develops most readily in dense or stagnated stands (Baxter 1943).

In the Blue Mountains, old-growth in mixed conifer or white fir stands is defined as having at least 37 trees per hectare (15/acre) more than 53-centimeter (21-in) d.b.h., an average of 1.2 or more snags per hectare (0.5/acre) more than 53-centimeter (21-in) d.b.h., two or more canopy levels, more than 70-percent crown closure (overstory plus understory), and some trees with heart rot.





Optimum habitat for pileated woodpeckers is roughly synonymous with old-growth forest. The birds require dead trees at least 50.8-centimeter (20-in) d.b.h. for nesting and prefer to nest in two-storied stands such as the one above.



Intensive timber management	Habitat for pileated woodpeckers	
Intensive timber management with pre-commercial and commercial thinning to maintain rapid diameter growth and promote development of large trees that can become snags.	By age 120, diameter growth has slowed, stagnation is starting, and some trees are beginning to die.	Habitat suitable for pileated woodpeckers. By age 160, there are at least 37 trees per hectare (15/acre) over 53-centimeter (21-in) d.b.h., 1.2 snags per hectare (0.5/acre) over 53-centimeter (21-in) d.b.h., heart rot, and a two-storied stand with a total crown cover over 70 percent.

Figure 83. A 240-year rotation in Douglas-fir and white fir designed to attain optimum old-growth conditions for pileated woodpeckers. Commercial thinning is essential to stimulate diameter growth and produce the large trees required for cavity excavation.

Treatment Scheduling

The biggest challenge to silviculturists is to provide habitat requirements for the pileated woodpecker over long periods. Tree stocking density must be low enough to allow production of 53-centimeter (21-in) d.b.h. trees that will be, as they die, suitable for excavation by woodpeckers. The stand should also be permitted to stagnate at some time during the rotation to aid the development of heart rot in some trees.

A 240-year rotation with intensive timber management throughout half the life of the stand seems likely to mimic conditions in an old-growth forest (fig. 83). In the first 120 years of the rotation, both precommercial and commercial thinnings are necessary to sustain an average 10-year diameter growth rate of 5 centimeters (2 in). Four commercial thinnings should be made with a final thinning at stand age 100. The few young trees that survive after this last commercial thinning should be retained to produce a two-storied stand.

Stand Size and Arrangement

Pileated woodpeckers confine their activities mostly to forested sites—both for feeding and reproductive activities. The territorial requirement of the pileated woodpecker in the Blue Mountains is approximately 120 hectares (300 acres); therefore stand sizes should be multiples of that size to bring numbers of nesting pairs close to maximum density. As the best habitat for pileated woodpeckers is in old growth and mature forest stages, no particular arrangement of stand ages is required.

Stand Condition

One reason for commercial thinning in this plant community is to remove trees that would otherwise become unmerchantable because of heart rot. Another reason is to maintain rapid diameter growth in the remaining trees. This tends to discourage heart rot (Baxter 1943), particularly in white fir stands. Thus, commercial thinning strictly to enhance wood production will create a condition far below the optimum for pileated woodpeckers. The purpose for commercial thinning in the initial 100 years of this 240-year rotation is to enhance diameter growth on selected trees. Thinning will produce large diameter trees over a much shorter period than would be possible in an unmanaged stand. These large diameter trees will furnish saw logs or serve as nest sites for pileated woodpeckers.

Bark knocked off during logging provides stimulation for development of heart rot fungus (Aho 1966, Hubert 1955, Wright and Isaac 1956). The stand should begin to stagnate about 20 years after the last thinning—at age 120. By this time, the stand will have grown for 120 years at an approximate average rate of 5 centimeters (2 in) in diameter per 10 years. The stand will have produced at least 37 trees per hectare (15/acre) of more than 53-centimeter (21-in) d.b.h. As they die, these trees, particularly those with heart rot, will provide suitable sites for cavity excavation by pileated woodpeckers as long as they stand. Trees infected by heart rot will also provide suitable habitat for carpenter ants and the necessary foraging substrate for pileated woodpeckers.

By age 160, the stand should meet the definition of old growth—many large trees (both dead and alive), two or more canopy levels, and both dead and alive trees with heart rot. In a 240-year rotation, the stand will be in old growth for approximately 80 years. At some time after age 240, the stand will deteriorate until it contains less than 37 trees per hectare (15/acre) of more than 53-centimeter (21-in) d.b.h. At this point, the stand is probably past optimum habitat condition for pileated woodpeckers and other old-growth-associated wildlife and should be a candidate for final harvest cut and subsequent regeneration.

In this example, an old-growth rotation was designed to optimize habitat for pileated woodpeckers. In such a rotation, both wood production and habitat conditions for elk are less than optimum. Only 60 to 80 percent of potential timber yields are possible because the goal was to produce a deteriorated stand in which 20 to 40 percent of the trees would be considered defective as crop trees. Forage areas for elk will be reduced to only 30 percent of the rotation—one-half the 60-percent optimum. The stand will provide hiding cover for only 20 years, or 8 percent of the rotation.

Once old-growth conditions are achieved, however, there may be an increase in hiding cover. As the stand begins to deteriorate and lose dominant trees, understory vegetation will respond to the increased light reaching the forest floor.

Intensive silviculture is likely to be required in white fir and mixed conifer stands in the Blue Mountains to create old-growth conditions. Nonmanagement is not a realistic alternative. If the management decision is to maintain some old growth in the managed forest at all times, the silviculturist must learn to produce old-growth stands. This seems inevitable as: (1) the existing old growth will eventually deteriorate, and (2) the increasing demands for products from the managed forest precludes the option of holding large blocks of forest land in a protected state for 240 years or more.

Again, as in the example for elk, optimum habitat for pileated woodpeckers will be provided only if the old-growth rotation cycle is repeated, at different intervals, over areas of sufficient size. In this way, some stands will be in old-growth condition while others are in younger stages. But there should always be adequate stands in old-growth to provide habitat for a viable population of pileated woodpeckers.

Effect of Land-Type

Unlike elk, pileated woodpeckers confine themselves primarily to forests. Elk make good use of land-types which have a natural pattern of forest and nonforest vegetation, such as land-type 4. Pileated woodpeckers, however, cannot attain 100 percent of their potential population density in land-type 4 because it is only 60 percent forested. Their occurrence will be limited by the number of forested blocks of appropriate size and the number of suitable forage and nesting snags available. The territorial requirement of pileated woodpeckers is about 121 hectares (300 acres) (appendix 21).

The pileated woodpecker requires 16 snags ≧50.8-centimeter (≧20-in) d.b.h. per 100 hectares (7 per 100 acres) to support a population density of 50 percent of the potential under continuous forest conditions (appendix 22). In land-type 4, which is 60 percent forested, this same population level needs 27 nest snags per 100 forested hectares (12 per 100 acres). The same population density cannot be attained on land-type 5 which will have only 35 percent in potential forested sites. If all forested areas were managed so as to support maximum population levels, only 35 percent of that potential would be realized with 32 snags per 100 hectares (14 per 100 acres) (appendix 22).

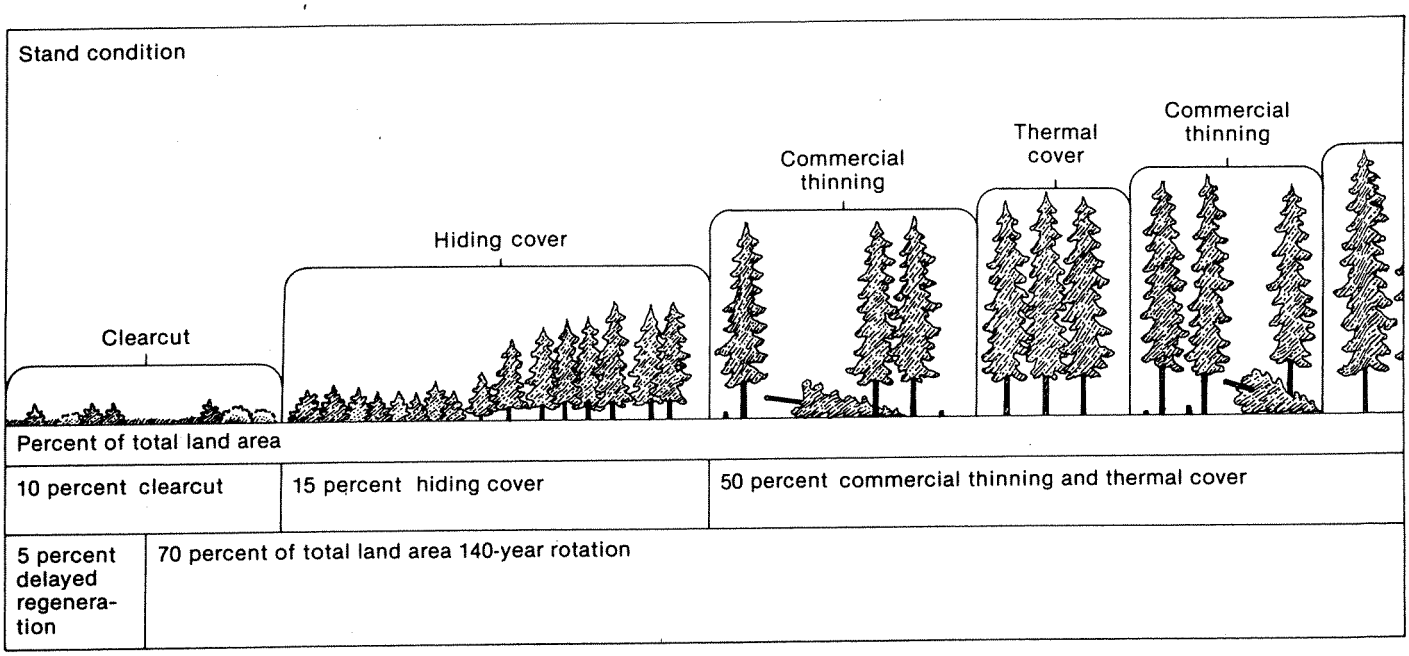
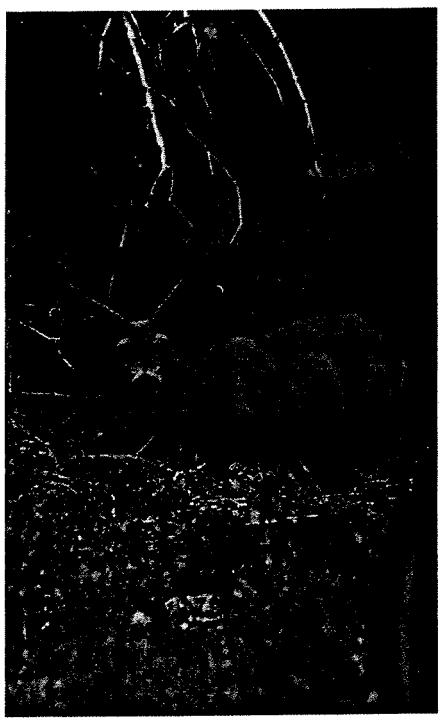


Figure 84. Silvicultural treatment to attain about 10 percent of the land area in each of the habitats critical for elk and pileated woodpeckers: old growth, clearcut, shrubland, and elk hiding cover. A 140-year rotation is applied to 70 percent of the total land area, a 240-year rotation to 25 percent, and delayed regeneration to 5 percent.

Forested areas that provide suitable habitat for elk will also meet the habitat requirements for deer.



Balancing Habitat Needs

The key to balancing habitat needs of pileated woodpeckers and elk is to correctly proportion the amount of old growth, thermal cover, hiding cover, and forage areas. Assume that the objective is to have 10 percent of the forested land area in each of these conditions—thermal cover, hiding cover, forage areas, and old growth. This goal might be obtained by scheduling a 140-year rotation on 70 percent of the forested land and a 240-year rotation on 25 percent of the forested land (fig. 84). The 140-year rotation is shown in figure 78 and the 240-year rotation in figure 83. In addition, regeneration must be delayed on 5 percent of the forest area to maintain 10 percent of the total area in stands less than 10 years old. The 140-year rotation was selected as the shortest rotation during which trees of adequate size could be produced for use by all primary excavators and other cavity nesters.

This combination of 140- and 240-year rotation has only a moderately negative effect on commercial timber production. Both require thinning to achieve management objectives. Nearly 100 percent of the potential wood productivity might be attained on 70 percent of the area and 60 to 80 percent of full productivity on 25 percent of the area. An additional 5 percent would be lost because of the intentionally delayed regeneration of some forest sites.

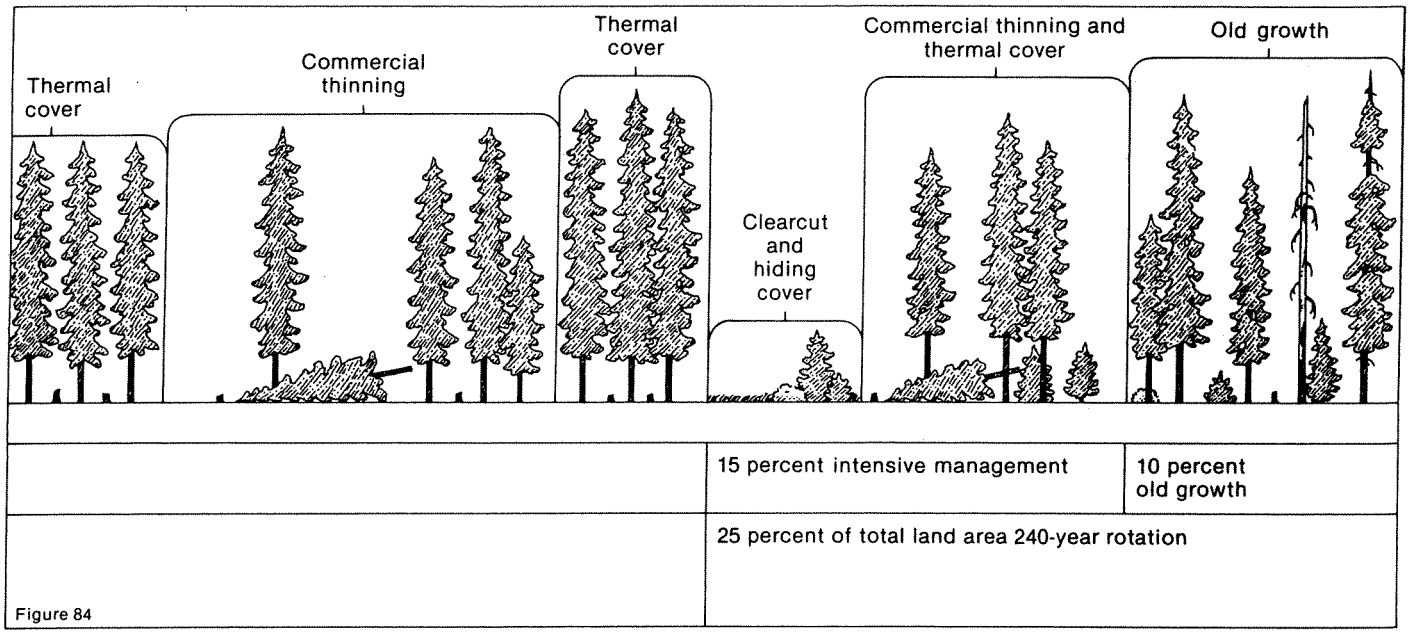


Figure 84

Recoverable wood volume should approach 85 to 90 percent of biological potential. This does not, however, account for the intentional retention of snags in the 140-year rotation which would further reduce the wood volume harvested, probably to 70 or 80 percent of potential.

As mentioned earlier, a silviculturist has considerable latitude in meeting requirements for elk habitat. Rotation ages can range from 50 to 140 years. The requirement for pileated woodpeckers is more restrictive because their optimum habitat is old growth, requiring a rotation of 240 years.

Even when featured species management is being practiced, the needs of other wildlife must also be considered when a rotation age is selected. The discussion in the next section is pertinent.

Management for Species Richness

The goal of management for species richness is to insure that most indigenous wildlife species are maintained in viable numbers in the managed forest (King 1966); the habitat requirements of all species must be accounted for. This is in decided contrast to featured species management in which the requirements of only a few species must be met.

Management for species richness can be achieved by modifying silvicultural practices to provide a broad spectrum of habitat conditions, for example, adequate amounts of each successional stage of each plant community and identified special and unique habitats—riparian zones, edges, snags, dead and down woody material, cliffs, caves, and talus.

To evaluate the probable results of altering stand conditions on wildlife welfare, it is necessary to: (1) classify the change in habitat in a consistent manner and (2) anticipate the response of wildlife to changes in habitat. In the system used in the Blue Mountains, the change in habitat is classified by successional stage and plant community. Silvicultural or other treatments are conceived of as either advancing or retarding a stand's successional condition. These artificially produced conditions mimic the wildlife habitat conditions produced under natural succession. Examples of such anticipated reactions to silvicultural treatment are shown in table 3, chapter 2. The response of wildlife to changes in habitat can be determined quickly, although somewhat crudely, by considering the data on the response of life forms to alteration in successional stages (appendix 10). Similar information is found for each species in appendices 8 and 9. Data on the importance of special and unique habitat features for each species are given in appendix 14.

Species richness in the managed forest is most heavily influenced by the presence of early (grass-forb and shrub-seedling) and late (mature and old-growth) forest successional stages (figure 15, chapter 2). Few wildlife species of the Blue Mountains find their optimum habitats in the intermediate (pole-sapling and young) forest successional stages. No species is confined to these habitats. The vast majority of species find optimum habitat conditions in the two early and two late successional stages or in combinations of those stages. Many species are found in viable numbers only in those habitats.

Species richness in the managed forest is most heavily influenced by the presence of early and late forest successional stages. Clearcuts (above) provide suitable habitat for many species including the yellow pine chipmunk.

Silvicultural Considerations

Management for species richness requires that the silviculturist provide or maintain sufficient stands in each successional stage to insure the needed spectrum of habitats. This may necessitate deviations from the silvicultural prescriptions that maximize wood production.

There are two primary silvicultural approaches—uneven-aged and even-aged management. The silviculturist will be hard pressed to meet a goal of management for species richness using an exclusively uneven-aged timber management system. Even-aged management is a much better way to meet the goal of management for species richness because all successional stages are created. Early successional stages occur as a result of regeneration cuts and the late mature and old-growth stages can be produced by commercial thinning and sanitation harvesting.

Uneven-aged timber management produces stands with trees of all ages (Ford-Robertson 1971) that are "continuously or periodically regenerated, tended, or harvested with no real beginning or end" (Alexander and Edminster 1977, p. 5). Over time, the structure of the majority of the forest will be rather homogeneous and there will be a decrease in the amount and contrast of edges.

Under uneven-aged management, early successional stages will exist only if stands are lost to natural factors such as wildfire or insect outbreaks, or if regeneration of a stand is necessary. Such forests will lack the variety of distinct successional stages that insure diversity and a myriad of habitat niches. Although the structural diversity of the stands appear similar to late-mature and old-growth successional stages, the trees will not be large enough, large snags will be absent, and there will be no trees with heart rot.

Since it seems unlikely that uneven-aged management will meet species richness goals, the remainder of this section will deal with even-aged timber management.

Management for species richness can be achieved under even-aged timber management but not without some loss in wood production because of trade-offs to wildlife habitat. For maximum wood production, it is necessary to shorten the time in early successional stages and to harvest crop trees at the appropriate time to insure desirable stand conditions and maximum growth rates. Any management action that prolongs early successional stages or allows selected stands to go into old-growth condition will be accomplished only at some cost in wood production.

Most silviculturists have been trained or directed to recognize timber production as their first responsibility. Silvicultural goals and treatments should be developed from the biological requirements of the tree species, stand conditions, and capability of the site to produce wood on a sustained yield basis. These goals and treatments are then modified by multiple use constraints, such as wildlife habitat goals.

In modifying silvicultural practices to achieve management for species richness, the silviculturist considers the same five factors discussed earlier under featured species management: (1) scheduling of silvicultural treatments, (2) arrangement of stands in time and space, (3) stand conditions, (4) size of treatment area, and (5) land-type.

Treatment Scheduling

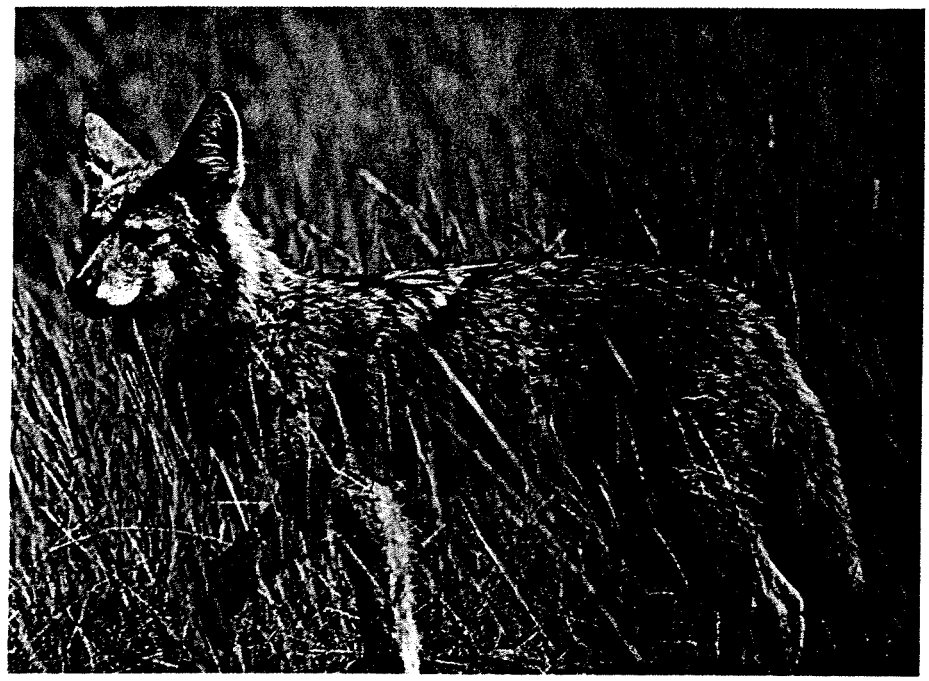
To manage for species richness, it is necessary to maintain an appropriate amount of each successional stage of major plant communities at all times. But forest stands always change following treatment (table 3, chapter 2). Often, management activities speed the stand toward maturity. Other management practices, such as clearcutting, will cause the area to revert to an earlier successional stage. Maintenance of the appropriate set of wildlife habitat conditions, then, is dependent on the scheduling of silvicultural treatment.

For example, well-stocked clearcuts in mixed conifer forests will remain in the grass-forb and shrub-seedling stage for 10-15 years before they enter the pole-sapling stage. The transition will result in the loss of habitat for wildlife associated with the grass-forb and shrub-seedling stages and will gain habitat for species that use the pole-sapling stage.

Length of the rotation is the key to assuring existence of an appropriate amount of area in early successional stages. A 50-year rotation will provide 20 percent of the forested land in grass-forb and shrub-seedling stages by means of clearcuts less than 10 years old. A 100-year rotation will provide 10 percent; a 140-year rotation, 7 percent; and a 240-year rotation, only 4 percent. The longer the rotation age, the less the area in early successional stages.

If a decision is made to carry some stands to very long rotation ages, there will be a wildlife trade-off in the decrease of stands in regeneration cuts less than 10 years old. With the exception of old-growth rotations, rotation age will not adversely affect wood volume production; but it will alter the type of wood products that are produced.

The silviculturist can also alter or delay treatment of regeneration cuts to maintain them in earlier successional stages longer. Such options include allowing stands to regenerate naturally (more slowly), planting grass (Klock et al. 1975) to compete with tree establishment in regeneration cuts, and allowing shrubs to compete with trees. Decisions such as these, however, will have dramatic impacts on timber production.



Coyotes feed on small mammals common in early successional stages and use downed logs as denning sites.

Arrangement of Stands

For best results in terms of wildlife species richness, stands should be arranged to make a maximum contribution to habitat diversity. The manager can accomplish this by paying attention to both the amount of edge and the degree of contrast between stands produced and maintained by the silvicultural treatment. The shape of stands should be manipulated to achieve the greatest possible amount of edge (chapter 4). In addition, a high degree of contrast between adjacent stands, as between a clearcut and mature timber, will enhance species richness. In general, the greater the contrast, the greater the habitat diversity.

Stand Conditions

Modification of standard silvicultural practices to produce or prolong certain stand conditions beneficial to wildlife is a distinct challenge for the silviculturist. Modifications for wildlife habitat are likely to have negative impacts on wood production. At the same time, they are apt to have dramatic effects in insuring appropriate habitat conditions.

The silviculturist may have made the best possible selection of stands for harvest. The scheduling of treatment may be well planned. But if the silvicultural treatments are inappropriately prescribed or executed, the wildlife goals will not be attained.

There are potentially hundreds of modifications in standard silvicultural practices to achieve wildlife habitat objectives. It would be impossible to list them all, but a few examples will help illustrate the point. For example, a delay in planting a clearcut where natural regeneration had failed would maintain the grass-forb stage for a longer period. Heavily seeding a new clearcut with a mixture containing sod-forming grasses would delay forest regeneration. Both modifications would benefit wildlife that require early successional stages and might be used to increase the amount of these successional stages. If such early stages occur in more than desired amounts, tree planting could be emphasized in conjunction with elimination of grass and shrub competition to speed reforestation of the site.

Commercial thinnings might be forgone in relatively mature stands to encourage the creation and maintenance of late mature or old-growth conditions. Or, commercial thinnings might be done earlier or heavier than dictated by maximum timber production to encourage more rapid development of a multitiered forest canopy.

Size of Treatment Area

The size of areas to be treated to enhance wildlife species richness is influenced by the requirements of individual species for food, cover, water, and size of territory. The relationship of size of treatment area to species richness was detailed in chapter 4. There is a relationship between the size of a habitat and the number of species that will occur within it. It is anticipated that species richness in the Blue Mountains will increase with size of treatment area to about 34 hectares (84 acres) as shown in figure 31, chapter 4. Beyond that size, species richness will decline because of a reduction in the occurrence of species associated with edges and ecotones.

The size of treatment area expected to enhance species richness is about three times larger than the 11-hectare (28 acre) circular stands or openings that provide maximum use of the maximum area by deer or elk (figure 67, chapter 8). In other words, management for species richness may lead to far less than maximum potential populations for many, if not most, species. Areas larger than 34 hectares (84 acres) may accommodate the few species that require larger blocks of habitat whereas smaller areas will enhance edge habitats which accommodate species adapted to such edges.

Consideration of Land-type

It is necessary to consider the general mixture of plant communities of the area to be managed, particularly the arrangement and ratio of natural openings to forest sites. This may be determined from the land-type (fig. 79) and from aerial photographs.

The natural layout of the area will have a profound influence on management prescriptions. For example, land-type 4 is composed of 40-percent natural openings classified in the "other grasses" community on steep slopes. This would preclude any need to worry about grass-forb stages. There is still a need to provide some areas in shrub-seedling stages, however. The land-type is 60 percent forested, so there is sufficient forest vegetation to allow a relatively nonconstrained approach to forest management.

Land-type 5 is only 35 percent forested. As a result, the manager has less leeway if wildlife diversity is to be maintained. There is less opportunity, for example, to create forest stands of adequate size to enhance wildlife species richness due to arrangement of the majority of the stands in stringers and clumps. And openings created in forest stands will create little contrast along edges where they meet natural openings.

In the Blue Mountains, land-type 14 affords the maximum opportunity to enhance species richness. This land-type is 100 percent forested in mixed conifer and white fir on relatively gentle terrain. This affords maximum flexibility to schedule treatments, arrange stands in time and space, control stand conditions, and dictate the size of treatment areas.

Habitat Prescriptions

Given that timber management is presently the dominant land management activity in the Blue Mountains and that silviculturists will make most of the management prescriptions, wildlife goals can be appropriately accomplished through the technique of constraints. Wildlife management for species richness is accomplished by insuring the presence of adequate amounts of each plant community in each recognizable successional stage and by providing appropriate management for special and unique habitats. The constraints should include: (1) a statement of the amount, by plant community, of each successional stage that will be maintained per unit of area, and (2) a statement concerning the treatment of special and unique habitats. For example, the supervisors of the National Forests in the Blue Mountains have issued the following constraints:

1. The general forested plant communities will be divided into 2 240- to 4 860-hectare (8,000- to 12,000-acre) management units. Five percent of the area in each forested community will be maintained in each of the six distinct successional stages.
2. Snags will be maintained at a level and distribution that will provide for at least 40 percent of the potential maximum nesting population of all primary excavators (woodpeckers). Details on the relationship of snag sizes and numbers to potential populations of cavity nesting birds are found in chapter 5.

These constraints did not direct specific attention to the other special and unique habitats—riparian zones, edges, dead and down woody material, and cliffs, caves, and talus. A complete program of management for species richness must address management objectives of identified special and unique habitats as well as insure the continuous existence of successional stages for each plant community.

Table 32. Association of life forms with successional stages in the mixed conifer forest community according to their requirements for reproduction and feeding (adapted from appendices 7 and 10)

Life form	Reproduces	Feeds	Orientation	Successional stage: Grass-forb	Shrub-seedling	Pole-sapling	Young	Mature	Old growth
2	in water	on the ground, in bushes, and/or in trees	R	4	3	4	4	4	4
			F	4	3	4	4	4	4
3	on the ground around water	on the ground, and in bushes, trees, and water	R	4	5	4	5	6	6
			F	5	6	4	4	5	5
4	in cliffs, caves, rimrock, and/or talus	on the ground or in the air	R	5	6	4	4	4	5
			F	9	8	5	5	5	7
5	on the ground without specific water, cliff, rimrock, or talus association	on the ground	R	3	12	12	6	7	5
			F	13	15	14	14	14	13
6	on the ground	in bushes, trees, or the air	R	0	2	1	1	1	0
			F	1	2	2	2	1	0
7	in bushes	on the ground, in water, or the air	R	1	8	8	6	6	4
			F	7	11	11	11	10	8
8	in bushes	in trees, bushes, or the air	R	0	1	1	1	1	1
			F	1	2	2	2	2	2
9	primarily in deciduous trees	in trees, bushes, or the air	R	0	0	0	0	0	0
			F	1	2	2	2	2	1
10	primarily in conifers	in trees, bushes, or the air	R	0	1	4	9	12	12
			F	1	5	10	13	13	13
11	in conifers or deciduous trees	in trees, in bushes, on the ground, or in the air	R	0	1	8	14	19	16
			F	12	16	18	19	20	19
12	on very thick branches	on the ground or in water	R	0	0	0	2	5	5
			F	6	5	4	5	6	6
13	in own hole excavated in tree	in trees, in bushes, on the ground, or in the air	R	0	0	0	5	9	9
			F	2	2	1	5	10	10
14	in a hole made by another species or in a natural hole	on the ground, in water, or the air	R	0	0	3	11	23	23
			F	15	15	14	15	22	22
15	in a burrow underground	on the ground or under it	R	12	15	13	13	15	15
			F	17	17	16	16	17	17
16	in a burrow underground	in the air or in the water	R	3	3	3	3	3	3
			F	5	5	5	5	5	5

R Number of species reproducing ▒ F Number of species feeding □

The burrowing owl uses all successional stages in the non-forest communities.

Wildlife Response

As the wildlife biologist and the silviculturist work together to accomplish the goal of wildlife management for species richness, they will find it necessary to evaluate the impact of various management alternatives on wildlife species. In the preliminary planning stages, a good first estimate can be made from the information on wildlife life forms associated with plant communities and successional stages (appendices 8, 9, and 10).

Suppose the management alternative being examined requires that at least 5 percent of each forested plant community be maintained in each of the six successional stages. In addition, sufficient snags must be maintained to provide habitat for nesting populations of woodpeckers at 40 percent of the potential. The alternative is a scheme for maximum timber production in which a strict, even-aged timber management regime with a 100-year rotation will be instituted.

The plant community being considered is the mixed conifer community in land-type 14. Land-type 14 is 100 percent forested and occupies relatively gentle terrain (fig. 79 and table 31).

Table 32 displays information on life form association with successional stages within mixed conifer communities. The analyst can quickly discern that only life forms 4, 5, 7, 10, 11, 12, 13, and 14 show a clear association with successional stages. Life forms 2, 3, 6, 8, 9, 15, and 16 will be little influenced by the constraint under consideration.

The 100-year rotation proposed will provide 10 percent of the area in clearcuts less than 10 years of age (grass-forb and shrub-seedling successional stages). Therefore, the wildlife constraint of 5 percent each (total 10 percent) will be met. The existence of the two earliest successional stages will assure habitat for life forms 4, 5, 7, and 12.

Late-mature and old-growth successional stages would not exist with the 100-year rotation. The management constraint to assure existence of at least 5 percent of each stage will require a rotation longer than 100 years. Both could be accommodated in the 240-year rotation discussed under management for pileated woodpeckers. Five percent each in late-mature and old-growth stages would require that about 15 percent of the land area be in the 240-year rotation. The welfare of life forms 10, 11, 12, 13, and 14 would be strongly enhanced by late-mature and old-growth stands.

The proposed constraints would seem to go a long way toward assuring that all indigenous species associated with mixed conifer forests have some suitable habitat. But the small percentage (5 percent) dictated will mean that the majority of the forest will be in a condition that mimics the pole-sapling and young forest successional stages. Although many species use these stages, few of them find optimum habitat conditions there.

The existence of suitable snags is critical to life forms 13 and 14. Care should also be given to the size of treatment area and to increasing the amount and quality of edges to achieve maximum species richness.

A more detailed analysis would require information on the association of individual wildlife species with successional stages. Such information is found in appendices 8 and 9. Appendix 8 shows the association of species to plant communities, and appendix 9 shows their relationship to successional stages. For example, consider life form 13 which has 13 species. Ten of these 13 occur commonly in mixed conifer forests (appendix 8). Nine species (pileated, Lewis', hairy, white-headed and black-backed three-toed woodpeckers; common flicker; Williamson's sapsucker; white-breasted and red-breasted nuthatches) both feed and reproduce in mixed conifer. One (pygmy nuthatch) feeds in mixed conifer but does not usually reproduce there.

Of the 10 species commonly found in mixed conifer forests, 5 both feed and reproduce in the young forest successional stage (appendix 9): Lewis', hairy, and black-backed three-toed woodpeckers; common flicker; and red-breasted nuthatch. These species would probably occur in the absence of late-mature and old-growth stages.

Four species, however, generally confine their feeding and reproductive activities to mature and old-growth stages: pileated and white-headed woodpeckers, Williamson's sapsucker, and white-breasted nuthatch. These four species would be eliminated or much reduced without the existence of mature and old-growth stages. The pileated woodpecker finds optimum habitat conditions in old growth. The pygmy nuthatch does not commonly reproduce in mixed conifer forests but does feed there—mainly in mature and old-growth stages.

Appendix 12 gives a measure of versatility for each species in relationship to its use of plant communities and successional stages. The presence of species with low versatility ratings should alert the analyst to be particularly careful to insure existence of suitable habitat.

Attention is now directed to appendix 6 which provides additional habitat information for individual species. For example, the pileated woodpecker is a year-round resident that feeds and reproduces in ponderosa pine, white fir, and mixed conifer communities and also feeds in lodgepole and subalpine fir communities. The species has no particular attachment to riparian zones or to edges and their ecotones. Pileated woodpeckers require large snags for nesting and both snags and decaying logs for forage substrate. Similar information can easily be developed for the other bird species.

Of the 10 species in life form 13 that are commonly associated with mixed conifer, 8 have low versatility ratings (appendix 12): pileated, Lewis', white-headed, and black-backed three-toed woodpeckers; Williamson's sapsucker; and white-breasted, red-breasted, and pygmy nuthatches. The common flicker and the hairy woodpecker have medium versatility ratings. The entire life form has a low versatility rating (appendix 13). Particular attention should therefore be paid to life forms as a whole and to individual species within the life form that have low versatility ratings.

A look at appendix 4 will indicate if any of the species within the life form require special consideration. Three of the species under discussion have been so identified. The Lewis' and hairy woodpeckers are listed in the Audubon "blue list" of 1976 (Arbib 1975) as being potentially threatened with decline and the red-breasted nuthatch is in the USDA Forest Service's Research Natural Area "yellow book" (Dyrness et al. 1975); these references should be consulted for additional details.

Such information can be readily analyzed as needed for each species within each life form. In this way the wildlife biologist and silviculturist can formulate and evaluate alternative schemes to insure the existence of most or all indigenous species in viable numbers.

Foresters have no problem providing habitat for the porcupine in the managed forest. This species is commonly found in all forest successional stages except old growth.

Summary

It is possible to accomplish both wildlife and timber management objectives in the managed forest. This chapter has explained how that can be done for the two primary wildlife management systems—featured species management and management for species richness. Any combination of these two approaches can also be used. Silvicultural prescriptions can be used to produce wood at a high percentage of the forest's biological potential while simultaneously providing wildlife habitat. Trade-offs are mandatory, but the degree to which timber production or wildlife habitat is traded off to meet either objective depends on management goals.

On public lands, these goals are prescribed by law and instituted through a required process of land-use planning. It is not a question of whether or not to produce both timber and wildlife in the managed forest—that is required by law. And it is not a question of whether both can be produced—they can. But there must be a commitment to do the job right and the necessary creative skill on the part of the forester and wildlife biologist to set objectives and make equitable trade-offs.

10
Impacts on Wood Production

by
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All timber management decisions have consequences in terms of how much wildlife habitat they either create or destroy. The forest manager must evaluate these consequences and make decisions that give full consideration to the habitat requirements of wildlife. The prudent manager of public forest lands operates under the multiple use concept in which timber and wildlife are both valid products of the managed forest. The manager must, therefore, be able to evaluate the costs of providing wildlife habitat in terms of impacts on wood production.

Evaluating Trade-Offs

All allocations of forest resources under the multiple use management concept are made in an atmosphere where trade-offs are implicit in every decision. It is important for the forest manager to evaluate the trade-offs and display them fully in the decisionmaking process.

How can the forest manager account for the costs of providing wildlife habitat? There are many possible approaches. The technique described here is now being used on National Forests in the Blue Mountains. It compares estimates of wood production under two timber management goals—one designed to produce the maximum cubic volume of wood and the other modified to provide desired wildlife habitat. The key to this technique is the ability to construct yield tables that reflect management goals.

Yield tables (such as Meyer 1961) are used to forecast how much and what kind of wood products can be expected from managed stands. Such tables show the expected growth pattern of a managed stand for one or more tree species. In the Blue Mountains, the USDA Forest Service derives managed yield tables by forecasting stand conditions at periodic intervals. These descriptions of stand condition include data on mean stand diameter at breast height (d.b.h.), average tree height, number of stems per hectare (acre), form class, and mortality. From these data, the forest manager can calculate the wood volume to be removed in commercial thinnings and in the final harvest cut. Fortunately, certain wildlife habitat requirements can be assessed in terms of wood products forgone by examining variables used in the construction of managed yield tables.

Methods of Calculating Impacts

The USDA Forest Service uses a stand projection model called Timber RAM (Timber Resource Allocation Model) to calculate timber harvest levels (Navon 1971). Timber RAM is a computer program designed to forecast timber production by 10-year periods. It considers management constraints such as laws and policies, managed yield tables, and the area in each stand type. The effect on wood production of changes in any of these four factors can be determined.

Timber RAM can also measure the effect on wood production of alternative forest management strategies by contrasting the wood volumes expected under each set of constraints. The costs of attaining wildlife habitat goals can be demonstrated when management strategies to achieve such goals are contrasted with strategies designed to produce maximum amounts of wood. Timber RAM is a fairly complex method of measuring impacts on wood production. A less complex method is to compare expected wood production from a stand managed primarily for timber with one in which due consideration is given to selected wildlife values as well as timber production.

The important point is that the manager can evaluate costs of achieving wildlife habitat objectives by modifying commonly used timber management techniques. Two very different forest management schemes designed to produce two distinct kinds of wildlife habitat are considered in this chapter: (1) those schemes designed to provide snags for primary and secondary cavity users and (2) those schemes that produce old-growth habitat. These two kinds of habitat appear to be similar, but they are actually quite different. The purpose in producing and retaining snags is to provide a single habitat element for a distinct group of species throughout a variety of forest communities and successional stages; the purpose in providing old-growth is to provide a *total* habitat condition in which large snags are an integral part.

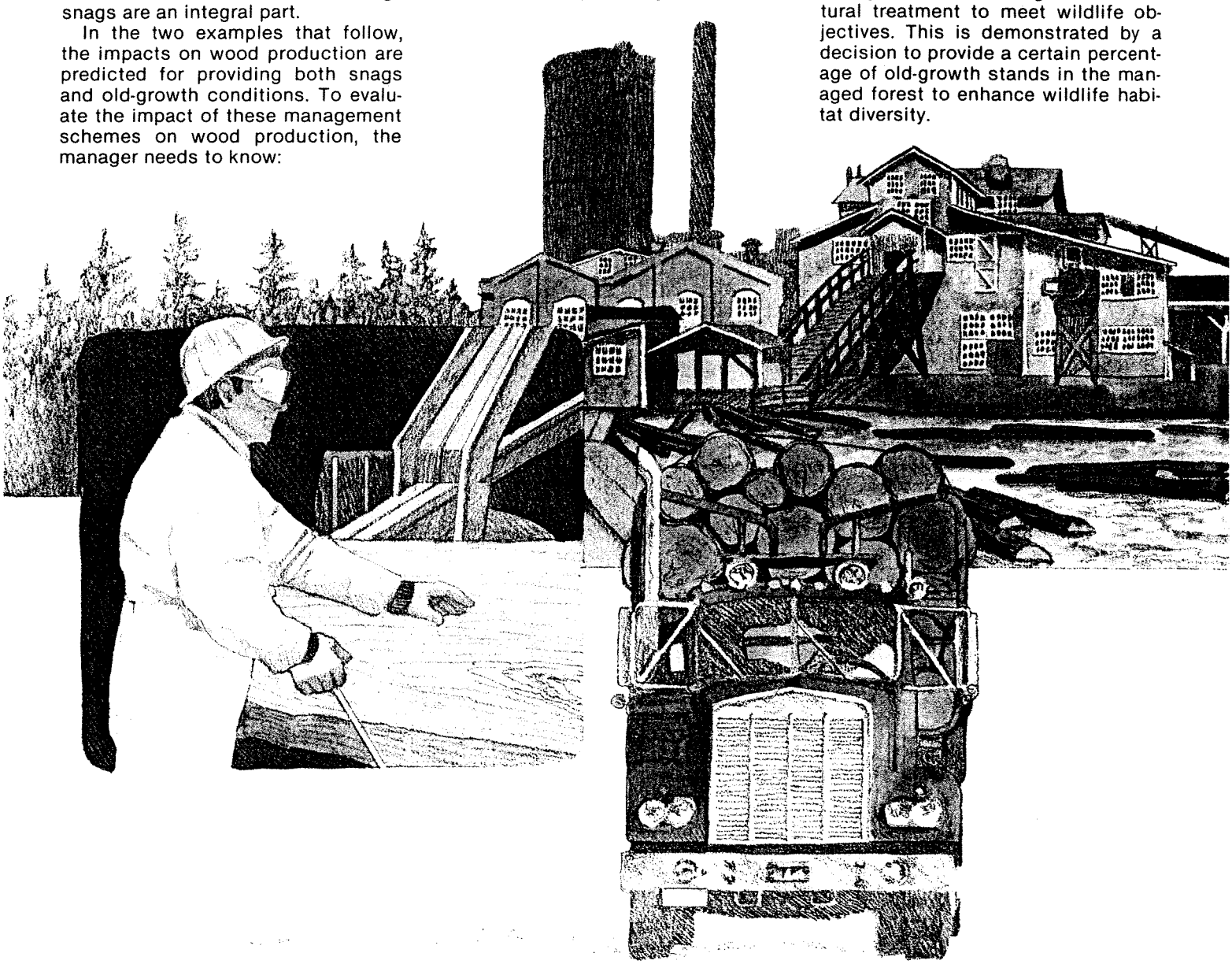
In the two examples that follow, the impacts on wood production are predicted for providing both snags and old-growth conditions. To evaluate the impact of these management schemes on wood production, the manager needs to know:

1. Management constraints: These deal primarily with the flow of timber to market over time. Section 11 of the National Forest Management Act of 1976 (U.S. Laws, Statutes, etc. Public Law 94-588) specifies that National Forests be managed to limit the sale of timber from each National Forest to a quantity equal to or less than that which can be removed annually in perpetuity on a sustained-yield basis.

2. Data in managed yield tables: Standard yield tables forecast growth of both existing and future forest stands. In the process described here, standard yield tables will be modified to account for the wood yields required to meet wildlife management objectives. Contrasting these two tables will show the cost of the wildlife management action in terms of wood yield forgone.

3. Area in each stand type: The forest is usually divided into stands or areas that will receive a similar type of management based on age class, species, and the specific management objectives for the site.

The examples which follow will demonstrate how to evaluate the impact on wood production of the two most common silvicultural adjustments required to meet wildlife habitat objectives. The first example shows how to judge the impact caused by forgoing harvest of some trees at different stages in stand development. This is demonstrated by examining the consequences to wood production of a decision to provide snag habitat for cavity-excavating birds and their associated secondary cavity users. The second example deals with the impact of changes in scheduling of silvicultural treatment to meet wildlife objectives. This is demonstrated by a decision to provide a certain percentage of old-growth stands in the managed forest to enhance wildlife habitat diversity.



Letter code	Life form	Species	Min. snag d.b.h. in centimeters (in)	Snags required per hectare (acre) to support various percentages of maximum woodpecker populations									
				100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
DRPI	13	pileated woodpecker	≧50.8 (≧20)	0.32 (0.14)	0.28 (0.12)	0.25 (0.11)	0.22 (0.09)	0.19 (0.08)	0.16 (0.07)	0.13 (0.05)	0.09 (0.04)	0.06 (0.03)	0.03 (0.01)
SPTH	13	Williamson's sapsucker	≧30.5 (≧12)	3.71 (1.50)	3.33 (1.35)	2.96 (1.20)	2.59 (1.05)	2.22 (0.90)	1.85 (0.75)	1.48 (0.60)	1.11 (0.45)	0.74 (0.30)	0.37 (0.15)
ASLE	13	Lewis' woodpecker	≧3.05 (≧12)	2.49 (1.01)	2.24 (0.90)	1.99 (0.80)	1.74 (0.70)	1.49 (0.60)	1.25 (0.50)	1.00 (0.40)	0.75 (0.30)	0.50 (0.20)	0.25 (0.10)
COAU	13	common flicker	≧30.5 (≧12)	0.93 (0.38)	0.84 (0.34)	0.74 (0.30)	0.65 (0.26)	0.56 (0.23)	0.47 (0.19)	0.37 (0.15)	0.28 (0.11)	0.19 (0.08)	0.09 (0.04)
DEAL	13	white-headed woodpecker	≧25.4 (≧10)	5.58 (2.25)	5.02 (2.03)	4.46 (1.80)	3.91 (1.58)	3.35 (1.35)	2.79 (1.13)	2.23 (0.90)	1.67 (0.68)	1.12 (0.45)	0.56 (0.23)
DEVI	13	hairy woodpecker	≧25.4 (≧10)	4.46 (1.80)	4.01 (1.62)	3.56 (1.44)	3.12 (1.26)	2.67 (1.08)	2.23 (0.90)	1.78 (0.72)	1.34 (0.54)	0.89 (0.36)	0.45 (0.18)

Table 33. Hard snag requirements for woodpeckers in the ponderosa pine community (source: appendix 22, modified to reflect snags required per hectare (acre))

Snag d.b.h. size class in centimeters (in)[2]	Snags required per hectare (acre) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the ponderosa pine community[1]									
	Percent of maximum potential populations									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
≧50.8 (≧20)	0.32 (0.14)	0.28 (0.12)	0.25 (0.11)	0.22 (0.09)	0.19 (0.08)	0.16 (0.07)	0.13 (0.05)	0.09 (0.04)	0.06 (0.03)	0.03 (0.01)
≧30.5 (≧12)	3.39 (1.36)	3.05 (1.23)	2.71 (1.09)	2.37 (0.96)	2.03 (0.82)	1.69 (0.68)	1.35 (0.55)	1.02 (0.41)	0.68 (0.27)	0.34 (0.14)
≧25.4 (≧10)	1.87 (0.75)	1.69 (0.68)	1.50 (0.60)	1.32 (0.53)	1.13 (0.45)	0.94 (0.38)	0.75 (0.30)	0.56 (0.23)	0.38 (0.15)	0.19 (0.08)
Total	5.58 (2.25)	5.02 (2.03)	4.46 (1.80)	3.91 (1.58)	3.35 (1.35)	2.79 (1.13)	2.23 (0.90)	1.67 (0.68)	1.12 (0.45)	0.56 (0.23)

See appendix 23 for footnotes and pages 70, 71, and 72 of chapter 5 for computation method.

Table 34. Snags required per hectare (acre) by d.b.h. class to meet the needs of woodpeckers at various population levels in the ponderosa pine community (source: appendix 23, modified to reflect snags required per hectare (acre))

Example 1: Providing Snag Habitat

To evaluate the impact of providing snags for cavity-excavating birds, the manager needs to have the following information:

1. Stand type: ponderosa pine.
2. Primary cavity-excavating species to be considered: pileated woodpecker, Williamson's sapsucker, Lewis' woodpecker, common flicker, white-headed woodpecker, and hairy woodpecker (table 33).
3. Maximum woodpecker population level per hectare (acre) for which snag habitat will be provided: 60 percent.
4. Site index: 72.
5. Number of snags required per unit area for each d.b.h. class to maintain woodpeckers at 60 percent of their maximum potential population level (table 34): 0.19 snag per hectare (0.08 snag/acre) ≧ 50.8-centimeter (≧20-in) d.b.h.; 2.03 snags per hectare (0.82 snag/acre) ≧30.5-centimeter (≧12-in) d.b.h.; and 1.13 snags per hectare (0.45 snag/acre) ≧25.4-centimeter (≧10-in) d.b.h.
6. Cubic stem volume for each selected snag class (fig. 85): 50.8-centimeter (20-in) d.b.h., 1.72 cubic meters (60.6 ft^3); 30.5-centimeter (12-in) d.b.h., 0.42 cubic meters (14.7 ft^3); 25.4-centimeter (10-in) d.b.h., 0.25 cubic meters (8.7 ft^3).
7. The percent of commercial forest land on which snag levels will be met: 50 percent.
8. The effective snag life by tree species and d.b.h. class: ponderosa pine snags 50.8-centimeter (20-in) d.b.h. will stand an average of 11 years; 30.5-centimeter (12-in) d.b.h., 7 years; and 25.4-centimeter (10-in) d.b.h., 6 years (fig. 86).

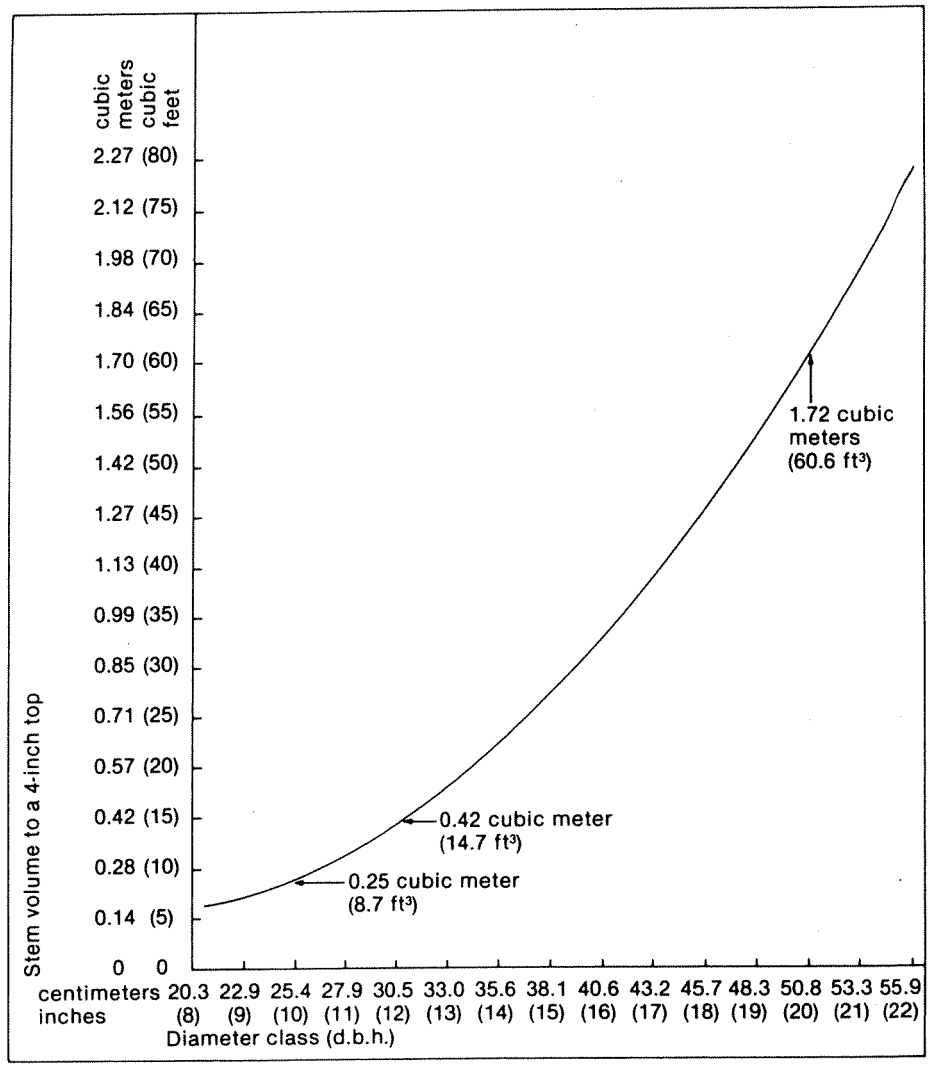


Figure 85. Cubic stem volume (to a 4-inch top) by diameter class (d.b.h.) for a ponderosa pine stand with a site index of 72. Average d.b.h. of all trees from table 35. Cubic volume per tree from table 36.

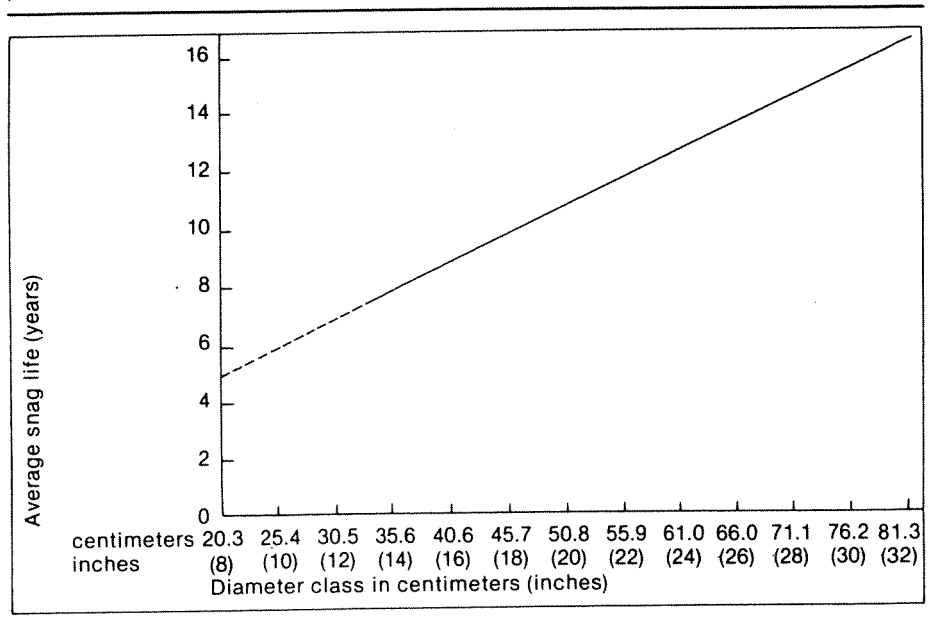


Figure 86. Average snag life for fire-killed ponderosa pine by diameter class (d.b.h.) as converted from Dahm's 1949 data (Dahms 1949).

Stand age (years)	Tree height in meters (ft)	Average d.b.h. in centimeters (inches)		
		All trees	Trees cut	Trees left
20	5.5 (18)	5.1 (2.0)	4.3 (1.7)	6.9 (2.7)
40	11.0 (36)	21.3 (8.4)	9.9 (3.9)	7.9 (3.1)
60	15.8 (52)	30.2 (11.9)	30.5 (12.0)	30.2 (11.9)
80	19.8 (65)	37.3 (14.7)	36.8 (14.5)	37.6 (14.8)
100	22.9 (75)	44.2 (17.4)	44.5 (17.5)	44.2 (17.4)
120	25.6 (84)	50.3 (19.8)		50.3 (19.8)
140	28.0 (92)	55.9 (22.0)		55.9 (22.0)
150	29.0 (95)	58.4 (23.0)		58.4 (23.0)
160	29.9 (98)	60.7 (23.9)		60.7 (23.9)
170	30.8 (101)	62.5 (24.6)		62.5 (24.6)
240	34.1 (112)	68.1 (26.8)		68.1 (26.8)

Stand age (years)	Number of trees per hectare (acre)			Mortality (number of trees per hectare (acre))
	All trees	Trees cut	Trees left	
20	2,469 (999)	1,851 (749)	618 (250)	37.0 (15)
40	581 (235)	225 (91)	336 (144)	7.4 (3)
60	348 (141)	91 (37)	257 (104)	4.9 (2)
80	252 (102)	62 (25)	190 (77)	2.5 (1)
100	188 (76)	40 (16)	148 (60)	0.0 (0)
120	148 (60)		148 (60)	0.0 (0)
140	148 (60)		148 (60)	4.9 (2)
150	143 (58)		143 (58)	0.0 (0)
160	141 (57)		141 (57)	2.5 (1)
170	138 (56)		138 (56)	19.8 (8)
240	119 (48)		119 (48)	0.0 (0)

Table 35. Stand data used to construct a yield table (table 36) for a managed ponderosa pine stand with a site index of 72 (based on managed yield tables developed for the Umatilla National Forest)

9. The length of time snags will be provided: continuously.

Average snag life is important in determining the number of snags in each d.b.h. class that will be provided throughout a rotation. As snag life increases, the impact on timber yield decreases dramatically. There seems to be a direct relationship between snag diameter and longevity (fig. 86) (Dahms 1949, Keen 1929, Hinds et al. 1965, Mielke 1950, Lyon 1977). Since an estimate of average snag life is required to adjust the standard yield tables, information presented by Dahms (1949) was adapted to develop relationships between snag diameter and longevity in a ponderosa pine forest. Most of the data on this subject are site- and species-specific; significant error may result if such data are applied too broadly.

Figure 87 shows the normal distribution of d.b.h. for trees in the stand. Trees could be selected for potential snags at any point along the curve. It is silviculturally desirable to select potential snags from trees in the d.b.h. and crown classes smaller than the stand average (figure 87). This increases the probability that the trees selected will become natural mortality because they are smaller and will probably die as a result of competition for growing space, nutrients, and water. Also, the larger trees can be commercially harvested while smaller snags from naturally occurring mortality are saved for wildlife.

Now the manager is ready to assess the impacts on wood production. There are two approaches: (1) a comparison of wood volume from managed yield tables which meet snag habitat requirements with wood volume from a managed yield table which maximizes timber yield and (2) an assessment of changes in first-decade timber yields resulting from changes in all three components of Timber RAM—management constraints, managed yield tables, and area in each stand type.

To construct managed yield tables with wildlife emphasis, it is necessary to determine the number of snags by size class needed to provide the desired level of snags (table 34). Table 35 is then used to determine how many snags are expected to occur as stand mortality.

In this example, the forest wildlife biologist recommends that snags be provided to maintain cavity-excavating birds at 60 percent of their potential maximum population, on 50 percent

Stand age (years)	All trees			Cut trees		
	Not adjusted for openings (area completely forested)		Adjusted for openings (10 percent of area in nonforested openings)	Not adjusted for openings		Adjusted for openings
	Cubic meters/tree[1] (ft^3/tree)[2]	Cubic meters/ hectare (ft^3/acre)	Cubic meters/ hectare (ft^3/acre)	Cubic meters/ tree (ft^3/tree)	Cubic meters/ hectare (ft^3/acre)	Cubic meters/ hectare (ft^3/acre)
20	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
40	0.15 (5.28)	86.8 (1,241)	78.2 (1,117)	0.17 (6.01)	38.3 (547)	34.4 (492)
60	0.40 (14.30)	141.1 (2,016)	126.9 (1,814)	0.41 (14.55)	37.6 (538)	33.9 (484)
80	0.74 (26.16)	186.7 (2,668)	168.0 (2,401)	0.72 (25.44)	44.5 (636)	40.0 (572)
100	1.18 (41.71)	221.8 (3,170)	199.6 (2,853)	1.19 (42.19)	47.2 (675)	42.5 (607)
120	1.67 (58.87)	247.1 (3,532)	222.4 (3,179)			
140	2.26 (79.78)	335.0 (4,787)	301.4 (4,308)			[3]
150	2.53 (89.43)	363.0 (5,187)	326.6 (4,668)			
160	2.80 (98.97)	394.7 (5,641)	355.3 (5,077)			
170	3.04 (107.38)	420.8 (6,013)	378.7 (5,412)			
240	3.92 (138.44)	465.0 (6,645)	418.5 (5,981)			[3]

[1]Cubic-meter volume per tree was converted from cubic-foot volume by using a conversion factor of 0.0283 cubic meter = 1 cubic foot.

[2]Cubic-foot volume is measured to a 4-inch top diameter.

[3]This table is used to develop yields for both the standard 140-year rotation and the extended 240-year rotation. For the standard rotation, 211.3 cubic meters per hectare (3,020 ft^3/acre) are removed at the shelterwood cut at age 140 years and an additional 98.0 cubic meters per hectare (1,400 ft^3/acre) are cut during overstory removal at age 150. For the extended rotation, 320.5 cubic meters per hectare (4,580 ft^3/acre) are removed at the shelterwood cut at age 240 years and an additional 98.0 cubic meters per hectare (1,400 ft^3/acre) are cut during overstory removal at age 250.

Table 36. Managed yield table for a ponderosa pine stand with a site index of 72

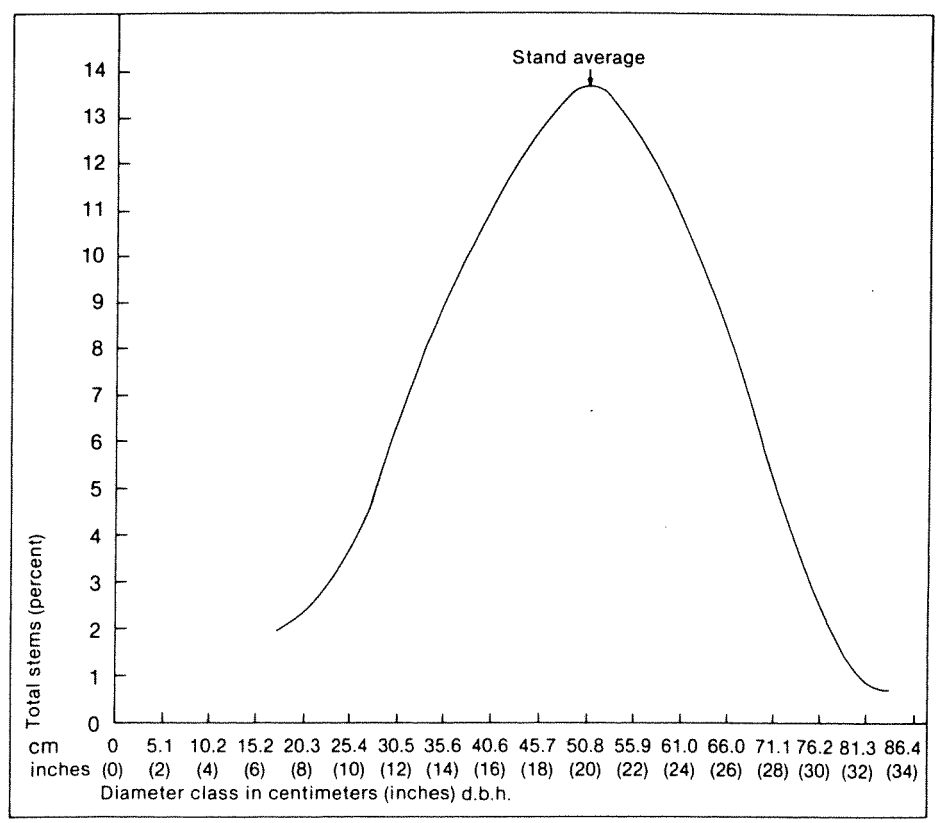


Figure 87. Characteristic shape of the curve depicting a typical distribution of diameter (d.b.h.) classes for a managed ponderosa pine stand with an average stand d.b.h. of 50.8 centimeters (20 in) (adapted from Meyer 1961, p. 36, table 27).

of the commercial forest land. To make an informed decision on this recommendation, the forest manager requests information on the volume of wood products that must be forgone to achieve the recommended snag level. A managed yield table (table 36) emphasizing timber outputs is calculated for the site using data in table 35. These tables display the conditions of the managed stand over time, including anticipated mortality, cubic volume growth, and cubic volume harvested. Tables 35 and 36 contain the basic data needed to compute the wood volume harvest that must be given up to meet snag habitat requirements.

Stage age (years)	Silvicultural treatment	Total wood yield (standard yield) in cubic meters/hectare (ft^3/acre) (source: table 36)	Yield forgone in cubic meters/hectare (ft^3/acre) to provide snags (source: table 38)	Adjusted yield in cubic meters/hectare (ft^3/acre)[1]
0 or 150	Overstory removal	98.0 (1,400)	16.7 (239)	81.3 (1,161)
40	Thinning	34.4 (492)	0.0 (0)	34.4 (492)
60	Thinning	33.9 (484)	0.0 (0)	33.9 (484)
80	Thinning	40.0 (572)	2.7 (38)	37.3 (534)
100	Thinning	42.5 (607)	6.8 (95)	35.7 (512)
140	Shelterwood cut	211.3 (3,020)	0.5 (7)	210.8 (3,013)
	Total	460.1 (6,575)	26.7 (379)	433.4 (6,196)

[1]Derived by subtracting yield forgone from standard yield.

Table 37. Managed yield table adjusted for reduced yields to provide snag habitat at the 60 percent management level

Stand age (years)	Silvicultural treatment
0 or 150	Overstory removal— the new stand is established. Mature trees left as seed sources and protection for the newly developing stands are removed. The few trees needed for snags are left—a modification in standard silvicultural practice.
40	Commercial thinning— a certain number of trees are cut and sold; this salvages mortality and encourages better growth in the remaining trees.
60	Commercial thinning.
80	Commercial thinning.
100	Commercial thinning.
140	Shelterwood cut— the mature stand is harvested except for trees left to provide seed to start a new stand and to ameliorate the environment for seedlings during their establishment.
150 or 0	Overstory removal— this is the final harvest cut.

Figure 88. A shelterwood silvicultural system for a ponderosa pine stand with site index of 72.

For this example, a shelterwood system has been selected. The periodic silvicultural treatment planned for the stand (ponderosa pine, site index 72) is shown in figure 88. A managed yield table, adjusted to account for natural openings in the stand, is constructed (table 36). This yield table is compared with another yield table (table 37) that shows wood production from the same area managed under a silvicultural prescription modified to meet snag requirements. The difference in wood volume produced under the two management schemes is the cost of providing snags. Reduction in wood production because of providing snags is computed as occurring at the times of commercial thinning or harvest.

Only one major modification in the standard management scheme (fig. 88) is required to meet snag requirements. Some mature trees must be left standing during final overstory removal at stand age 150. These trees will provide snags while the developing stand is too small to provide snags of appropriate size.

The formula used to compute the snag volume required at each stage of the selected silvicultural system is:

$$S = V[(A \times B) - M];$$

where S is the total cubic wood volume of snags intentionally left at the time of silvicultural treatment, V is the cubic wood volume per snag (fig. 85), A is the number of snags by d.b.h. class needed to meet hard snag requirements (table 34), B is the adjustment factor for the period snags will be provided, and M is the number of snags per unit area expected to occur naturally in the interval between silvicultural treatments. Values for M are obtained from the mortality column in table 35. B is calculated by dividing the number of years snags will be provided by the average number of years of snag life for the d.b.h. class desired. For example, consider a situation where 25.4-centimeter (10-in) d.b.h. snags must be provided for 60 years after

silvicultural treatment. Since the average snag of this size stands for an average of 6 years (fig. 86), the adjustment factor will be:

$$B = \frac{\text{years snags provided}}{\text{average years of snag life}} = \frac{60}{6} = 10.$$

Table 38 shows how the formula $S = V[(A \times B) - M]$ is used to calculate wood volume that must be retained for wildlife habitat, and therefore lost in commercial wood production. Table 38 shows the calculations of wood volume that must be retained at the time of overstory removal and at stand ages 60, 80, and 100 when commercial thinnings are made. No calculations are shown for thinning at age 40 because the average stand diameter is less than the minimum size required for snags.

Table 37 shows that 26.7 cubic meters of commercial wood volume per hectare (379 ft^3/acre) is required to provide snags at the 60 percent management level selected to provide habitat for woodpeckers. This represents a 5.8-percent reduction in wood yield:

Reduction in commercial wood yield (metric)

$$= \frac{26.7\ m^3/ha \text{ in snags}}{460.1\ m^3/ha \text{ total wood yield}}(100) = 5.8\%;$$

Reduction in commercial wood yield (English)

$$= \frac{379\ ft^3/acre \text{ in snags}}{6{,}575\ ft^3/acre \text{ total wood yield}}(100) = 5.8\%.$$

Remember, in this example the goal was to manage 50 percent of the ponderosa pine sites as snag habitat. Therefore, the percent reduction in wood production expected from all such sites would be:

$$(0.50)(0.058)(100) = 2.9\%.$$

This figure can then be used to make a proportional adjustment for the entire working circle.

If a stand projection model such as Timber RAM is available, more precise estimates of the amount of wood forgone in order to obtain wildlife objectives can be calculated. Two separate Timber RAM calculations must be made. The first calculation uses yield tables developed to optimize wood production. The second calculation uses the yield table in table 37 for one-half of the area (the goal was to manage for snags on 50 percent of the area) and yield tables developed for optimum wood production on the other half (table 36). A comparison of the first decade wood production from these two sets of calculations is the impact on wood production attributed to meeting snag habitat for wildlife.

Example 2: Providing Old-Growth Habitat

The first example dealt with the cost of providing snag habitat or harvest forgone under a standard rotation. The second example deals with providing old-growth stands as a specialized habitat or harvest forgone because of rotations extended beyond the normal length. The following information must be provided:

1. Plant community or timber type: ponderosa pine.
2. A definition of old growth: to qualify as old growth, the stand must have at least 37 trees per hectare (15 trees/acre) over 53.3-centimeter (21-in) d.b.h.; at least 1.2 snags per hectare (0.5 snag/acre) over 53.3-centimeter (12-in) d.b.h.; two or more canopy levels; and the presence of trees with heart rot and other signs of decadence.
3. Percent of commercial forest to be maintained in old growth: 5 percent.
4. Size of planning area: 2 023 hectares (5,000 acres).
5. Availability of areas reserved from cutting or scheduled for long rotations for other purposes: those with fragile soils, stream management units, visual management zones, or roadless areas that can satisfy old-growth requirements.

To simplify this example, it was assumed that no areas had already been set aside that could fill the old-growth requirement. In actual forest management situations, such substitutable areas frequently exist and can be subtracted from the old-growth requirement. This is a bookkeeping maneuver that prevents wood production losses from being counted twice. There would still be a loss in wood volume, but the loss can be legitimately attributed to a combination of factors rather than to wildlife habitat alone. The wood volume lost would not be diminished, but the loss attributed to providing wildlife habitat would be reduced.

The impact on wood volume yields would also vary depending on the primary classification of the area substituted. If the area was designated as a roadless area, it would very likely meet old-growth habitat conditions and could be considered substitutable. This would markedly reduce the loss in wood volume because old-growth conditions would probably last for an extended period.

If visual resource management areas are substituted for old growth, there would be an even smaller real decline in amount of wood production forgone because these stands would be subject to timber harvest; the only constraint is that the stand must present the visual impression of relatively mature and unbroken forest.

Stand age (years)	Scheduled silvicultural treatment	Snag d.b.h. class in centimeters (in)	Comments	Wood production forgone Formula: Snag volume = V [(A × B) − M]
0 or 150	Overstory removal	≧25.4 (≧10)	This site will not provide 25.4-centimeter (10-in) d.b.h. snags until the second commercial thinning at stand age 60 (table 35). Such snags and potential snags must be provided here for the first 60 years of the next stand.	$0.25[(1.13 \times \frac{60}{6}) - 0] = 2.8$ m³/ha $8.7[(0.45 \times \frac{60}{6}) - 0] = 39$ ft³/acre
		≧30.5 (≧12)	This site will not provide 30.5-centimeter (12-in) d.b.h. snags until the third commercial thinning at stand age 80 (table 35). Such snags and potential snags must be provided here for the first 80 years of the next stand.	$0.42[(2.03 \times \frac{80}{7}) - 0] = 9.7$ m³/ha $14.7[(0.82 \times \frac{80}{7}) - 0] = 138$ ft³/acre
		≧50.8 (≧20)	This site will not provide 50.8-centimeter (20-in) d.b.h. snags until the shelterwood cut at stand age 140 (table 35). Such snags and potential snags must be provided here for the first 140 years of the next stand.	$1.72[(0.19 \times \frac{140}{11}) - 0] = 4.2$ m³/ha $60.6[(0.08 \times \frac{140}{11}) - 0] = 62$ ft³/acre
Total volume forgone at stand age 150: 16.7 m³/hectare (239 ft³/acre)				
40	Commercial thinning	≧25.4 (≧10)	This site will not produce ≧25.4 centimeter (≧10-in) d.b.h. snags at this time. Snags were already provided at time of overstory removal at stand age 0 or 150 years.	
		≧30.5 (≧12)	Already provided at time of overstory removal at stand age 0 or 150 years.	
		≧50.8 (≧20)	Already provided at time of overstory removal at stand age 0 or 150 years.	
Total volume forgone at stand age 40: 0 m³/hectare (0 ft³/acre)				
60	Commercial thinning	≧25.4 (≧10)	At this entry, snags 25.4-centimeter (10-in) d.b.h. will be provided for the next 20 years.	$0.25[(1.13 \times \frac{20}{6}) - 4.9] = 0$ m³/ha[1] $8.7[(0.45 \times \frac{20}{6}) - 2] = 0$ ft³/acre[1]
		≧30.5 (≧12)	Already provided at time of overstory removal at stand age 0 or 150 years.	
		≧50.8 (≧20)	Already provided at time of overstory removal at stand age 0 or 150 years.	
Total volume forgone at stand age 60: 0 m³/hectare (0 ft³/acre)				

Stand age (years)	Scheduled silvicultural treatment	Snag d.b.h. class in centimeters (in)	Comments	Wood production forgone Formula: Snag volume = V [(A × B) − M]
80	Commercial thinning	≧25.4 (≧10)	At this entry, snags 25.4-centimeter (10-in) d.b.h. will be provided for the next 20 years.	$0.25[(1.13 \times \frac{20}{6}) - 2.5] = 0.3$ m³/ha $8.7[(0.45 \times \frac{20}{6}) - 1] = 4$ ft³/acre
		≧30.5 (≧12)	At this entry, snags 30.5-centimeter (12-in) d.b.h. will be provided for the next 20 years.	$0.42[(2.03 \times \frac{20}{7}) - 0] = 2.4$ m³/ha $14.7[(0.82 \times \frac{20}{7}) - 0] = 34$ ft³/acre
		≧50.8 (≧20)	Already provided at time of overstory removal at stand age 0 or 150 years.	
Total volume forgone at stand age 80: 2.7 m³/hectare (38 ft³/acre)				
100	Commercial thinning	≧25.4 (≧10)	At this entry, snags 25.4-centimeter (10-in) d.b.h. will be provided for the next 40 years.	$0.25[(1.13 \times \frac{40}{6}) - 0] = 1.9$ m³/ha $8.7[(0.45 \times \frac{40}{6}) - 0] = 26$ ft³/acre
		≧30.5 (≧12)	At this entry, snags 30.5-centimeter (12-in) d.b.h. will be provided for the next 40 years.	$0.42[(2.03 \times \frac{40}{7}) - 0] = 4.9$ m³/ha $14.7[(0.82 \times \frac{40}{7}) - 0] = 69$ ft³/acre
		≧50.8 (≧20)	Already provided at time of overstory removal at stand age 0 or 150 years.	
Total volume forgone at stand age 100: 6.8 m³/hectare (95 ft³/acre)				
140	Shelterwood cut	≧25.4 (≧10)	At this entry, snags 25.4-centimeter (10-in) d.b.h. will be provided for the next 10 years.	$0.25[(1.13 \times \frac{10}{6}) - 2.5] = 0$ m³/ha[1] $8.7[(0.45 \times \frac{10}{6}) - 1] = 0$ ft³/acre[1]
		≧30.5 (≧12)	At this entry, snags 30.5-centimeter (12-in) d.b.h. will be provided for the next 10 years.	$0.42[(2.03 \times \frac{10}{7}) - 2.5] = 0.2$ m³/ha $14.7[(0.82 \times \frac{10}{7}) - 1] = 3$ ft³/acre
		≧50.8 (≧20)	At this entry, snags 50.8-centimeter (20-in) d.b.h. will be provided for the next 10 years.	$1.72[(0.19 \times \frac{10}{11}) - 0] = 0.3$ m³/ha $60.6[(0.08 \times \frac{10}{11}) - 0] = 4$ ft³/acre
Total volume forgone at stand age 140: 0.5 m³/hectare (7 ft³/acre)				
150 or 0			See 0 to 150 years.	
Total volume forgone over entire rotation to provide snags for wildlife habitat: 26.7 m³/hectare (379 ft³/acre)				

[1]Where available mortality exceeds the calculated minimum number of snags, the volume forgone is shown as 0.

Table 38. Commercial wood production forgone at each stage of silvicultural treatment to provide snag habitat at the 60-percent level in a ponderosa pine stand with a site index of 72

Stand age (years)	Silvicultural treatment	Stand condition
0 or 240	Overstory removal (new stand has regenerated under the shelterwood)	Intensive forest management. Stand is thrifty and growth is maximized.
20		
40	Commercial thinning	
60	Commercial thinning	
80	Commercial thinning	
100	Commercial thinning	
120		No silvicultural practices applied. Stand progresses toward old-growth habitat condition.
140		
160		Approximates old-growth conditions. Stand decadence increasing.
180		
200		
220		
240 or 0	Shelterwood cut	

Figure 89. A silvicultural plan to achieve old-growth condition in a managed ponderosa pine stand with a site index of 72.

Stand age (years)	Silvicultural treatment	Wood volume harvested in cubic meters/hectare (ft^3/acre)	
		Standard 140-year rotation	Extended 240-year old-growth rotation
0 or 150	Overstory removal	98.0 (1,400)	98.0 (1,400)
40	Commercial thinning	34.4 (492)	34.4 (492)
60	Commercial thinning	33.9 (484)	33.9 (484)
80	Commercial thinning	40.0 (572)	40.0 (572)
100	Commercial thinning	42.5 (607)	42.5 (607)
140	Shelterwood cut	211.3 (3,020)	
240	Shelterwood cut		320.5 (4,580)
	Total	460.1 (6,575)	569.3 (8,135)

Table 39. Standard yield tables for a ponderosa pine type, with site index 72, comparing a standard 140-year rotation with an extended 240-year rotation that provides old-growth habitat

In this example, there are no substitutable areas and it is necessary to manage 3 hectares (7.4 acres) in extended rotations to keep 1 hectare (2.5 acres) in old-growth habitat condition. The desired age class distribution would be one stand in the 0-80 age class, one in the 81-160 age class, and one in the 161-240 age class which should mimic old-growth conditions. The area selected to provide the old-growth stand would be maintained in these three age classes so one-third would be in old growth at all times. This means that 15 percent of the forest area would be managed under a rotation of approximately 240 years. Such old-growth areas are considered part of the commercial forest base, and the products forgone are counted against full commercial potential.

If old-growth stands are to be maintained in the managed forest, they must be planned for and produced through silviculture. It seems possible to produce such stands by managing intensively for the first 100 years, then leaving the stand unmanaged until age 160 when it enters old-growth condition, and finally, delaying further harvest so long as the stand continues to meet the definition of old growth. Deterioration of the stand because of advancing decadence will finally produce conditions that do not meet management objectives. The stand would then be commercially harvested and regenerated.

Under the management scheme to provide old-growth habitat, the rotation age must be extended from 140 to 240 years. The stand should approach old-growth habitat condition at about age 160 and would probably provide old-growth habitat for about 80 years before final harvest. The

basic silvicultural plan for management of such stands is shown in figure 89. The impact on timber production of such a management scheme would come from: (1) the reduction in mean annual increment (MAI) because of the 100-year extension beyond the normal 140-year rotation period and (2) the loss in wood volume caused by scheduling harvest cuts to keep 5 percent of the planning area in old growth.

In this example, three separate stands—15 percent of the commercial forest land in the planning area—must be brought into three age classes and managed with extended rotations to provide the specified amount of old growth. As one old-growth stand reaches the scheduled replacement age of 240 years, another stand is ready to assume that role, and still another stand is being prepared to fill in behind that one.

The commercial wood volume forgone to provide old growth is calculated by comparing mean annual increments of stands in the 140-year rotation with stands in the 240-year rotation. The following formulas and calculations demonstrate this comparison:

$$\text{MAI} = \frac{L}{N};$$

where MAI is the mean annual increment, L is wood production in cubic meters per hectare or cubic feet per acre, and N is length of the rotation in years. The MAI for the standard 140-year rotation is computed from the totals in table 39:

$$\underset{\text{(metric)}}{\text{MAI}} = \frac{L}{N} = \frac{460.1}{140}$$

$$= 3.29 \text{ m}^3\text{/ha per year;}$$

$$\underset{\text{(English)}}{\text{MAI}} = \frac{L}{N} = \frac{6{,}575}{140}$$

$$= 46.96 \text{ ft}^3\text{/acre per year.}$$

The MAI for the extended 240-year rotation is computed the same way:

$$\underset{\text{(metric)}}{\text{MAI}} = \frac{L}{N} = \frac{569.3}{240}$$

$$= 2.37 \text{ m}^3\text{/ha per year;}$$

$$\underset{\text{(English)}}{\text{MAI}} = \frac{L}{N} = \frac{8{,}135}{240}$$

$$= 33.90 \text{ ft}^3\text{/acre per year.}$$

Next, the percent reduction in the mean annual increment between rotations is computed:

$$A = \frac{(B - C)}{B}(100);$$

where A is the percent reduction in MAI because of the extended rotation, B is the MAI for the standard 140-year rotation previously calculated, and C is the MAI for the extended 240-year rotation. Solving this equation:

$$\underset{\text{(metric)}}{A} = \frac{(B - C)}{B}(100)$$

$$= \frac{(3.29 - 2.37)}{3.29}(100) = 28\%;$$

$$\underset{\text{(English)}}{A} = \frac{(B - C)}{B}(100)$$

$$= \frac{(46.96 - 33.90)}{46.96}(100) = 28\%.$$

This measure of percent reduction in MAI is then used to compute the percent decline in wood production in the planning area as a result of maintaining 15 percent of the area in old growth. The percent loss in wood produced for any length of time is computed:

$$E = (F)(G)(100);$$

where E is the percent decline in wood production in the planning area caused by the decline in the MAI, F is the percent decline (expressed as a decimal) in wood production on areas subject to extended rotation, and G is the percent (expressed as a decimal) of the commercial forest land in the planning area managed under extended rotation. Solving this equation gives the result:

$$E = (F)(G)(100) = (0.28)(0.15)(100) = 4.2\%.$$

The 4.2-percent decline is the loss of wood volume that would be sustained over the planning area to satisfy old-growth habitat requirements. There is a 28-percent reduction in MAI in the area (15 percent of the total) actually under extended rotation management. The remaining area (85 percent of the total) is managed for a maximum MAI.

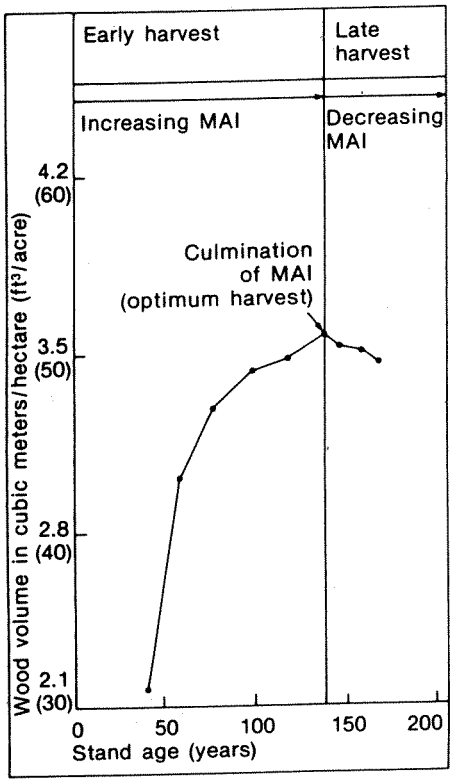


Figure 90. Harvest cuts that occur either before or after culmination of mean annual increment (MAI) result in loss of wood volume production. Data are from a ponderosa pine stand with a site index of 72 in the Umatilla National Forest.

Impact of Scheduling on Wood Production

There is an additional impact from providing old-growth habitat. This is the loss caused by less than optimum scheduling of silvicultural treatments to bring the stands into condition to meet the definition of old growth at the desired time. Such losses may vary from severe to almost nothing depending on the age class distribution of existing stands. The closer the stands are to the desired age class distribution the less the cost of modifying their condition.

For example, if the planning area already contains adequate acreage in stands of the right age classes (0-80, 81-160, and 161-240 years), there would be little or no impact from scheduling. But if the stands are all in one condition and of one age class, the cost of bringing the required 15 percent of the area into a regulated condition would be high.

The technique used to regulate the harvest of wood products over time can also be used to determine the impact of scheduling on wood production. There are essentially two ways to regulate harvest to meet management objectives—area regulation and volume regulation. Under area regulation, the decision of how much and when to cut is based on the amount of area stocked. Under volume regulation, the decision is based on the growing-stock volume and growth increment—area is disregarded.

In the Blue Mountains, there is currently an uneven distribution of age classes. Furthermore, current USDA Forest Service timber management planning is based on volume regulation which does not necessarily produce stands evenly distributed by age class. If a special distribution of age classes is needed for a particular purpose, this distribution must be intentionally produced through management; it will not occur as a matter of course.

The impact on wood production arises from the necessity to regenerate some stands at times other than the optimum age for timber production or culmination of MAI. If such harvesting occurs either before or after culmination of MAI, there is a loss in total wood volume production (fig. 90). The loss of potential wood volume in an old-growth management regime would be most pronounced in the early years of such a regime. Once the desired regulated state is obtained, loss in wood production would be limited to reductions in MAI caused by extending the rotation age.

These early impacts on wood production, because of requirements for stand regulation, may also be evaluated with the Timber RAM program. The approach is similar to that described for evaluating the impact on wood production of providing snags. The data from the standard yield table for extended rotation management (table 39) are added to Timber RAM's data base, and additional stand age classes are created for those stands to be managed under extended rotations.

In example 2, the 2 023-hectare (5,000-acre) planning area is covered by ponderosa pine. Old growth is to be maintained on 5 percent of the area or 101 hectares (250 acres). Stands of 3 age classes (0-80, 81-160, and 161-240 years) are designated for extended rotations. Each of these stands must be at least 101 hectares (250 acres) in size. This results in at least 303 hectares (750 acres) under rotations of approximately 240 years.

The regeneration schedule for each stand is based on the necessity to maintain the three appropriate age classes so that one will be in old growth at all times. Timber RAM can be used to compare wood volume produced between a working circle managed under volume regulation with a 140-year rotation and a similar regime with 15 percent of the planning area managed under a 240-year rotation.

During the first decade of management, the impact on wood harvested because of scheduling may be high—as much as 12 to 14 percent. This impact will gradually lessen with time, reaching zero when the desired regulation is obtained. At that point, the only loss in wood production would be attributable to extended rotation of stands presently in, or scheduled for, old-growth habitat.

Costs in wood volume production associated with providing wildlife habitat can be calculated for other silvicultural operations by adjusting the yield tables as needed and comparing them with standard yield tables. When such costs are computed for a planning area or a combination of planning areas, or with two or more adjustments for habitat, a computer program like Timber RAM can be helpful.

Trade-Offs Must Be Identified

It is useful again to recall two of Commoner's (1971) "laws" of ecology: "everything is connected to everything else," and "there is no such thing as a free lunch." Those concerned with wildlife in the managed forest should be aware that all adjustments in forest management for the welfare of wildlife also have impacts on wood production.

These "laws" of ecology might just as well be called "laws" of economics. Adjustments in forest management schemes that optimize wood production to provide wildlife habitat will cause some loss in wood available for harvest. That loss is directly related to dollars and jobs.

The prudent manager of public forest lands, operating under the multiple use management concept, must evaluate the costs of providing wildlife habitat in terms of wood products forgone. All multiple use forest management takes place in an environment where trade-offs are the standard operating procedure. These trade-offs are appropriate only when the manager is able and willing to compare costs and benefits for both wildlife and wood products and to reveal them fully.

Appendices

Introduction

The 29 appendices display basic information about wildlife species in the Blue Mountains. They also provide a means for relating wildlife to habitats for ready use in forest management and land-use planning. This information is specific to the Blue Mountains, but the appendices illustrate a format for organizing and displaying wildlife information for use in planning that can be applied in other regions. The displays can easily be converted for computer manipulation. In fact, the system presented here was designed to be compatible with the USDA Forest Service's Total Resource Inventory (TRI) system (USDA Forest Service 1978b) and the "Run Wild" wildlife data handling system (Patton 1978). The appendices are interrelated and were built in stages with many interlocking parts (fig. 91).

Appendix 1 lists in phylogenetic order the common and scientific names of 378 species of wildlife that occur in the Blue Mountains. Information was obtained from Stebbins (1966), American Ornithologists' Union (1957, 1973a, 1973b), Hall and Kelson (1959), and Johnson and Ostenson (1959).

Appendix 2 lists computer codes for the species in appendix 1. The codes are the first two letters of each part of the scientific name. For example, the species code for the American wigeon (***Anas americana***) is ANAM. In cases where more than one species would have the same letter code, 5 or 6 letters may be necessary. For example, the code for the pronghorn (***Antilocapra americana***) is listed as ANAME to distinguish it from the wigeon. These codes are abbreviations that are especially useful in computer processing.

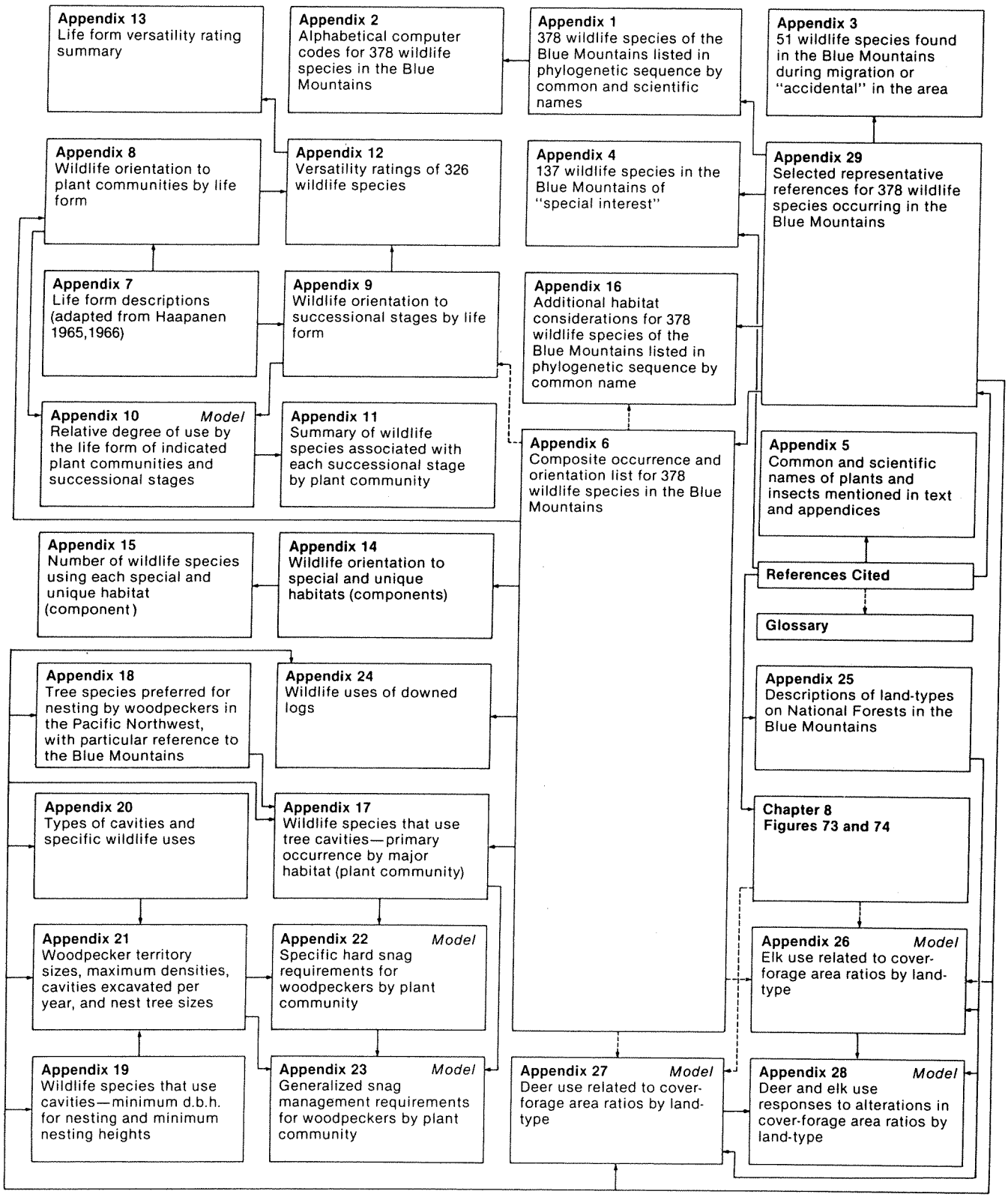
Appendix 3 lists 51 nonresident bird species whose dependence on habitats in the Blue Mountains is seasonal or "accidental." Except for appendix 6, these species are not included in any other appendices. Habitat management for resident species was assumed to have similar effects for nonresident species of the same life form.

Appendix 4 lists 137 wildlife species of special interest due to their status as threatened or endangered. Forest managers are advised to more carefully consider the impact of forest management activities on these species.

Appendix 5 lists the common and scientific names of plants and insects mentioned in text and appendices.

Appendix 6 displays wildlife orientation to various habitats for feeding or reproduction and contains most of the information upon which other appendices are built. Blank spaces indicate that information was lacking. The blanks can be filled as data become available. Such information may differ significantly from region to region. This display was constructed to allow easy inclusion of locally significant, new, or improved information. Data in appendix 6 often include "best estimates" based on the rationale that few land management activities will be deferred until scientifically derived data are at hand.

Figure 91. Relationship between appendices. Solid arrows indicate the sequence of development of the appendices. Dashed arrows show where additional supporting data were obtained.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Appendix 7 categorizes wildlife into life forms based on orientation to plant communities and successional stages for purposes of reproduction and feeding. The life form display was adapted from Haapanen (1965, 1966) and groups species that use the same habitats for feeding and reproduction. The response of most species in a life form to habitat manipulation is similar.

Appendix 8 demonstrates orientation of life forms to plant communities. Some 326 of the 378 wildlife species found in the Blue Mountains are included in appendix 8 and in appendices 9-15. Fifty-two are excluded —the sole member of life form 1, the semiterrestrial bullfrog, and 51 migratory and "accidental" species listed in appendix 3.

Appendix 9 relates feeding and reproductive orientations of each species to successional stages of the plant communities identified in appendix 8.

Appendix 10 shows the relative degree of use of plant communities and successional stages by life forms and can be used to analyze responses of life forms to habitat alterations.

Appendix 11 is a summary of wildlife species associated with each successional stage by plant community. It provides information on the importance of each plant community and successional stage in terms of the number of wildlife species supported.

Appendix 12 is a versatility rating for wildlife species derived from the number of plant communities and successional stages used for feeding or reproduction or both. These ratings can alert the analyst to species with the greatest sensitivity to habitat manipulation.

Appendix 13 gives the versatility rating of each life form. The ratings were derived by taking the mean of the versatility scores of the species in each life form. This appendix shows which life forms are most sensitive to habitat manipulation.

Appendix 14 refines and expands information from appendix 6 to show orientation of life forms to special and unique habitats and other habitat components.

Appendix 15 shows the number of species associated with special and unique habitat features for reproduction and feeding and is a summary of the species totals from appendix 14.

Appendix 16 identifies particular habitat orientations of wildlife species not described elsewhere.

Appendix 17 identifies plant communities required by cavity-using wildlife. Sources used were Miller and Miller (1974-75) and species-specific references in appendix 29.

Appendix 18 is a guide to tree species preferred for nesting by woodpeckers in the Pacific Northwest, with particular reference to the Blue Mountains.

Appendix 19 gives the minimum d.b.h. of trees used for nesting and nest heights for wildlife species that use cavities.

Appendix 20 lists the type of cavities and the specific cavity use by wildlife species.

Appendix 21 rearranges the information on habitat requirements of woodpeckers in appendices 19 and 20 to provide the source data for the snag management models in appendices 22 and 23.

Appendix 22 lists by plant community, the hard snag requirements for woodpeckers. Data from appendix 21 were used to determine the snags required per 100 hectares (100 acres) to support various population levels of primary excavators. Appendix 22 enables the user to consider different populations for each species. If all species are to be managed at the same level, appendix 23 should be used.

Appendix 23 uses information in appendix 22 to develop snag requirements by d.b.h. class for primary excavators as a group.

Appendix 24 relates five condition classes of logs to wildlife use.

Appendix 25 describes the geophysical, edaphic, and vegetational characteristics of the Blue Mountains by land-type.

The potential natural vegetation classifications or "K" numbers used in appendix 25 are from the 1975 revised map developed by Küchler (1964). These "K" numbers are different from Küchler (1970) (table 40) and from those used in USDA Forest Service (1978a). Refer to manual developed by Bailey (1978) for descriptions of ecoregions on map in USDA Forest Service (1978a).

Appendix 26 describes potential elk use as related to cover-forage area ratios by land-type. Sources used in appendix 26 were Craighead et al. (1973), Franklin et al. (1975), Lyon (1975) and appendices 6, 25, and 29. Appendix 27 gives the same information for deer. Sources used in appendix 27 were Cronemiller and Bartholomew (1950), Dasmann and Taber (1956), Linsdale and Tomich (1953), Tueller and Monroe [1975], and appendices 6, 25, and 29.

Appendix 28 illustrates the response of deer and elk to alterations in cover-forage area ratios by land-type.

Appendix 29 is a list of particularly pertinent literature references for each of the wildlife species in the Blue Mountains. The literature cited sections of these references will guide the reader to additional literature.

Comparison between two potential natural vegetation classifications			
From 1975 revised map (Küchler 1964) [use this]		From 1966 map (Küchler 1970) [do *not* use this]	
Ponderosa shrub forest (*Pinus*)	K10	K10	Western ponderosa forest (*Pinus*)
Western ponderosa forest (*Pinus*)	K11	K10	Western ponderosa forest (*Pinus*)
Douglas-fir forest (*Pseudotsuga*)	K12	K11	Douglas-fir forest (*Pseudotsuga*)
Grand fir-Douglas-fir forest (*Abies-Pseudotsuga*)	K14	K13	Grand fir-Douglas-fir forest (*Abies-Pseudotsuga*)
Western spruce-fir forest (*Picea-Abies*)	K15	K14	Western spruce-fir forest (*Picea-Abies*)
Juniper steppe woodland (*Juniperus-Artemisia-Agropyron*)	K24	K49	Sagebrush steppe (*Artemisia-Agropyron*)
Mountainmahogany-oak scrub (*Cercocarpus-Quercus*)	K37	K31	Mountainmahogany-oak scrub (*Cercocarpus-Quercus*)
Wheatgrass-bluegrass (*Agropyron-Poa*)	K51	K44	Wheatgrass-bluegrass (*Agropyron-Poa*)
Alpine meadows and barren (*Agrostis, Carex, Festuca, Poa*)	K52	K45	Alpine meadows and barren (*Agrostis, Carex, Festuca, Poa*)
Sagebrush steppe (*Artemisia-Agropyron*)	K55	K49	Sagebrush steppe (*Artemisia-Agropyron*)

Table 40. Two potential natural vegetation classifications used by Küchler (1964, 1970). Küchler (1964) is the correct reference

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Specific hard snag requirements for woodpeckers by plant community

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Generalized snag management requirements for woodpeckers by plant community

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Elk use related to cover-forage area ratios by land-type

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Selected representative references for 378 wildlife species occurring in the Blue Mountains

Appendix 1

378 wildlife species of the Blue Mountains listed in phylogenetic sequence by common and scientific names

Letter code	Life form	Common name	Scientific name
AMPHIBIANS			
AMTI	2	tiger salamander	*Ambystoma tigrinum*
AMMA	2	long-toed salamander	*Ambystoma macrodactylum*
ASTR	2	tailed frog	*Ascaphus truei*
SCIN	2	Great Basin spadefoot toad	*Scaphiopus intermontanus*
BUBO	2	western toad	*Bufo boreas*
BUWO	2	Woodhouse toad	*Bufo woodhousei*
HYRE	2	Pacific treefrog	*Hyla regilla*
RAPR	2	spotted frog	*Rana pretiosa*
RAPI	2	leopard frog	*Rana pipiens*
RACA	1	bullfrog	*Rana catesbeiana*
REPTILES			
CHPI	3	painted turtle	*Chrysemys picta*
SCOC	5	western fence lizard	*Sceloporus occidentalis*
SCGR	5	sagebrush lizard	*Sceloporus graciosus*
UTST	4	side-blotched lizard	*Uta stansburiana*
PHDO	5	short-horned lizard	*Phrynosoma douglassi*
EUSK	3	western skink	*Eumeces skiltonianus*
CNTI	5	western whiptail	*Cnemidophorus tigris*
CHBO	15	rubber boa	*Charina bottae*
DIPU	3	ringneck snake	*Diodophis punctatus*
COCO	5	yellow-bellied racer	*Coluber constrictor*
MATA	5	striped whipsnake	*Masticophis taeniatus*
PIME	5	gopher snake	*Pituophis melanoleucus*
THSI	3	common garter snake	*Thamnophis sirtalis*
THEL	5	western terrestrial garter snake	*Thamnophis elegans*
HYTO	5	night snake	*Hypsiglena torquata*
CRVI	5	western rattlesnake	*Crotalus viridis*
BIRDS			
GAIM	3	common loon	*Gavia immer*
GAAR	3	Arctic loon	*Gavia arctica*
POGR	3	red-necked grebe	*Podiceps grisegena*
POAU	3	horned grebe	*Podiceps auritus*
PONI	3	eared grebe	*Podiceps nigricollis*
AEOC	3	western grebe	*Aechmophorus occidentalis*
POPO	3	pied-billed grebe	*Podilymbus podiceps*

Letter code	Life form	Common name	Scientific name
BIRDS			
PEER	3	white pelican	*Pelecanus erythrorhynchos*
PHAU	3	double-crested cormorant	*Phalacrocorax auritus*
ARHE	12	great blue heron	*Ardea herodias*
CAAL	7	common egret	*Casmerodius albus*
NYNY	7	black-crowned night heron	*Nycticorax nycticorax*
BOLE	3	American bittern	*Botaurus lentiginosus*
PLCH	12	white-faced ibis	*Plegadis chihi*
CYOL	3	mute swan	*Cygnus olor*
OLCO	3	whistling swan	*Olor columbianus*
BRCA	3	Canada goose	*Branta canadensis*
BRNI	3	black brant	*Branta nigricans*
ANAL	3	white-fronted goose	*Anser albifrons*
CHCA	3	snow goose	*Chen caerulescens*
CHRO	3	Ross' goose	*Chen rossii*
ANPL	3	mallard	*Anas platyrhynchos*
ANST	3	gadwall	*Anas strepera*
ANAC	3	pintail	*Anas acuta*
ANCR	3	green-winged teal	*Anas crecca*
ANDI	3	blue-winged teal	*Anas discors*
ANCY	3	cinnamon teal	*Anas cyanoptera*
ANPE	3	European wigeon	*Anas penelope*
ANAM	3	American wigeon	*Anas americana*
ANCL	3	northern shoveler	*Anas clypeata*
AISP	14	wood duck	*Aix sponsa*
AYAM	3	redhead	*Aythya americana*
AYCO	3	ring-necked duck	*Aythya collaris*
AYVA	3	canvasback	*Aythya valisineria*
AYMA	3	greater scaup	*Aythya marila*
AYAF	3	lesser scaup	*Aythya affinis*
BUCL	14	common goldeneye	*Bucephala clangula*
BUIS	14	Barrow's goldeneye	*Bucephala islandica*
BUAL	14	bufflehead	*Bucephala albeola*
HIHI	3	harlequin duck	*Histrionicus histrionicus*
MEDE	3	white-winged scoter	*Melanitta deglandi*
OXJA	3	ruddy duck	*Oxyura jamaicensis*
LOCU	14	hooded merganser	*Lophodytes cucullatus*
MEME	14	common merganser	*Mergus merganser*
MESE	3	red-breasted merganser	*Mergus serrator*
CAAU	4	turkey vulture	*Cathartes aura*
ELLE	11	white-tailed kite	*Elanus leucurus*

Letter code	Life form	Common name	Scientific name
BIRDS			
ACGE	11	goshawk	*Accipiter gentilis*
ACST	11	sharp-shinned hawk	*Accipiter striatus*
ACCO	11	Cooper's hawk	*Accipiter cooperii*
BUJA	12	red-tailed hawk	*Buteo jamaicensis*
BUSW	7	Swainson's hawk	*Buteo swainsoni*
BULA	5	rough-legged hawk	*Buteo lagopus*
BURE	4	ferruginous hawk	*Buteo regalis*
AQCH	12	golden eagle	*Aquila chrysaetos*
HALE	12	bald eagle	*Haliaeetus leucocephalus*
CICY	5	marsh hawk	*Circus cyaneus*
PAHA	12	osprey	*Pandion haliaetus*
FAME	4	prairie falcon	*Falco mexicanus*
FAPE	4	peregrine	*Falco peregrinus*
FACO	11	merlin	*Falco columbarius*
FASP	14	American kestrel	*Falco sparverius*
DEOB	5	blue grouse	*Dendragapus obscurus*
CACA	5	Franklin's grouse	*Canachites canadensis*
BOUM	5	ruffed grouse	*Bonasa umbellus*
LALE	4	white-tailed ptarmigan	*Lagopus leucurus*
PEPH	5	sharp-tailed grouse	*Pedioecetes phasianellus*

Letter code	Life form	Common name	Scientific name
CEUR	5	sage grouse	*Centrocercus urophasianus*
COVI	5	bobwhite	*Colinus virginianus*
LOCA	5	California quail	*Lophortyx californicus*
ORPI	5	mountain quail	*Oreortyx pictus*
ALCH	4	chukar	*Alectoris chukar*
PEPE	5	gray partridge	*Perdix perdix*
PHCO	5	ring-necked pheasant	*Phasianus colchicus*
MEGA	5	turkey	*Meleagris gallopavo*
GRCA	3	sandhill crane	*Grus canadensis*
RALI	3	Virginia rail	*Rallus limicola*
POCA	3	sora	*Porzana carolina*
FUAM	3	American coot	*Fulica americana*
CHAL	3	snowy plover	*Charadrius alexandrinus*
CHVO	3	killdeer	*Charadrius vociferus*
CHMO	3	mountain plover	*Charadrius montanus*
CAGA	3	common snipe	*Capella gallinago*
NUAM	3	long-billed curlew	*Numenius americanus*
BALO	5	upland sandpiper	*Bartramia longicauda*
ACMA	3	spotted sandpiper	*Actitis macularia*

Letter code	Life form	Common name	Scientific name
BIRDS			
TRSO	7	solitary sandpiper	*Tringa solitaria*
TRME	3	greater yellowlegs	*Tringa melanoleuca*
TRFL	3	lesser yellowlegs	*Tringa flavipes*
CASE	3	willet	*Catoptrophorus semipalmatus*
CAME	3	pectoral sandpiper	*Calidris melanotos*
CABA	3	Baird's sandpiper	*Calidris bairdii*
CAMI	3	least sandpiper	*Calidris minutilla*
CAMA	3	western sandpiper	*Calidris mauri*
LISC	3	long-billed dowitcher	*Limnodromus scolopaceus*
REAM	3	American avocet	*Recurvirostra americana*
STTR	3	Wilson's phalarope	*Steganopus tricolor*
LOLO	3	northern phalarope	*Lobipes lobatus*
LAAR	3	herring gull	*Larus argentatus*
LACA	3	California gull	*Larus californicus*
LADE	3	ring-billed gull	*Larus delawarensis*
LAPI	3	Franklin's gull	*Larus pipixcan*
LAPH	3	Bonaparte's gull	*Larus philadelphia*

Letter code	Life form	Common name	Scientific name
STFO	3	Forster's tern	*Sterna forsteri*
HYCA	3	Caspian tern	*Hydroprogne caspia*
CHNI	3	black tern	*Chlidonias niger*
COFA	11	band-tailed pigeon	*Columba fasciata*
COLI	4	rock dove	*Columba livia*
ZEMA	11	mourning dove	*Zenaida macroura*
COAM	8	yellow-billed cuckoo	*Coccyzus americanus*
TYAL	14	barn owl	*Tyto alba*
OTAS	14	screech owl	*Otus asio*
OTFL	14	flammulated owl	*Otus flammeolus*
BUVI	12	great horned owl	*Bubo virginianus*
NYSC	5	snowy owl	*Nyctea scandiaca*
GLGN	14	pygmy owl	*Glaucidium gnoma*
SPCU	15	burrowing owl	*Speotyto cunicularia*
STVA	14	barred owl	*Strix varia*
STOC	14	spotted owl	*Strix occidentalis*
STNE	12	great gray owl	*Strix nebulosa*
ASOT	11	long-eared owl	*Asio otus*
ASFL	5	short-eared owl	*Asio flammeus*
AEAC	14	saw-whet owl	*Aegolius acadicus*
PHNU	6	poorwill	*Phalaenoptilus nuttallii*
CHMI	6	common nighthawk	*Chordeiles minor*

Letter code	Life form	Common name	Scientific name
BIRDS			
CYNI	4	black swift	*Cypseloides niger*
CHVA	14	Vaux's swift	*Chaetura vauxi*
AESA	4	white-throated swift	*Aeronautes saxatalis*
ARAL	7	black-chinned hummingbird	*Archilochus alexandri*
SEPL	7	broad-tailed hummingbird	*Selasphorus platycercus*
SERU	11	rufous hummingbird	*Selasphorus rufus*
STCA	7	calliope hummingbird	*Stellula calliope*
MEAL	16	belted kingfisher	*Megaceryle alcyon*
COAU	13	common flicker	*Colaptes auratus*
DRPI	13	pileated woodpecker	*Dryocopus pileatus*
ASLE	13	Lewis' woodpecker	*Asyndesmus lewis*
SPVA	13	yellow-bellied sapsucker	*Sphyrapicus varius*
SPTH	13	Williamson's sapsucker	*Sphyrapicus thyroideus*
DEVI	13	hairy woodpecker	*Dendrocopos villosus*
DEPU	13	downy woodpecker	*Dendrocopos pubescens*
DEAL	13	white-headed woodpecker	*Dendrocopos albolarvatus*

Letter code	Life form	Common name	Scientific name
PIAR	13	black-backed three-toed woodpecker	*Picoides arcticus*
PITR	13	northern three-toed woodpecker	*Picoides tridactylus*
TYTY	7	eastern kingbird	*Tyrannus tyrannus*
TYVE	11	western kingbird	*Tyrannus verticalis*
MYCI	14	ash-throated flycatcher	*Myiarchus cinerascens*
SASA	4	Say's phoebe	*Sayornis saya*
EMTR	7	willow flycatcher	*Empidonax traillii*
EMHA	11	Hammond's flycatcher	*Empidonax hammondii*
EMOB	8	dusky flycatcher	*Empidonax oberholseri*
EMWR	7	gray flycatcher	*Empidonax wrightii*
EMDI	10	western flycatcher	*Empidonax difficilis*
COVIR	9	eastern wood pewee	*Contopus virens*
COSO	11	western wood pewee	*Contopus sordidulus*
NUBO	10	olive-sided flycatcher	*Nuttallornis borealis*
ERAL	5	horned lark	*Eremophila alpestris*
TATH	14	violet-green swallow	*Tachycineta thalassina*

Letter code	Life form	Common name	Scientific name
BIRDS			
IRBI	14	tree swallow	*Iridoprocne bicolor*
RIRI	16	bank swallow	*Riparia riparia*
STRU	16	rough-winged swallow	*Stelgidopteryx ruficollis*
HIRU	4	barn swallow	*Hirundo rustica*
PEPY	4	cliff swallow	*Petrochelidon pyrrhonota*
PECA	11	gray jay	*Perisoreus canadensis*
CYCR	9	blue jay	*Cyanocitta cristata*
CYST	11	Steller's jay	*Cyanocitta stelleri*
PIPI	7	black-billed magpie	*Pica pica*
COCOR	4	common raven	*Corvus corax*
COBR	11	common crow	*Corvus brachyrhynchos*
GYCY	10	pinyon jay	*Gymnorhinus cyanocephalus*
NUCO	10	Clark's nutcracker	*Nucifraga columbiana*
PAAT	14	black-capped chickadee	*Parus atricapillus*
PAGA	14	mountain chickadee	*Parus gambeli*
PARU	14	chestnut-backed chickadee	*Parus rufescens*

Letter code	Life form	Common name	Scientific name
PSMI	8	bushtit	*Psaltriparus minimus*
SICA	13	white-breasted nuthatch	*Sitta carolinensis*
SICAN	13	red-breasted nuthatch	*Sitta canadensis*
SIPY	13	pygmy nuthatch	*Sitta pygmaea*
CEFA	14	brown creeper	*Certhia familiaris*
CIME	3	dipper	*Cinclus mexicanus*
TRAE	14	house wren	*Troglodytes aedon*
TRTR	3	winter wren	*Troglodytes troglodytes*
TEPA	3	long-billed marsh wren	*Telmatodytes palustris*
CAMEX	4	canyon wren	*Catherpes mexicanus*
SAOB	4	rock wren	*Salpinctes obsoletus*
MIPO	7	mockingbird	*Mimus polyglottos*
DUCA	7	gray catbird	*Dumetella carolinensis*
ORMO	7	sage thrasher	*Oreoscoptes montanus*
TUMI	7	American robin	*Turdus migratorius*
IXNA	11	varied thrush	*Ixoreus naevius*

Letter code	Life form	Common name	Scientific name
BIRDS			
CAGU	5	hermit thrush	*Catharus guttatus*
CAUS	7	Swainson's thrush	*Catharus ustulatus*
CAFU	5	veery	*Catharus fuscescens*
SIME	14	western bluebird	*Sialia mexicana*
SICU	14	mountain bluebird	*Sialia currucoides*
MYTO	6	Townsend's solitaire	*Myadestes townsendi*
RESA	10	golden-crowned kinglet	*Regulus satrapa*
RECA	10	ruby-crowned kinglet	*Regulus calendula*
ANSP	5	water pipit	*Anthus spinoletta*
BOGA	8	Bohemian waxwing	*Bombycilla garrulus*
BOCE	9	cedar waxwing	*Bombycilla cedrorum*
LAEX	7	northern shrike	*Lanius excubitor*
LALU	7	loggerhead shrike	*Lanius ludovicianus*
STVU	14	starling	*Sturnus vulgaris*
VISO	11	solitary vireo	*Vireo solitarius*
VIOL	11	red-eyed vireo	*Vireo olivaceus*
VIGI	11	warbling vireo	*Vireo gilvus*
VECE	6	orange-crowned warbler	*Vermivora celata*

Letter code	Life form	Common name	Scientific name
VERU	6	Nashville warbler	*Vermivora ruficapilla*
PAAM	10	northern parula	*Parula americana*
DEPE	8	yellow warbler	*Dendroica petechia*
DECO	10	yellow-rumped warbler	*Dendroica coronata*
DENI	10	black-throated gray warbler	*Dendroica nigrescens*
DETO	10	Townsend's warbler	*Dendroica townsendi*
SENO	3	northern waterthrush	*Seiurus noveboracensis*
OPTO	7	MacGillivray's warbler	*Oporornis tolmiei*
GETR	3	common yellowthroat	*Geothlypis trichas*
ICVI	8	yellow-breasted chat	*Icteria virens*
WIPU	5	Wilson's warbler	*Wilsonia pusilla*
SERUT	9	American redstart	*Setophaga ruticilla*
PADO	14	house sparrow	*Passer domesticus*
DOOR	5	bobolink	*Dolichonyx oryzivorus*
STNEG	5	western meadowlark	*Sturnella neglecta*
XAXA	7	yellow-headed blackbird	*Xanthocephalus xanthocephalus*

Letter code	Life form	Common name	Scientific name
BIRDS			
AGPH	7	red-winged blackbird	*Agelaius phoeniceus*
ICSP	9	orchard oriole	*Icterus spurius*
ICGA	9	northern oriole	*Icterus galbula*
EUCY	7	Brewer's blackbird	*Euphagus cyanocephalus*
QUQU	7	common grackle	*Quiscalus quiscula*
MOAT	7	brown-headed cowbird	*Molothrus ater*
PILU	10	western tanager	*Piranga ludoviciana*
PHME	11	black-headed grosbeak	*Pheucticus melanocephalus*
PAAMO	7	lazuli bunting	*Passerina amoena*
HEVE	11	evening grosbeak	*Hesperiphona vespertina*
CAPU	11	purple finch	*Carpodacus purpureus*
CACAS	11	Cassin's finch	*Carpodacus cassinii*
CAMEXI	9	house finch	*Carpodacus mexicanus*
PIEN	11	pine grosbeak	*Pinicola enucleator*
LETE	4	gray-crowned rosy finch	*Leucosticte tephrocotis*

Letter code	Life form	Common name	Scientific name
LEAT	4	black rosy finch	*Leucosticte atrata*
SPPI	11	pine siskin	*Spinus pinus*
SPTR	8	American goldfinch	*Spinus tristis*
SPPS	7	lesser goldfinch	*Spinus psaltria*
LOCUR	10	red crossbill	*Loxia curvirostra*
LOLE	10	white-winged crossbill	*Loxia leucoptera*
CHCH	7	green-tailed towhee	*Chlorura chlorura*
PIER	7	rufous-sided towhee	*Pipilo erythrophthalmus*
PASA	5	savannah sparrow	*Passerculus sandwichensis*
AMSA	5	grasshopper sparrow	*Ammodramus savannarum*
POGRA	5	vesper sparrow	*Pooecetes gramineus*
CHGR	5	lark sparrow	*Chondestes grammacus*
AMBE	7	sage sparrow	*Amphispiza belli*
JUHY	5	dark-eyed junco	*Junco hyemalis*
SPAR	7	tree sparrow	*Spizella arborea*
SPPA	7	chipping sparrow	*Spizella passerina*
SPBR	7	Brewer's sparrow	*Spizella breweri*
ZOLE	7	white-crowned sparrow	*Zonotrichia leucophrys*

Letter code	Life form	Common name	Scientific name
BIRDS			
ZOAT	5	golden-crowned sparrow	*Zonotrichia atricapilla*
ZOAL	5	white-throated sparrow	*Zonotrichia albicollis*
PAIL	7	fox sparrow	*Passerella iliaca*
MELI	6	Lincoln's sparrow	*Melospiza lincolnii*
MEMEL	7	song sparrow	*Melospiza melodia*
CALA	5	Lapland longspur	*Calcarius lapponicus*
PLNI	5	snow bunting	*Plectrophenax nivalis*
MAMMALS			
DIMA	5	opossum	*Didelphis marsupialis*
SOPR	15	Malheur shrew	*Sorex preblei*
SOVA	15	vagrant shrew	*Sorex vagrans*
SOOB	15	dusky shrew	*Sorex obscurus*
SOPA	16	northern water shrew	*Sorex palustris*
SOME	15	Merriam shrew	*Sorex merriami*
SCOR	15	coast mole	*Scapanus orarius*
MYLU	14	little brown myotis	*Myotis lucifugus*
MYYU	14	Yuma myotis	*Myotis yumanensis*
MYEV	14	long-eared myotis	*Myotis evotis*

Letter code	Life form	Common name	Scientific name
MYVO	14	long-legged myotis	*Myotis volans*
MYCA	14	California myotis	*Myotis californicus*
MYLE	4	small-footed myotis	*Myotis leibi*
LANO	14	silver-haired bat	*Lasionycteris noctivagans*
PIHE	4	western pipistrelle	*Pipistrellus hesperus*
EPFU	14	big brown bat	*Eptesicus fuscus*
LACI	11	hoary bat	*Lasiurus cinereus*
EUMA	4	spotted bat	*Euderma maculatum*
PLTO	4	western big-eared bat	*Plecotus townsendi*
ANPA	4	pallid bat	*Antrozous pallidus*
OCPR	4	pika	*Ochotona princeps*
SYID	15	pygmy rabbit	*Sylvilagus idahoensis*
SYNU	15	mountain cottontail	*Sylvilagus nuttalli*
LEAM	5	snowshoe hare	*Lepus americanus*
LETO	5	whitetail jackrabbit	*Lepus townsendi*

Letter code	Life form	Common name	Scientific name
MAMMALS			
LECA	5	blacktail jackrabbit	*Lepus californicus*
EUMI	15	least chipmunk	*Eutamias minimus*
EUAM	15	yellow pine chipmunk	*Eutamias amoenus*
MAFL	4	yellow-bellied marmot	*Marmota flaviventris*
SPTO	15	Townsend ground squirrel	*Spermophilus townsendi*
SPWA	15	Washington ground squirrel	*Spermophilus washingtoni*
SPBE	15	Belding ground squirrel	*Spermophilus beldingi*
SPCO	15	Columbian ground squirrel	*Spermophilus columbianus*
SPLA	15	mantled ground squirrel	*Spermophilus lateralis*
SCGRI	10	western gray squirrel	*Sciurus griseus*
SCNI	14	eastern fox squirrel	*Sciurus niger*
TAHU	10	red squirrel	*Tamiasciurus hudsonicus*
TADO	10	chickaree	*Tamiasciurus douglasi*
GLSA	14	northern flying squirrel	*Glaucomys sabrinus*

Letter code	Life form	Common name	Scientific name
THTO	15	Townsend pocket gopher	*Thomomys townsendi*
THTA	15	northern pocket gopher	*Thomomys talpoides*
PEPA	15	Great Basin pocket mouse	*Perognathus parvus*
DIOR	15	Ord kangaroo rat	*Dipodomys ordi*
CACAN	16	beaver	*Castor canadensis*
REME	15	western harvest mouse	*Reithrodonotomys megalotis*
PECR	4	canyon mouse	*Peromyscus crinitus*
PEMA	15	deer mouse	*Peromyscus maniculatus*
PETR	4	pinyon mouse	*Peromyscus truei*
ONLE	15	northern grass-hopper mouse	*Onychomys leucogaster*
NECI	4	bushy-tailed woodrat	*Neotoma cinerea*
CLGA	15	Gapper red-backed vole	*Clethrionomys gapperi*
PHIN	15	heather vole	*Phenacomys intermedius*
MIMO	15	mountain vole	*Microtus montanus*
MILO	15	long-tailed vole	*Microtus longicaudus*

Letter code	Life form	Common name	Scientific name
MAMMALS			
MIRI	16	water vole	*Microtus richardsoni*
LACU	15	sagebrush vole	*Lagurus curtatus*
ONZI	16	muskrat	*Ondatra zibethicus*
RANO	15	Norway rat	*Rattus norvegicus*
MUMU	15	house mouse	*Mus musculus*
ZAPR	3	western jumping mouse	*Zapus princeps*
ERDO	6	porcupine	*Erethizon dorsatum*
MYCO	16	nutria	*Myocastor coypus*
CALAT	15	coyote	*Canis latrans*
CALU	15	gray wolf	*Canis lupus*
VUVU	15	red fox	*Vulpes vulpes*
URCI	15	gray fox	*Urocyon cinereoargenteus*
URAM	15	black bear	*Ursus americanus*
PRLO	14	raccoon	*Procyon lotor*
MAAM	14	marten	*Martes americana*
MAPE	14	fisher	*Martes pennanti*
MUER	15	short-tailed weasel	*Mustela erminea*
MUFR	15	long-tailed weasel	*Mustela frenata*

Letter code	Life form	Common name	Scientific name
MUVI	16	mink	*Mustela vison*
GUGU	5	wolverine	*Gulo gulo*
TATA	15	badger	*Taxidea taxus*
SPPU	15	spotted skunk	*Spilogale putorius*
MEMEP	15	striped skunk	*Mephitis mephitis*
LUCA	16	river otter	*Lutra canadensis*
FECO	4	puma	*Felis concolor*
FECA	5	feral house cat	*Felis catus*
LYCA	5	lynx	*Lynx canadensis*
LYRU	4	bobcat	*Lynx rufus*
EQCA	5	feral horse	*Equus cabalus*
CEEL	5	elk	*Cervus elaphus*
ODHE	5	mule deer	*Odocoileus hemionus*
ODVI	5	white-tailed deer	*Odocoileus virginianus*
ANAME	5	pronghorn	*Antilocapra americana*
ORAM	4	mountain goat	*Oreamnos americanus*
OVCA	4	big-horned sheep	*Ovis canadensis*

Appendix 2

Alphabetical computer codes for 378 wildlife species in the Blue Mountains

Letter code	Life form	Scientific name	Common name
ACCO	11	*Accipiter cooperii*	Cooper's hawk
ACGE	11	*Accipiter gentilis*	goshawk
ACMA	3	*Actitis macularia*	spotted sandpiper
ACST	11	*Accipiter striatus*	sharp-shinned hawk
AEAC	14	*Aegolius acadicus*	saw-whet owl
AEOC	3	*Aechmophorus occidentalis*	western grebe
AESA	4	*Aeronautes saxatalis*	white-throated swift
AGPH	7	*Agelaius phoeniceus*	red-winged blackbird
AISP	14	*Aix sponsa*	wood duck
ALCH	4	*Alectoris chukar*	chukar
AMBE	7	*Amphispiza belli*	sage sparrow
AMMA	2	*Ambystoma macrodactylum*	long-toed salamander
AMSA	5	*Ammodramus savannarum*	grasshopper sparrow
AMTI	2	*Ambystoma tigrinum*	tiger salamander
ANAC	3	*Anas acuta*	pintail
ANAL	3	*Anser albifrons*	white-fronted goose
ANAM	3	*Anas americana*	American wigeon
ANAME	5	*Antilocapra americana*	pronghorn
ANCL	3	*Anas clypeata*	northern shoveler
ANCR	3	*Anas crecca*	green-winged teal
ANCY	3	*Anas cyanoptera*	cinnamon teal
ANDI	3	*Anas discors*	blue-winged teal
ANPA	4	*Antrozous pallidus*	pallid bat
ANPE	3	*Anas penelope*	European wigeon
ANPL	3	*Anas platyrhynchos*	mallard
ANSP	5	*Anthus spinoletta*	water pipit
ANST	3	*Anas strepera*	gadwall
AQCH	12	*Aquila chrysaetos*	golden eagle
ARAL	7	*Archilochus alexandri*	black-chinned hummingbird
ARHE	12	*Ardea herodias*	great blue heron
ASFL	5	*Asio flammeus*	short-eared owl
ASLE	13	*Asyndesmus lewis*	Lewis' woodpecker
ASOT	11	*Asio otus*	long-eared owl
ASTR	2	*Ascaphus truei*	tailed frog
AYAF	3	*Aythya affinis*	lesser scaup
AYAM	3	*Aythya americana*	redhead
AYCO	3	*Aythya collaris*	ring-necked duck
AYMA	3	*Aythya marila*	greater scaup
AYVA	3	*Aythya valisineria*	canvasback
BALO	5	*Bartramia longicauda*	upland sandpiper
BOCE	9	*Bombycilla cedrorum*	cedar waxwing
BOGA	8	*Bombycilla garrulus*	Bohemian waxwing

Letter code	Life form	Scientific name	Common name
BOLE	3	*Botaurus lentiginosus*	American bittern
BOUM	5	*Bonasa umbellus*	ruffed grouse
BRCA	3	*Branta canadensis*	Canada goose
BRNI	3	*Branta nigricans*	black brant
BUAL	14	*Bucephala albeola*	bufflehead
BUBO	2	*Bufo boreas*	western toad
BUCL	14	*Bucephala clangula*	common goldeneye
BUIS	14	*Bucephala islandica*	Barrow's goldeneye
BUJA	12	*Buteo jamaicensis*	red-tailed hawk
BULA	5	*Buteo lagopus*	rough-legged hawk
BURE	4	*Buteo regalis*	ferruginous hawk
BUSW	7	*Buteo swainsoni*	Swainson's hawk
BUVI	12	*Bubo virginianus*	great horned owl
BUWO	2	*Bufo woodhousei*	Woodhouse toad
CAAL	7	*Casmerodius albus*	common egret
CAAU	4	*Cathartes aura*	turkey vulture
CABA	3	*Calidris bairdii*	Baird's sandpiper
CACA	5	*Canachites canadensis*	Franklin's grouse
CACAN	16	*Castor canadensis*	beaver

Letter code	Life form	Scientific name	Common name
CACAS	11	*Carpodacus cassinii*	Cassin's finch
CAFU	5	*Catharus fuscescens*	veery
CAGA	3	*Capella gallinago*	common snipe
CAGU	5	*Catharus guttatus*	hermit thrush
CALA	5	*Calcarius lapponicus*	Lapland longspur
CALAT	15	*Canis latrans*	coyote
CALU	15	*Canis lupus*	gray wolf
CAMA	3	*Calidris mauri*	western sandpiper
CAME	3	*Calidris melanotos*	pectoral sandpiper
CAMEX	4	*Catherpes mexicanus*	canyon wren
CAMEXI	9	*Carpodacus mexicanus*	house finch
CAMI	3	*Calidris minutilla*	least sandpiper
CAPU	11	*Carpodacus purpureus*	purple finch
CASE	3	*Catoptrophorus semipalmatus*	willet
CAUS	7	*Catharus ustulatus*	Swainson's thrush
CEEL	5	*Cervus elaphus*	elk

Letter code	Life form	Scientific name	Common name
CEFA	14	*Certhia familiaris*	brown creeper
CEUR	5	*Centrocercus urophasianus*	sage grouse
CHAL	3	*Charadrius alexandrinus*	snowy plover
CHBO	15	*Charina bottae*	rubber boa
CHCA	3	*Chen caerulescens*	snow goose
CHCH	7	*Chlorura chlorura*	green-tailed towhee
CHGR	5	*Chondestes grammacus*	lark sparrow
CHMI	6	*Chordeiles minor*	common nighthawk
CHMO	3	*Charadrius montanus*	mountain plover
CHNI	3	*Chlidonias niger*	black tern
CHPI	3	*Chrysemys picta*	painted turtle
CHRO	3	*Chen rossii*	Ross' goose
CHVA	14	*Chaetura vauxi*	Vaux's swift
CHVO	3	*Charadrius vociferus*	killdeer
CICY	5	*Circus cyaneus*	marsh hawk
CIME	3	*Cinclus mexicanus*	dipper
CLGA	15	*Clethrionomys gapperi*	Gapper red-backed vole
CNTI	5	*Cnemidophorus tigris*	western whiptail

Letter code	Life form	Scientific name	Common name
COAM	8	*Coccyzus americanus*	yellow-billed cuckoo
COAU	13	*Colaptes auratus*	common flicker
COBR	11	*Corvus brachyrhynchos*	common crow
COCO	5	*Coluber constrictor*	yellow-bellied racer
COCOR	4	*Corvus corax*	common raven
COFA	11	*Columba fasciata*	band-tailed pigeon
COLI	4	*Columba livia*	rock dove
COSO	11	*Contopus sordidulus*	western wood pewee
COVI	5	*Colinus virginianus*	bobwhite
COVIR	9	*Contopus virens*	eastern wood pewee
CRVI	5	*Crotalus viridis*	western rattlesnake
CYCR	9	*Cyanocitta cristata*	blue jay
CYNI	4	*Cypseloides niger*	black swift
CYOL	3	*Cygnus olor*	mute swan
CYST	11	*Cyanocitta stelleri*	Steller's jay
DEAL	13	*Dendrocopos albolarvatus*	white-headed woodpecker
DECO	10	*Dendroica coronata*	yellow-rumped warbler

Letter code	Life form	Scientific name	Common name
DENI	10	*Dendroica nigrescens*	black-throated gray warbler
DEOB	5	*Dendragapus obscurus*	blue grouse
DEPE	8	*Dendroica petechia*	yellow warbler
DEPU	13	*Dendrocopos pubescens*	downy woodpecker
DETO	10	*Dendroica townsendi*	Townsend's warbler
DEVI	13	*Dendrocopos villosus*	hairy woodpecker
DIMA	5	*Didelphis marsupialis*	opossum
DIOR	15	*Dipodomys ordi*	Ord kangaroo rat
DIPU	3	*Diodophis punctatus*	ringneck snake
DOOR	5	*Dolichonyx oryzivorus*	bobolink
DRPI	13	*Dryocopus pileatus*	pileated woodpecker
DUCA	7	*Dumetella carolinensis*	gray catbird
ELLE	11	*Elanus leucurus*	white-tailed kite
EMDI	10	*Empidonax difficilis*	western flycatcher
EMHA	11	*Empidonax hammondii*	Hammond's flycatcher
EMOB	8	*Empidonax oberholseri*	dusky flycatcher
EMTR	7	*Empidonax traillii*	willow flycatcher
EMWR	7	*Empidonax wrightii*	gray flycatcher
EPFU	14	*Eptesicus fuscus*	big brown bat
EQCA	5	*Equus cabalus*	feral horse
ERAL	5	*Eremophila alpestris*	horned lark
ERDO	6	*Erethizon dorsatum*	porcupine
EUAM	15	*Eutamias amoenus*	yellow pine chipmunk
EUCY	7	*Euphagus cyanocephalus*	Brewer's blackbird
EUMA	4	*Euderma maculatum*	spotted bat
EUMI	15	*Eutamias minimus*	least chipmunk
EUSK	3	*Eumeces skiltonianus*	western skink
FACO	11	*Falco columbarius*	merlin
FAME	4	*Falco mexicanus*	prairie falcon
FAPE	4	*Falco peregrinus*	peregrine
FASP	14	*Falco sparverius*	American kestrel
FECA	5	*Felis catus*	feral house cat
FECO	4	*Felis concolor*	puma
FUAM	3	*Fulica americana*	American coot
GAAR	3	*Gavia arctica*	Arctic loon
GAIM	3	*Gavia immer*	common loon

Letter code	Life form	Scientific name	Common name
GETR	3	*Geothlypis trichas*	common yellowthroat
GLGN	14	*Glaucidium gnoma*	pygmy owl
GLSA	14	*Glaucomys sabrinus*	northern flying squirrel
GRCA	3	*Grus canadensis*	sandhill crane
GUGU	5	*Gulo gulo*	wolverine
GYCY	10	*Gymnorhinus cyanocephalus*	pinyon jay
HALE	12	*Haliaeetus leucocephalus*	bald eagle
HEVE	11	*Hesperiphona vespertina*	evening grosbeak
HIHI	3	*Histrionicus histrionicus*	harlequin duck
HIRU	4	*Hirundo rustica*	barn swallow
HYCA	3	*Hydroprogne caspia*	Caspian tern
HYRE	2	*Hyla regilla*	Pacific treefrog
HYTO	5	*Hypsiglena torquata*	night snake
ICGA	9	*Icterus galbula*	northern oriole
ICSP	9	*Icterus spurius*	orchard oriole
ICVI	8	*Icteria virens*	yellow-breasted chat
IRBI	14	*Iridoprocne bicolor*	tree swallow
IXNA	11	*Ixoreus naevius*	varied thrush
JUHY	5	*Junco hyemalis*	dark-eyed junco

Letter code	Life form	Scientific name	Common name
LAAR	3	*Larus argentatus*	herring gull
LACA	3	*Larus californicus*	California gull
LACI	11	*Lasiurus cinereus*	hoary bat
LACU	15	*Lagurus curtatus*	sagebrush vole
LADE	3	*Larus delawarensis*	ring-billed gull
LAEX	7	*Lanius excubitor*	northern shrike
LALE	4	*Lagopus leucurus*	white-tailed ptarmigan
LALU	7	*Lanius ludovicianus*	loggerhead shrike
LANO	14	*Lasionycteris noctivagans*	silver-haired bat
LAPH	3	*Larus philadelphia*	Bonaparte's gull
LAPI	3	*Larus pipixcan*	Franklin's gull
LEAM	5	*Lepus americanus*	snowshoe hare
LEAT	4	*Leucosticte atrata*	black rosy finch
LECA	5	*Lepus californicus*	blacktail jackrabbit
LETE	4	*Leucosticte tephrocotis*	gray-crowned rosy finch
LETO	5	*Lepus townsendi*	whitetail jackrabbit
LISC	3	*Limnodromus scolopaceus*	long-billed dowitcher

Letter code	Life form	Scientific name	Common name
LOCA	5	*Lophortyx californicus*	California quail
LOCU	14	*Lophodytes cucullatus*	hooded merganser
LOCUR	10	*Loxia curvirostra*	red crossbill
LOLE	10	*Loxia leucoptera*	white-winged crossbill
LOLO	3	*Lobipes lobatus*	northern phalarope
LUCA	16	*Lutra canadensis*	river otter
LYCA	5	*Lynx canadensis*	lynx
LYRU	4	*Lynx rufus*	bobcat
MAAM	14	*Martes americana*	marten
MAFL	4	*Marmota flaviventris*	yellow-bellied marmot
MAPE	14	*Martes pennanti*	fisher
MATA	5	*Masticophis taeniatus*	striped whipsnake
MEAL	16	*Megaceryle alcyon*	belted kingfisher
MEDE	3	*Melanitta deglandi*	white-winged scoter
MEGA	5	*Meleagris gallopavo*	turkey
MELI	6	*Melospiza lincolnii*	Lincoln's sparrow
MEME	14	*Mergus merganser*	common merganser
MEMEL	7	*Melospiza melodia*	song sparrow
MEMEP	15	*Mephitis mephitis*	striped skunk
MESE	3	*Mergus serrator*	red-breasted merganser
MILO	15	*Microtus longicaudus*	long-tailed vole
MIMO	15	*Microtus montanus*	mountain vole
MIPO	7	*Mimus polyglottos*	mockingbird
MIRI	16	*Microtus richardsoni*	water vole
MOAT	7	*Molothrus ater*	brown-headed cowbird
MUER	15	*Mustela erminea*	short-tailed weasel
MUFR	15	*Mustela frenata*	long-tailed weasel
MUMU	15	*Mus musculus*	house mouse
MUVI	16	*Mustela vison*	mink
MYCA	14	*Myotis californicus*	California myotis
MYCI	14	*Myiarchus cinerascens*	ash-throated flycatcher
MYCO	16	*Myocastor coypus*	nutria
MYEV	14	*Myotis evotis*	long-eared myotis
MYLE	4	*Myotis leibi*	small-footed myotis

Letter code	Life form	Scientific name	Common name
MYLU	14	*Myotis lucifugus*	little brown myotis
MYTO	6	*Myadestes townsendi*	Townsend's solitaire
MYVO	14	*Myotis volans*	long-legged myotis
MYYU	14	*Myotis yumanensis*	Yuma myotis
NECI	4	*Neotoma cinerea*	bushy-tailed woodrat
NUAM	3	*Numenius americanus*	long-billed curlew
NUBO	10	*Nuttallornis borealis*	olive-sided flycatcher
NUCO	10	*Nucifraga columbiana*	Clark's nutcracker
NYNY	7	*Nycticorax nycticorax*	black-crowned night heron
NYSC	5	*Nyctea scandiaca*	snowy owl
OCPR	4	*Ochotona princeps*	pika
ODHE	5	*Odocoileus hemionus*	mule deer
ODVI	5	*Odocoileus virginianus*	white-tailed deer
OLCO	3	*Olor columbianus*	whistling swan
ONLE	15	*Onychomys leucogaster*	northern grass-hopper mouse
ONZI	16	*Ondatra zibethicus*	muskrat

Letter code	Life form	Scientific name	Common name
OPTO	7	*Oporornis tolmiei*	MacGillivray's warbler
ORAM	4	*Oreamnos americanus*	mountain goat
ORMO	7	*Oreoscoptes montanus*	sage thrasher
ORPI	5	*Oreortyx pictus*	mountain quail
OTAS	14	*Otus asio*	screech owl
OTFL	14	*Otus flammeolus*	flammulated owl
OVCA	4	*Ovis canadensis*	big-horned sheep
OXJA	3	*Oxyura jamaicensis*	ruddy duck
PAAM	10	*Parula americana*	northern parula
PAAMO	7	*Passerina amoena*	lazuli bunting
PAAT	14	*Parus atricapillus*	black-capped chickadee
PADO	14	*Passer domesticus*	house sparrow
PAGA	14	*Parus gambeli*	mountain chickadee
PAHA	12	*Pandion haliaetus*	osprey
PAIL	7	*Passerella iliaca*	fox sparrow
PARU	14	*Parus rufescens*	chestnut-backed chickadee
PASA	5	*Passerculus sandwichensis*	savannah sparrow
PECA	11	*Perisoreus canadensis*	gray jay

Letter code	Life form	Scientific name	Common name
PECR	4	*Peromyscus crinitus*	canyon mouse
PEER	3	*Pelecanus erythrorhynchos*	white pelican
PEMA	15	*Peromyscus maniculatus*	deer mouse
PEPA	15	*Perognathus parvus*	Great Basin pocket mouse
PEPE	5	*Perdix perdix*	gray partridge
PEPH	5	*Pedioecetes phasianellus*	sharp-tailed grouse
PEPY	4	*Petrochelidon pyrrhonota*	cliff swallow
PETR	4	*Peromyscus truei*	pinyon mouse
PHAU	3	*Phalacrocorax auritus*	double-crested cormorant
PHCO	5	*Phasianus colchicus*	ring-necked pheasant
PHDO	5	*Phrynosoma douglassi*	short-horned lizard
PHIN	15	*Phenacomys intermedius*	heather vole
PHME	11	*Pheucticus melanocephalus*	black-headed grosbeak
PHNU	6	*Phalaenoptilus nuttallii*	poorwill
PIAR	13	*Picoides arcticus*	black-backed three-toed woodpecker
PIEN	11	*Pinicola enucleator*	pine grosbeak

Letter code	Life form	Scientific name	Common name
PIER	7	*Pipilo erythrophthalmus*	rufous-sided towhee
PIHE	4	*Pipistrellus hesperus*	western pipistrelle
PILU	10	*Piranga ludoviciana*	western tanager
PIME	5	*Pituophis melanoleucus*	gopher snake
PIPI	7	*Pica pica*	black-billed magpie
PITR	13	*Picoides tridactylus*	northern three-toed woodpecker
PLCH	12	*Plegadis chihi*	white-faced ibis
PLNI	5	*Plectrophenax nivalis*	snow bunting
PLTO	4	*Plecotus townsendi*	western big-eared bat
POAU	3	*Podiceps auritus*	horned grebe
POCA	3	*Porzana carolina*	sora
POGR	3	*Podiceps grisegena*	red-necked grebe
POGRA	5	*Pooecetes gramineus*	vesper sparrow
PONI	3	*Podiceps nigricollis*	eared grebe
POPO	3	*Podilymbus podiceps*	pied-billed grebe
PRLO	14	*Procyon lotor*	raccoon
PSMI	8	*Psaltriparus minimus*	bushtit

Letter code	Life form	Scientific name	Common name
QUQU	7	*Quiscalus quiscula*	common grackle
RACA	1	*Rana catesbeiana*	bullfrog
RALI	3	*Rallus limicola*	Virginia rail
RANO	15	*Rattus norvegicus*	Norway rat
RAPI	2	*Rana pipiens*	leopard frog
RAPR	2	*Rana pretiosa*	spotted frog
REAM	3	*Recurvirostra americana*	American avocet
RECA	10	*Regulus calendula*	ruby-crowned kinglet
REME	15	*Reithrodonotomys megalotis*	western harvest mouse
RESA	10	*Regulus satrapa*	golden-crowned kinglet
RIRI	16	*Riparia riparia*	bank swallow
SAOB	4	*Salpinctes obsoletus*	rock wren
SASA	4	*Sayornis saya*	Say's phoebe
SCGR	5	*Sceloporus graciosus*	sagebrush lizard
SCGRI	10	*Sciurus griseus*	western gray squirrel
SCIN	2	*Scaphiopus intermontanus*	Great Basin spadefoot toad
SCNI	14	*Sciurus niger*	eastern fox squirrel
SCOC	5	*Sceloporus occidentalis*	western fence lizard
SCOR	15	*Scapanus orarius*	coast mole
SENO	3	*Seiurus noveboracensis*	northern waterthrush
SEPL	7	*Selasphorus platycercus*	broad-tailed hummingbird
SERU	11	*Selasphorus rufus*	rufous hummingbird
SERUT	9	*Setophaga ruticilla*	American redstart
SICA	13	*Sitta carolinensis*	white-breasted nuthatch
SICAN	13	*Sitta canadensis*	red-breasted nuthatch
SICU	14	*Sialia currucoides*	mountain bluebird
SIME	14	*Sialia mexicana*	western bluebird
SIPY	13	*Sitta pygmaea*	pygmy nuthatch
SOME	15	*Sorex merriami*	Merriam shrew
SOOB	15	*Sorex obscurus*	dusky shrew
SOPA	16	*Sorex palustris*	northern water shrew
SOPR	15	*Sorex preblei*	Malheur shrew
SOVA	15	*Sorex vagrans*	vagrant shrew
SPAR	7	*Spizella arborea*	tree sparrow
SPBE	15	*Spermophilus beldingi*	Belding ground squirrel
SPBR	7	*Spizella breweri*	Brewer's sparrow
SPCO	15	*Spermophilus columbianus*	Columbian ground squirrel

Letter code	Life form	Scientific name	Common name
SPCU	15	*Speotyto cunicularia*	burrowing owl
SPLA	15	*Spermophilus lateralis*	mantled ground squirrel
SPPA	7	*Spizella passerina*	chipping sparrow
SPPI	11	*Spinus pinus*	pine siskin
SPPS	7	*Spinus psaltria*	lesser goldfinch
SPPU	15	*Spilogale putorius*	spotted skunk
SPTH	13	*Sphyrapicus thyroideus*	Williamson's sapsucker
SPTO	15	*Spermophilus townsendi*	Townsend ground squirrel
SPTR	8	*Spinus tristis*	American goldfinch
SPVA	13	*Sphyrapicus varius*	yellow-bellied sapsucker
SPWA	15	*Spermophilus washingtoni*	Washington ground squirrel
STCA	7	*Stellula calliope*	calliope hummingbird
STFO	3	*Sterna forsteri*	Forster's tern
STNE	12	*Strix nebulosa*	great gray owl
STNEG	5	*Sturnella neglecta*	western meadowlark
STOC	14	*Strix occidentalis*	spotted owl
STRU	16	*Stelgidopteryx ruficollis*	rough-winged swallow
STTR	3	*Steganopus tricolor*	Wilson's phalarope
STVA	14	*Strix varia*	barred owl
STVU	14	*Sturnus vulgaris*	starling
SYID	15	*Sylvilagus idahoensis*	pygmy rabbit
SYNU	15	*Sylvilagus nuttalli*	mountain cottontail
TADO	10	*Tamiasciurus douglasi*	chickaree
TAHU	10	*Tamiasciurus hudsonicus*	red squirrel
TATA	15	*Taxidea taxus*	badger
TATH	14	*Tachycineta thalassina*	violet-green swallow
TEPA	3	*Telmatodytes palustris*	long-billed marsh wren
THEL	5	*Thamnophis elegans*	western terrestrial garter snake
THSI	3	*Thamnophis sirtalis*	common garter snake
THTA	15	*Thomomys talpoides*	northern pocket gopher
THTO	15	*Thomomys townsendi*	Townsend pocket gopher
TRAE	14	*Troglodytes aedon*	house wren
TRFL	3	*Tringa flavipes*	lesser yellowlegs

Letter code	Life form	Scientific name	Common name
TRME	3	*Tringa melanoleuca*	greater yellowlegs
TRSO	7	*Tringa solitaria*	solitary sandpiper
TRTR	3	*Troglodytes troglodytes*	winter wren
TUMI	7	*Turdus migratorius*	American robin
TYAL	14	*Tyto alba*	barn owl
TYTY	7	*Tyrannus tyrannus*	eastern kingbird
TYVE	11	*Tyrannus verticalis*	western kingbird
URAM	15	*Ursus americanus*	black bear
URCI	15	*Urocyon cinereoargenteus*	gray fox
UTST	4	*Uta stansburiana*	side-blotched lizard
VECE	6	*Vermivora celata*	orange-crowned warbler
VERU	6	*Vermivora ruficapilla*	Nashville warbler
VIGI	11	*Vireo gilvus*	warbling vireo
VIOL	11	*Vireo olivaceus*	red-eyed vireo
VISO	11	*Vireo solitarius*	solitary vireo
VUVU	15	*Vulpes vulpes*	red fox
WIPU	5	*Wilsonia pusilla*	Wilson's warbler
XAXA	7	*Xanthocephalus xanthocephalus*	yellow-headed blackbird

Letter code	Life form	Scientific name	Common name
ZAPR	3	*Zapus princeps*	western jumping mouse
ZEMA	11	*Zenaida macroura*	mourning dove
ZOAL	5	*Zonotrichia albicollis*	white-throated sparrow
ZOAT	5	*Zonotrichia atricapilla*	golden-crowned sparrow
ZOLE	7	*Zonotrichia leucophrys*	white-crowned sparrow

Appendix 3

51 wildlife species found in the Blue Mountains during migration or "accidental" in the area

Letter code	Life form	Common name
GAIM	3	common loon
GAAR	3	Arctic loon
POGR	3	red-necked grebe†
POAU	3	horned grebe†
AEOC	3	western grebe†
PEER	3	white pelican†
CAAL	7	common egret
PLCH	12	white-faced ibis†
CYOL	3	mute swan
OLCO	3	whistling swan
BRNI	3	black brant
ANAL	3	white-fronted goose†
CHCA	3	snow goose
CHRO	3	Ross' goose
ANPE	3	European wigeon†
AYVA	3	canvasback†
AYMA	3	greater scaup
BUCL	14	common goldeneye
MEDE	3	white-winged scoter†
MESE	3	red-breasted merganser
ELLE	11	white-tailed kite
BULA	5	rough-legged hawk†
CHMO	3	mountain plover†
TRME	3	greater yellowlegs
TRFL	3	lesser yellowlegs
CAME	3	pectoral sandpiper

Letter code	Life form	Common name
CABA	3	Baird's sandpiper†
CAMI	3	least sandpiper
CAMA	3	western sandpiper
LISC	3	long-billed dowitcher
LOLO	3	northern phalarope
LAAR	3	herring gull
LAPH	3	Bonaparte's gull
HYCA	3	Caspian tern†
COFA	11	band-tailed pigeon
NYSC	5	snowy owl†
STOC	14	spotted owl†
COVIR	9	eastern wood pewee
CYCR	9	blue jay
MIPO	7	mockingbird†
BOGA	8	Bohemian waxwing†
LAEX	7	northern shrike
PAAM	10	northern parula
ICSP	9	orchard oriole
QUQU	7	common grackle
LOLE	10	white-winged crossbill
SPAR	7	tree sparrow†
ZOAT	5	golden-crowned sparrow
ZOAL	5	white-throated sparrow
CALA	5	Lapland longspur
PLNI	5	snow bunting

†Species of special interest; see appendix 4.

Appendix 4

137 wildlife species in the Blue Mountains of "special interest"

References

The following 10 references were used, respectively, as sources for the eight status classification columns in this appendix.

1. U.S. Fish and Wildlife Service. 1976. Endangered and threatened wildlife and plants: Republication of the list of species. Fed. Regist. 41(Oct. 27):47179-47198.
2. Oregon State Department of Fish and Wildlife. [1977.] Oregon's threatened or endangered wildlife. [Ron Shay, ed.] 13 p. Oreg. State Dep. Fish and Wildl., Portland.
3. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife. 1973. Threatened wildlife of the United States. ["Red Book."] Resour. Publ. 114, 289 p. Off. Endangered Species and Int. Act., Washington, D.C.
4. Dyrness, C. T., Jerry F. Franklin, Chris Maser, Stanton A. Cook, James D. Hall, and Glenda Faxon. 1975. Research Natural Area needs in the Pacific Northwest: A contribution to land-use planning. ["Yellow Book."] USDA For. Serv. Gen. Tech. Rep. PNW-38, 231 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.
5. Storm, Robert M. 1966. Endangered plants and animals of Oregon: II. Amphibians and reptiles. Agric. Exp. Stn. Spec. Rep. 206, 12 p. Oreg. State Univ., Corvallis.

   Marshall, David B. 1969. Endangered plants and animals of Oregon: III. Birds. Agric. Exp. Stn. Spec. Rep. 278, 23 p. Oreg. State Univ., Corvallis.

   Olterman, James H., and B. J. Verts. 1972. Endangered plants and animals of Oregon: IV. Mammals. Agric. Exp. Stn. Spec. Rep. 364, 47 p. Oreg. State Univ., Corvallis.
6. Arbib, Robert. 1975. The blue list for 1976. Am. Birds 29(6):1067-1072.
7. U.S. Department of Agriculture, Forest Service. 1971. Endangered-rare-unique species in Region 6 as of March 1971. Unpublished report on file at Reg. 6, Portland, Oreg.
8. Mohler, Levi L. 1974. Threatened wildlife of Idaho. Idaho Wildl. Rev. 26(5):3-5.

		Species	1	2	3	4	5	6	7	8
		AMPHIBIANS								
ASTR	2	tailed frog				SI	X		U	
RAPR	2	spotted frog		T		SI	X		U	
		REPTILES								
PHDO	5	short-horned lizard					T			
CNTI	5	western whiptail				SI				
HYTO	5	night snake				SI				
CRVI	5	western rattlesnake				SI	X			
		BIRDS								
POGR	3	red-necked grebe*				SI	P	X		
POAU	3	horned grebe*				SI	P			
Letter code	Life form	E-Endangered P-Peripheral R-Rare SI-Species of special interest SU-Status undetermined T-Threatened U-Unique X-Occurs on list	1 Federal Register (endangered)	2 Oregon State (endangered or threatened)	3 U.S. Dep. Inter. Fish & Wildl. Serv. "Red Book"	4 USDA FS RNA "Yellow Book"	5 OSU endangered plants & animals of Oregon	6 Audubon—Blue list for 1976	7 USDA FS R-6	8 Threatened wildlife of Idaho

*May feed in the Blue Mountains but is not known to reproduce there. Shown on this list but not on the individual life form lists in appendices 8, 9, 10, 11, 12, 13, 14, and 15. These are the 51 species listed in appendix 3.

Species			1	2	3	4	5	6	7	8
BIRDS										
AEOC	3	western grebe*						X		
PEER	3	white pelican*					R	X		
PHAU	3	double-crested cormorant						X		
NYNY	7	black-crowned night heron						X		
BOLE	3	American bittern				SI		X		
PLCH	12	white-faced ibis*			SU	SI	P	X		SU
BRCA	3	Canada goose[1]		E		SI	E			
ANAL	3	white-fronted goose[2]*					E			
ANPE	3	European wigeon*				SI				
AYCO	3	ring-necked duck					P			
AYVA	3	canvasback*						X		
AYAF	3	lesser scaup					P			
BUIS	14	Barrow's goldeneye					P			
BUAL	14	bufflehead					P			
HIHI	3	harlequin duck					R		U	
MEDE	3	white-winged scoter*				SI				
CAAU	4	turkey vulture				SI				
ACST	11	sharp-shinned hawk						X		
ACCO	11	Cooper's hawk						X		
BUJA	12	red-tailed hawk[3]				SI				
BUSW	7	Swainson's hawk					R	X		
BULA	5	rough-legged hawk*				SI				

Letter code

E - Endangered
P - Peripheral
R - Rare
SI - Species of special interest
SU - Status undetermined
T - Threatened
U - Unique
X - Occurs on list

Life form

1 Federal Register (endangered)
2 Oregon State (endangered or threatened)
3 U.S. Dep. Inter. Fish & Wildl. Serv. "Red Book"
4 USDA FS RNA "Yellow Book"
5 OSU endangered plants & animals of Oregon
6 Audubon—Blue list for 1976
7 USDA FS R-6
8 Threatened wildlife of Idaho

[1]A subspecies of the Canada goose, *Branta canadensis leucopareia* (Aleutian Canada goose), may occur in the Blue Mountains.
[2]A subspecies of the white-fronted goose, *Anser albifrons gambeli* (Tule white-fronted goose), may occur in the Blue Mountains.
[3]A subspecies of the red-tailed hawk, *Buteo jamaicensis alascensis* (Alaska red-tailed hawk), may occur in the Blue Mountains.

Species			1	2	3	4	5	6	7	8
BIRDS										
BURE	4	ferruginous hawk				SI	E	X		
AQCH	12	golden eagle				SI				
HALE	12	bald eagle		T		SI	E		U	
CICY	5	marsh hawk						X		
PAHA	12	osprey			SU	SI	R	X	U	SU
FAME	4	prairie falcon			T	SI	R	X	R	T
FAPE	4	peregrine	E	E	T	SI	E		E	T
FACO	11	merlin				SI	E	X		
FASP	14	American kestrel				SI		X		
CACA	5	Franklin's grouse				SI	E		U	
LALE	4	white-tailed ptarmigan			P					
PEPH	5	sharp-tailed grouse				SI	E			
CEUR	5	sage grouse						X		
ORPI	5	mountain quail						X		
GRCA	3	sandhill crane[4]				SI	E		R	
RALI	3	Virginia rail				SI				
CHAL	3	snowy plover[5]		T		SI	R	X		
CHMO	3	mountain plover*				SI				
NUAM	3	long-billed curlew			SU	SI				SU
BALO	5	upland sandpiper				SI	SU	X		
TRSO	7	solitary sandpiper				SI				
CASE	3	willet				SI				

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[4]A subspecies of the sandhill crane, *Grus canadensis tabida* (greater sandhill crane), may occur in the Blue Mountains.
[5]A subspecies of the snowy plover, *Charadrius alexandrinus nivosus* (western snowy plover), occurs in the Blue Mountains.

Species			1	2	3	4	5	6	7	8
		BIRDS								
CABA	3	Baird's sandpiper*				SI				
LAPI	3	Franklin's gull				SI	SU			
HYCA	3	Caspian tern*				SI	SU			
COAM	8	yellow-billed cuckoo				SI	SU	X		
TYAL	14	barn owl						X		
OTAS	14	screech owl				SI	SU			
OTFL	14	flammulated owl				SI	SU			
NYSC	5	snowy owl*				SI				
SPCU	15	burrowing owl			SU	SI		X		SU
STVA	14	barred owl				SI				
STOC	14	spotted owl*		T	T	SI	E		U	
STNE	12	great gray owl				SI	R		U	
ASFL	5	short-eared owl						X		
PHNU	6	poorwill				SI	SU			
CHMI	6	common nighthawk						X		
ASLE	13	Lewis' woodpecker						X		
DEVI	13	hairy woodpecker						X		
PITR	13	northern three-toed woodpecker				SI	R		U	
PEPY	4	cliff swallow						X		
PARU	14	chestnut-backed chickadee				SI				
SICAN	13	red-breasted nuthatch				SI				
MIPO	7	mockingbird*				SI	P			

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Species			1	2	3	4	5	6	7	8
		BIRDS								
DUCA	7	gray catbird				SI	P			
CAGU	5	hermit thrush				SI				
CAFU	5	veery				SI	P			
SIME	14	western bluebird				SI				
SICU	14	mountain bluebird						X		
ANSP	5	water pipit				SI	P			
BOGA	8	Bohemian waxwing*				SI	P			
LALU	7	loggerhead shrike						X		
VIOL	11	red-eyed vireo				SI				
VIGI	11	warbling vireo				SI				
VECE	6	orange-crowned warbler				SI				
DEPE	8	yellow warbler						X		
DECO	10	yellow-rumped warbler				SI				
DENI	10	black-throated gray warbler				SI				
SENO	3	northern waterthrush				SI				
OPTO	7	MacGillivray's warbler				SI				
GETR	3	common yellowthroat				SI				
ICVI	8	yellow-breasted chat						X		
SERUT	9	American redstart				SI	P			
DOOR	5	bobolink				SI	P			
STNEG	5	western meadowlark				SI				
PAAMO	7	lazuli bunting				SI				

Letter code	Life form	
		E - Endangered P - Peripheral R - Rare SI - Species of special interest SU - Status undetermined T - Threatened U - Unique X - Occurs on list

1	2	3	4	5	6	7	8
Federal Register (endangered)	Oregon State (endangered or threatened)	U.S. Dep. Inter. Fish & Wildl. Serv. "Red Book"	USDA FS RNA "Yellow Book"	OSU endangered plants & animals of Oregon	Audubon—Blue list for 1976	USDA FS R-6	Threatened wildlife of Idaho

		Species	1	2	3	4	5	6	7	8
		BIRDS								
PIEN	11	pine grosbeak				SI	SU			
LETE	4	gray-crowned rosy finch[6]			T	SI	SU		R	
LEAT	4	black rosy finch				SI	SU			
SPPS	7	lesser goldfinch						X		
AMSA	5	grasshopper sparrow				SI	SU	X		
POGRA	5	vesper sparrow				SI				
JUHY	5	dark-eyed junco[7]				SI				
SPAR	7	tree sparrow*				SI				
PAIL	7	fox sparrow[8]				SI				
		MAMMALS								
DIMA	5	opossum				SI				
SOPR	15	Malheur shrew				R	R			
SOME	15	Merriam shrew				R	R			
MYEV	14	long-eared myotis				U				
MYVO	14	long-legged myotis				R				
MYLE	4	small-footed myotis				R				
LANO	14	silver-haired bat				R				
PIHE	4	western pipistrelle					SU			
LACI	11	hoary bat				R	X			
EUMA	4	spotted bat			T					
ANPA	4	pallid bat				R				
SYID	15	pygmy rabbit				T	X			

Letter code	Life form	1 Federal Register (endangered)	2 Oregon State (endangered or threatened)	3 U.S. Dep. Inter. Fish & Wildl. Serv. "Red Book"	4 USDA FS RNA "Yellow Book"	5 OSU endangered plants & animals of Oregon	6 Audubon—Blue list for 1976	7 USDA FS R-6	8 Threatened wildlife of Idaho
E - Endangered									
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SI - Species of special interest									
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T - Threatened									
U - Unique									
X - Occurs on list									

[6]A subspecies of the gray-crowned rosy finch, *Leucosticte tephrocotis wallowa* (Wallowa gray-crowned rosy finch), breeds in the Blue Mountains.

[7]Two subspecies of the dark-eyed junco, *Junco hyemalis cismontanus* (Cassiar slate-colored junco) and *J. h. montanus* (interior slate-colored junco), may occur in the Blue Mountains.

[8]A subspecies of the fox sparrow, *Passerella iliaca zaboria* (Yukon fox sparrow), may occur in the Blue Mountains during winter.

Species			1	2	3	4	5	6	7	8
		MAMMALS								
LETO	5	whitetail jackrabbit				U	X			
SPWA	15	Washington ground squirrel				U	SU			
SCGRI	10	western gray squirrel							U	
SCNI	14	eastern fox squirrel				R				
DIOR	15	Ord kangaroo rat				R				
PETR	4	pinyon mouse				U				
ONLE	15	northern grasshopper mouse				U				
PHIN	15	heather vole				U	X			
LACU	15	sagebrush vole				U	X			
CALU	15	gray wolf[9]	E		T	E	E			
VUVU	15	red fox[10]				R				
MAAM	14	marten			SU		X			SU
MAPE	14	fisher			SU	R	R		U	SU
GUGU	5	wolverine		T	SU	T	E		U	SU
TATA	15	badger					X			
LUCA	16	river otter					X			
FECO	4	puma					X		U	
LYCA	5	lynx			SU	E	E		U	SU
ODVI	5	white-tailed deer				R	X			
ORAM	4	mountain goat				U				
OVCA	4	big-horned sheep				U	R		U	

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[9]A subspecies of the gray wolf, *Canis lupus irremotus* (Northern Rocky Mountain wolf), may still occur in the Blue Mountains.
[10]A subspecies of the red fox, *Vulpes vulpes cascadensis* (Cascade red fox), occurs in the Blue Mountains.

Appendix 5

Common and scientific names of plants and insects mentioned in text and appendices

Common name	Scientific name
PLANTS[1]	
alder	*Alnus* spp.
alpine fescue	*Festuca idahoensis*
alpine fleeceflower	*Polygonum phytolaccaefolium*
alpine sagebrush	*Artemisia tridentata* var. *vaseyana*
alpine sedge	*Carex hoodii*
aspen	(see quaking aspen)
bentgrass	*Agrostis* spp.
big huckleberry	*Vaccinium membranaceum*
big sagebrush	*Artemisia tridentata* var. *tridentata*
bitterbrush	*Purshia tridentata*
black cottonwood	*Populus trichocarpa*
bluegrass	*Poa* spp.
blue wildrye	*Elymus glaucus*
buckbrush	*Ceanothus* spp.
buckwheat	*Eriogonum heracleoides*
bunchgrass	*Agropyron* spp.
ceanothus	*Ceanothus* spp.
common timothy	*Phleum pratense*
cottonwood	(see black cottonwood)
curlleaf mountainmahogany	*Cercocarpus ledifolius*
Douglas-fir	*Pseudotsuga menziesii*
elk sedge	*Carex geyeri*
Engelmann spruce	*Picea engelmannii*
fescue	(see alpine fescue)

Common name	Scientific name
fir	*Abies* spp.
fleeceflower	(see pokeweed fleece-flower)
grand fir	*Abies grandis*
grouse huckleberry	*Vaccinium scoparium*
hemlock	*Tsuga* spp.
huckleberry	(see big huckleberry)
juniper	(see western juniper)
larch	(see western larch)
lodgepole pine	*Pinus contorta*
low sagebrush	*Artemisia arbuscula*
mahogany	(see curlleaf mountainmahogany)
mallow ninebark	*Physocarpus malvaceus*
mistletoe	(see yellow leafless mistletoe)
mountain alder	*Alnus incana*
mountainmahogany	(see curlleaf mountainmahogany)
needlegrass	*Stipa occidentalis*
ninebark	(see mallow ninebark)
oceanspray	*Holodiscus discolor*
orchardgrass	*Dactylis glomerata*
pinegrass	*Calamagrostis rubescens*
pinyon pine	*Pinus* spp.
pokeweed fleeceflower	*Polygonum phytolaccaefolium*
ponderosa pine	*Pinus ponderosa*
poplar	*Populus* spp.
quaking aspen	*Populus tremuloides*

See footnotes at end of appendix.

Common name	Scientific name
PLANTS[1]	
Ross sedge	*Carex rossii*
rush	*Juncus* spp.
sagebrush	*Artemisia* spp.
Sandberg's bluegrass	*Poa sandbergii*
sand dropseed	*Sporobolus cryptandrus*
sedge	*Carex* spp.
snowberry	*Symphoricarpos albus*
spruce	*Picea* spp.
stiff sage	*Artemisia rigida*
subalpine fir	*Abies lasiocarpa*
thinleaf alder	(see mountain alder)
threeawn	*Aristida* spp.
trembling aspen	(see quaking aspen)
true fir	*Abies* spp.
twinflower	*Linnaea borealis*
western juniper	*Juniperus occidentalis*

Common name	Scientific name
western larch	*Larix occidentalis*
wheatgrass	(see bunchgrass)
whitebark pine	*Pinus albicaulis*
white fir	(see grand fir)[2]
willow	*Salix* spp.
yellow leafless mistletoe	*Arceuthobium campylopodum*
INSECTS[3]	
beetle	Order Coleoptera
carpenter ant	*Camponotus* spp.
Douglas-fir tussock moth	*Orgyia pseudotsugata*
Engelmann spruce beetle	(see spruce beetle)
larch sawfly	*Pristiphora erichsonii*
southern hardwood borer	*Megacyllene* spp.
spruce beetle	*Dendroctonus rufipennis*
spruce budworm	*Choristoneura fumiferana*

[1]Plant names follow Franklin and Dyrness (1973) and Hall (1973).

[2]In this discussion, "white fir" includes both white fir and grand fir. There is a taxonomic argument as to whether this is one species or two. See grand fir (*Abies grandis*).

[3]Insect names follow Craighead (1950) and Furniss and Carolin (1977).

Appendix 6

Composite occurrence and orientation list for 378 wildlife species in the Blue Mountains

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		AMPHIBIANS															
AMTI	2	tiger salamander	L													approx. 50 eggs	h.r. ≦30.5 m (100 ft)/adult
AMMA	2	long-toed salamander	M													approx. 50 eggs	h.r. ≦30.5 m (100 ft)/adult
ASTR	2	tailed frog[10]	M													37-70 eggs	h.r. approx. 21.9 m (72 ft)/adult
SCIN	2	Great Basin spadefoot toad	M														
BUBO	2	western toad	H													100 + eggs	h.r. approx. 16.2 m^2 (174.3 ft^2)/adult
BUWO	2	Woodhouse toad	M													approx. 100 eggs	h.r. approx. 21.8-32.3 m^2 (234.6-347.5 ft^2)/adult
HYRE	2	Pacific treefrog	H													100 + eggs	
RAPR	2	spotted frog[10]	M														
RAPI	2	leopard frog	L														
RACA	1	bullfrog															
		REPTILES															
CHPI	3	painted turtle	L													6-20/clutch; 1 clutch	
SCOC	5	western fence lizard	M													8.7/clutch; 1-3 clutches	
SCGR	5	sagebrush lizard	M														
UTST	4	side-blotched lizard	L														h.r. 121-446 m^2 (1,302-4,799 ft^2)/adult
PHDO	5	short-horned lizard[10]	M													13.8/clutch; 1 clutch	
EUSK	3	western skink	M														

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
AMPHIBIANS																											
tiger salamander	one 0.8-ha (2-acre) pond/ population		● ■	● ■	● ■				□	● ■	□	□	□			○ □	● ■	● ■	● ■				■				
long-toed salamander	one 0.8-ha (2-acre) pond/ population		● ■	● ■	● ■	● ■		● ■	□	□	□	□	□	□	● ■	○ □	● ■	● ■	● ■				■			■	
tailed frog[10]											● ■	● ■	● ■	● ■	● ■	● ■				● ■							
Great Basin spadefoot toad		● ■		● ■	● ■	● ■		● ■								○ □	● ■	□	●					■			
western toad		□	● ■	□	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■		● ■	● ■	● ■	●		■		■	■		■	
Woodhouse toad		● ■	● ■	● ■	● ■	● ■		● ■								● ■	● ■	● ■	● ■						■	■	
Pacific treefrog	one 0.8-ha (2-acre) pond/ population	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■		● ■	● ■	● ■	● ■				■		□	■	
spotted frog[10]	one 0.8-ha (2-acre) pond/ population		○ □		● ■			● ■	● ■	● ■	● ■	● ■	● ■			○ ■	● ■	● ■	● ■	○ ■							
leopard frog	one 0.8-ha (2-acre) pond/ population		● ■													○ □	● ■	● ■	● ■	■							
bullfrog	one 1.6-ha (4-acre) pond/ population																● ■	● ■	● ■								
REPTILES																											
painted turtle																● ■	● ■		● ■								
western fence lizard	≧2.0 ha (5 acres)/ population	● ■		● ■	● ■			● ■		● ■	● ■					● ■					● ■		● ■		● ■	● ■	
sagebrush lizard	≧4.0 ha (10 acres)/ population				● ■	● ■		● ■		○ □	○ □										○ □						
side-blotched lizard	≧2.0 ha (5 acres)/ population	● ■		● ■	● ■	● ■		● ■								● ■	● ■				○ ■				● ■	● ■	
short-horned lizard[10]	≧8.1 ha (20 acres)/ population	● ■		● ■	● ■	● ■	● ■	● ■		● ■											● ■						
western skink		□		● □	● ■	● ■	● ■	● ■	● ■	● ■						● ■	● ■						● ■		□	○ □	

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		REPTILES															
CNTI	5	western whiptail[10]	M													3.4/clutch; 1 clutch	
CHBO	15	rubber boa	M													2-8/litter; 1 litter	
DIPU	3	ringneck snake	H													1-6/clutch; 1 clutch	
COCO	5	yellow-bellied racer	M													5-18/clutch; 1 clutch	
MATA	5	striped whipsnake	M													3-5/clutch; 1 clutch	
PIME	5	gopher snake	H													3-12/clutch; 1 clutch	
THSI	3	common garter snake	H													10-20/litter; 1 litter	
THEL	5	western terrestrial garter snake	M													10-20/litter; 1 litter	
HYTO	5	night snake[10]	M													2-6/clutch; 1 clutch	
CRVI	5	western rattlesnake[10]	M													5-6/clutch; 1 clutch/2 years	h.r. ≦ 457 ha (1,130 acres)/individual
		BIRDS															
GAIM	3	common loon[9]														1-3; avg. 2	
GAAR	3	Arctic loon[9]															
POGR	3	red-necked grebe[9 10]														3-8; avg. 5-6	
POAU	3	horned grebe[9 10]														3-10; avg. 4-5	
PONI	3	eared grebe	L													3-9; avg. 4-5	
AEOC	3	western grebe[9 10]														3-10; avg. 5-7	

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
REPTILES																											
western whiptail[10]	≧8.1 ha (20 acres)/ population				● ■	● ■		● ■		● ■						○ □					● ■					● ■	
rubber boa			● ■							■	● ■	● ■				○ ■	○ ■						● ■	● ■		● ■	
ringneck snake	≧8.1 ha (20 acres)/ population	● ■		● ■		● ■	● ■	● ■	● ■	● ■	● ■					● ■	● ■	● ■					● ■				
yellow-bellied racer	≧20.2 ha (50 acres)/ population	● ■	■	● ■	● ■	● ■		● ■		■	■					● ■	■				● ■					● ■	
striped whipsnake	≧20.2 ha (50 acres)/ population	● ■		● ■	● ■	● ■		● ■	□							○ □					● ■				■	● ■	
gopher snake	≧20.2 ha (50 acres)/ population	● ■	● ■	● ■	● ■	● ■	● ■	● ■	□	● ■						● ■	○ □	○ □			● ■		● ■		□	● ■	
common garter snake	≧10.1 ha (25 acres)/ population	● ■	● ■	● ■		● ■			● ■	● ■	● ■	● ■	● ■			● ■	● ■	● ■			□						
western terrestrial garter snake	≧10.1 ha (25 acres)/ population		● ■	● ■		● ■		● ■	■							● ■	● ■	□			● ■					○ □	
night snake[10]	≧20.2 ha (50 acres)/ population	○ ■	■	● ■	● ■	■	■	● ■													■			● ■	■	● ■	
western rattlesnake[10]	≧16.2 ha (40 acres)/ population	■	■	■	● ■	● ■	□	● ■	■	■	■					● ■	● ■	○ □			■		● ■		■	● ■	
BIRDS																											
common loon[9]	≧one 4-ha (10-acre) lake/ pair																		■								
Arctic loon[9]																			■								
red-necked grebe[9 10]																			■								
horned grebe[9 10]																			■								
eared grebe																●	● ■	● ■	● ■	□							
western grebe[9 10]																			■	□							

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
BIRDS																	
POPO	3	pied-billed grebe	L													3-10; avg. 5-7	
PEER	3	white pelican[9 10]														1-3; avg. 2	
PHAU	3	double-crested cormorant[10]	L													3-7; avg. 3-4	
ARHE	12	great blue heron	L													3-6	
CAAL	7	common egret[9]														3-5	
NYNY	7	black-crowned night heron[10]	L													3-6	
BOLE	3	American bittern[10]	L													3-7	
PLCH	12	white-faced ibis[9 10]														3-5	
CYOL	3	mute swan[9]														4-10	
OLCO	3	whistling swan[9]														2-7; avg. 4-5	
BRCA	3	Canada goose[10]	L													4-10; avg. 5-6	
BRNI	3	black brant[9]														4-8; avg. 5	
ANAL	3	white-fronted goose[9 10]														4-7; avg. 5-6	
CHCA	3	snow goose[9]														4-12; avg. 5-7	
CHRO	3	Ross' goose[9]														3-9; avg. 5-7	
ANPL	3	mallard	L													8-10	
ANST	3	gadwall	L													7-13	

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
pied-billed grebe																○	●	●	● ■	□							
white pelican[9 10]	requires protected island colonies																		■	□							
double-crested cormorant[10]	requires protected island colonies															●	●		● ■	□							
great blue heron	0.4 to 4 ha (1 to 10 acres)/ colony		■						●	○	○					● ■	● ■	● ■	■	■							
common egret[9]	0.4 to 4 ha (1 to 10 acres)/ colony		□													■	■	■	■								
black-crowned night heron[10]	0.4 to 4 ha (1 to 10 acres)/ colony		■			● ■			● ■							● ■	● ■	● ■	■								
American bittern[10]			■													■	● ■	● ■	■								
white-faced ibis[9 10]			□													■	■	■	■	□							
mute swan[9]			■	■												■	■		■	□							
whistling swan[9]			■	■												■	■		■	□							
Canada goose[10]		■	● ■	■												● ■	● ■	● ■	■				●		●		
black brant[9]																■	■		■								
white-fronted goose[9 10]			■	■												■	■	■	■	□							
snow goose[9]			■	■												■	■	■	■	□							
Ross' goose[9]			■	■												■	■		■								
mallard	0.2 ha (0.5 acre) emergent, riparian cover/pair	■	● ■	■												● ■	● ■	● ■	■	■			●				
gadwall	0.2 ha (0.5 acre) emergent, riparian cover/pair		● ■	■												○ □	● ■	● ■	■								

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)[4]
		BIRDS															
ANAC	3	pintail	L													6-12	
ANCR	3	green-winged teal	L													10-12	
ANDI	3	blue-winged teal	L													6-12	
ANCY	3	cinnamon teal	L													6-12	
ANPE	3	European wigeon[9 10]														6-12	
ANAM	3	American wigeon	L													6-12	
ANCL	3	northern shoveler	L													6-14	
AISP	14	wood duck	L													10-15	
AYAM	3	redhead	L													10-15	
AYCO	3	ring-necked duck[10]	L													6-12	
AYVA	3	canvasback[9 10]														7-9	
AYMA	3	greater scaup[9]														7-10	
AYAF	3	lesser scaup[10]	L													9-12	
BUCL	14	common goldeneye[9]														5-19; avg. 8-12	
BUIS	14	Barrow's goldeneye[10]	M													6-15; avg. 10	
BUAL	14	bufflehead[10]	M													6-14; avg. 10-12	
HIHI	3	harlequin duck[10]	L													5-9; avg. 7	

Activity; seasonal occurrence

L Low; M Medium; H High

Reproductive activity

Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
pintail	0.2 ha (0.5 acre) emergent, riparian cover/pair	■	● ■	■												○ □	● ■	● ■	■								
green-winged teal	0.2 ha (0.5 acre) emergent, riparian cover/pair	■	● ■	■												○ □	● ■	● ■	■								
blue-winged teal	0.2 ha (0.5 acre) emergent, riparian cover/pair		● ■	■												○ □	● ■	● ■	■								
cinnamon teal	0.2 ha (0.5 acre) emergent, riparian cover/pair		● ■	■												○ □	● ■	● ■	■								
European wigeon[9 10]																■	■		■								
American wigeon	0.2 ha (0.5 acre) emergent, riparian cover/pair	■	● ■	■												● ■	● ■	● □	■								
northern shoveler	0.2 ha (0.5 acre) emergent, riparian cover/pair	■	● ■	■												○ □	● ■	● ■	■								
wood duck	≧0.8 ha (2 acres) of suitable marsh/pair					■			■	■	■					● ■	● ■	● ■	■	■	○	●	●				
redhead	0.2 ha (0.5 acre) emergent, riparian cover/pair		● ■													○ □	● ■	■	■								
ring-necked duck[10]	0.2 ha (0.5 acre) emergent, riparian cover/pair	■	● ■	■												● ■	● ■	□	■	■							
canvasback[9 10]																	■		■								
greater scaup[9]																■	■		■								
lesser scaup[10]		■	● ■	■												● ■	● ■	● ■	■								
common goldeneye[9]																■	■		■	■		●	○				
Barrow's goldeneye[10]		■	■	■	■	■	■	■	■	■	■					● ■	● ■	● ■	■			●	○				
bufflehead[10]		■	■	■	■	■	■	■	■	■	■	■	■	● ■	■	○ ■	● ■	○ ■	■			●					
harlequin duck[10]											●	●	●	●		○ ■			□	● ■			●				

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
BIRDS																	
MEDE	3	white-winged scoter[9 10]														9-14	
OXJA	3	ruddy duck	L													6-10	
LOCU	14	hooded merganser	M													6-12	
MEME	14	common merganser	M													6-12	
MESE	3	red-breasted merganser[9]														8-10	
CAAU	4	turkey vulture[10]	M													1-3	
ELLE	11	white-tailed kite[9]														3-5	
ACGE	11	goshawk	L													3-5	nesting terr. 6.4-9.7 km (4-6 mi) radius
ACST	11	sharp-shinned hawk[10]	M													3-5	
ACCO	11	Cooper's hawk[10]	M													3-5	
BUJA	12	red-tailed hawk[10]	M													2-4	nesting terr. 1.3-7.8 km² (0.5-3 mi²)
BUSW	7	Swainson's hawk[10]	M													2-4	
BULA	5	rough-legged hawk[9 10]														2-6	
BURE	4	ferruginous hawk[10]	L													3-8	
AQCH	12	golden eagle[10]	M													1-3	
HALE	12	bald eagle[10]	M													2-3	

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
white-winged scoter[9 10]																■	■		■								
ruddy duck			■													○ □	● ■	● ■	■	□							
hooded merganser		■	■	■	■	■	■	■	■	■	■					● ■	● ■	○ ■	■			●	●				
common merganser		■	■	■	■	■	■	■	■	● ■						● ■	○ ■	● ■	■			●	●				
red-breasted merganser[9]																□	□		■	□							
turkey vulture[10]		● ■	■	● ■	■	■	■	● ■	■	● ■	■	■	■	■	■	■	■				■		●		●	■	
white-tailed kite[9]																■	■	■			■						
goshawk	12.1 ha/10 118 to 15 379 ha (30 acres/25,000–38,000 acres)/pair								■	○ ■	● ■	● ■	● ■	■		■		■				■	■		■	■	
sharp-shinned hawk[10]	10.1 ha/486 to 1 012 ha (25 acres/1,200–2,500 acres)/pair								■	■	● ■	● ■	● ■	○ ■		■		■			■	■	■				
Cooper's hawk[10]	8.1 ha/486 to 607 ha (20 acres/1,200–1,500 acres)/pair								■	● ■	● ■	● ■	■	■	■	● ■	■	■			■	■	■				
red-tailed hawk[10]		■	■	■	■	■	■	● ■	● ■	● ■	● ■	■	■	■	■	● ■	● ■	● ■			■	□			●	■	
Swainson's hawk[10]		● ■	■	● ■	● ■	● ■		● ■													● ■				■	■	
rough-legged hawk[9 10]		■	■	■	■	■	■	■	■	■											■						
ferruginous hawk[10]		● ■	■	● ■	● □	□	□	● ■	□	○ ■	□	□	□	□	□						■				●	■	
golden eagle[10]		■	■	■	■	■	■	■	■	● ■	● ■	■	■	■	■	■	■	■			■	□			● ■	■	
bald eagle[10]		■	■	■				■	■	● ■	● ■	■				● ■	● ■	■				■					

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
				Activity; seasonal occurrence													
BIRDS																	
CICY	5	marsh hawk[10]	L													4-6	
PAHA	12	osprey[10]	M													2-4	
FAME	4	prairie falcon[10]	L													3-6	
FAPE	4	peregrine[10]	H													2-4	
FACO	11	merlin[10]	M													3-6	
FASP	14	American kestrel[10]	M													3-5	
DEOB	5	blue grouse	M													5-10	
CACA	5	Franklin's grouse[10]	L													8-12	terr. 4-4.9 ha (10-12 acres)/male
BOUM	5	ruffed grouse	M													8-14	
LALE	4	white-tailed ptarmigan[10]	L													4-10	
PEPH	5	sharp-tailed grouse[10]	L													7-13	
CEUR	5	sage grouse[10]	L													7-13	
COVI	5	bobwhite	L													10-20	
LOCA	5	California quail	L													10-17	
ORPI	5	mountain quail[10]	L													5-15	
ALCH	4	chukar	L													8-15	
PEPE	5	gray partridge	L													10-22	

L Low; M Medium; H High ■ Reproductive activity ■ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Otlier grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
marsh hawk[10]		■	● ■	● ■		● ■										□	□	○ □			■						
osprey[10]		■	■	■	■	■	■	■	■	● ■	● ■					● ■	● ■		■	■		●					
prairie falcon[10]	0.4 km (0.25 mi) undisturbed cliff/pair	● ■	■	● ■											■	■	■	■							● □	■	
peregrine[10]	0.8 km (0.5 mi) undisturbed cliff/pair	■	■	■	■	■	■	■	■	■	● ■	● ■	● ■	● ■	● ■	■	■	■			■				● ■	■	
merlin[10]		■	■	■					■	■	● ■	● ■	● ■	● ■	■	○ ■	○ ■	■			■						
American kestrel[10]		■	■	■	■	■	■	● ■	● ■	● ■	●					● □	● □	● □			● ■	●			● ■	■	
blue grouse		■	■	■		● ■	■	■	● ■	● ■	● ■	■	■	■	■	□					● ■		● □				
Franklin's grouse[10]	≧4 ha (10 acres)/male					■						● ■	● ■	● ■		□					■		● ■				
ruffed grouse						● ■			● ■	● ■	● ■	■	■	■		● ■	● ■	□			● ■		● ■				
white-tailed ptarmigan[10]														■	● ■											● ■	
sharp-tailed grouse[10]		● ■	■	● ■	□	● ■										□	□										
sage grouse[10]	one protected lek/population		□	■	● ■	■		■								□	□				● ■						
bobwhite				□		● ■										● ■	● ■	□			● ■		● □				
California quail				□		● ■										● ■	● ■	□			● ■		● □				
mountain quail[10]						● ■			□	● ■	□					● ■	● ■				● ■		● ■				
chukar			□	○ □	○ □	● ■	● ■	■		□						○ □					● ■		○		● □	● ■	
gray partridge		● ■	● ■	● ■		● ■	○ □	□								○ □					● ■						

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		BIRDS															
PHCO	5	ring-necked pheasant	L													6-14	
MEGA	5	turkey	M													8-15	
GRCA	3	sandhill crane[10]	L													2	
RALI	3	Virginia rail[10]	L													5-12	
POCA	3	sora	L													6-15	
FUAM	3	American coot	L													8-12	
CHAL	3	snowy plover[10]	L													2-3	
CHVO	3	killdeer	L													4	
CHMO	3	mountain plover[9 10]														3	
CAGA	3	common snipe	L													4	
NUAM	3	long-billed curlew[10]	L													4	
BALO	5	upland sandpiper[10]	L													4	
ACMA	3	spotted sandpiper	L													4	
TRSO	7	solitary sandpiper	L													4	
TRME	3	greater yellowlegs[9]														4	
TRFL	3	lesser yellowlegs[9]														4	
CASE	3	willet[10]	L													3-4	

Activity; seasonal occurrence

L Low; M Medium; H High — Reproductive activity — Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
ring-necked pheasant		□	□	● ■		● ■										○ □	○ □	○ □			● ■		●				
turkey		■	■	■		● ■			● ■	● ■	● ■					○ ■					● ■		● ■			■	
sandhill crane[10]		■	● ■	○ ■												■	■	○ ■			■						
Virginia rail[10]			■													■	□	● ■	● ■		□						
sora																● ■	○ □	● ■	● ■	□	■						
American coot		■	■	■		● ■										● ■	● ■	● ■	● ■		○ □						
snowy plover[10]		● ■	■	■	■											■	■	■	■		■						
killdeer		● ■	● ■	● ■												● ■	● ■	○ ■									
mountain plover[9 10]		■		■	■													■			■						
common snipe			● ■	● ■												● ■	● ■	● ■	■	□							
long-billed curlew[10]	≧2 ha (5 acres) traditional sites/pair	■	■	● ■	● ■											■	■	■	■		● ■						
upland sandpiper[10]		■	● ■	■		□										○ □	○ □	□			■						
spotted sandpiper			● ■												● ■	● ■	● □	○ □	● ■	● ■	□						
solitary sandpiper	blackbird nests/pair	■	● ■	■		● ■				■						● ■	● ■	● ■			● ■						
greater yellowlegs[9]			□													■	■	■	■		□						
lesser yellowlegs[9]			□													■	■	■	■		□						
willet[10]		■	● ■	■												■	○ ■	● ■	● ■								

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
				Activity; seasonal occurrence													
BIRDS																	
CAME	3	pectoral sandpiper[9]														4	
CABA	3	Baird's sandpiper[9 10]														4	
CAMI	3	least sandpiper[9]														4	
CAMA	3	western sandpiper[9]														4	
LISC	3	long-billed dowitcher[9]														4	
REAM	3	American avocet	L													3-4	
STTR	3	Wilson's phalarope	L													4	
LOLO	3	northern phalarope[9]														4	
LAAR	3	herring gull[9]														2-3	
LACA	3	California gull	L													2-3	
LADE	3	ring-billed gull	L													2-4	
LAPI	3	Franklin's gull[10]	L													3	
LAPH	3	Bonaparte's gull[9]														2-4	
STFO	3	Forster's tern	L													3-4	
HYCA	3	Caspian tern[9 10]														2-3	
CHNI	3	black tern	L													3	
COFA	11	band-tailed pigeon[9]														1	

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
pectoral sandpiper[9]			□													■	■	■	■							■	
Baird's sandpiper[9 10]			□													■	■	■	■							■	
least sandpiper[9]			□													■	■	■	■								
western sandpiper[9]																■	■	■	■							■	
long-billed dowitcher[9]			■	■												■	■	■	■								
American avocet		■	● ■	● ■												● ■	● ■	● ■	● ■								
Wilson's phalarope			● ■													□	● ■	● ■	● ■								
northern phalarope[9]																■	■	■	■								
herring gull[9]		■	■	■												■	■	■	■								
California gull		● ■	■	● ■	● ■				■							● ■	● ■	○ ■	● ■								
ring-billed gull		● ■	■	● ■	● ■				■							○ ■	○ ■	○ ■	● ■								
Franklin's gull[10]		● ■	■	● ■	● ■				■							● ■	○ ■	● ■	● ■								
Bonaparte's gull[9]			■	■												■	■	■	■								
Forster's tern		● ■	■	●	●											■	● ■	● ■	● ■	■							
Caspian tern[9 10]																	■	■	■								
black tern		● ■	■	●												■	● ■	● ■	● ■								
band-tailed pigeon[9]				■					■	■						■	■										

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
BIRDS																	
COLI	4	rock dove	L													2	
ZEMA	11	mourning dove	M													2	
COAM	8	yellow-billed cuckoo[10]	L													2-4	
TYAL	14	barn owl[10]	M													5-7	h.r. ≧202 ha (500 acres)/pair
OTAS	14	screech owl[10]	L													4-5	
OTFL	14	flammulated owl[10]	L													2-4	terr. 6.1-12.1 ha (15-30 acres)
BUVI	12	great horned owl	M													2-3	h.r. 1 214 ha (3,000 acres)
NYSC	5	snowy owl[9 10]														5-8	
GLGN	14	pygmy owl	M													3-4	
SPCU	15	burrowing owl[10]	M													5-9	
STVA	14	barred owl[10]	L													2-3	h.r. 241 ha (595 acres)
STOC	14	spotted owl[9 10]														2-3	h.r. 162-243 ha (400-600 acres)
STNE	12	great gray owl[10]	L													2-5	
ASOT	11	long-eared owl	M													3-8	
ASFL	5	short-eared owl[10]	L													4-9	
AEAC	14	saw-whet owl	L													4-7	
PHNU	6	poorwill[10]	M													2	

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
rock dove		● ■	■	● ■	● □	■	■	■								■	■				■				●		
mourning dove		■	■	■	● ■	● ■	●	●	●	○						●	●	●			● ■						
yellow-billed cuckoo[10]						● ■			■							● ■	● ■	● ■			○ □		□				
barn owl[10]			■	■	■					● ■	● ■	● ■				● ■	● ■	○ ■			● ■	● □			● ■	■	●
screech owl[10]			■					● ■	■	□	○ □	○ □				● ■	● ■	● ■			● ■	●			● □	■	○
flammulated owl[10]										● ■	● ■										● ■	● □					
great horned owl		■	■	■	■	■	■	● ■	● ■	● ■	● ■	■	○ ■	○ ■	■	● ■	● ■	● ■			■	○ □			● ■	■	
snowy owl[9 10]		■	■	■	□	□		□	□	□						■	■	■									
pygmy owl		■	■			■		● ■	● ■	● ■	● ■	□	□	□		● ■	● ■	● ■			● ■	● ■				■	
burrowing owl[10]		● ■		● ■	● ■			● ■								□	□				● ■			●	□	□	
barred owl[10]										■	● ■	● ■				● ■	● ■	● ■				● ■	■				
spotted owl[9 10]											● ■	● ■				● ■						○ □	□				
great gray owl[10]			■								○ ■		● ■								● ■	○					
long-eared owl			■			■			● ■	■	● ■	● ■	● ■	● ■		● ■	● ■	● ■			■						
short-eared owl[10]		■	● ■	■	■	■										○ □	○ □	● ■			● ■						
saw-whet owl									■	● ■	● ■	● ■	■	□		● ■	● ■	● ■			● ■	●					
poorwill[10]		■	■	■	● ■	■	■	■		● ■						○ □	○ □	○ □			● ■				○ ■	○ ■	

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		BIRDS															
CHMI	6	common nighthawk[10]	M													2	
CYNI	4	black swift	L													1	
CHVA	14	Vaux's swift	L													3-5	
AESA	4	white-throated swift	L													3-6	
ARAL	7	black-chinned hummingbird	M													2	
SEPL	7	broad-tailed hummingbird	L													2	
SERU	11	rufous hummingbird	M													2	
STCA	7	calliope hummingbird	M													2	
MEAL	16	belted kingfisher	M													5-8	
COAU	13	common flicker	M													5-10	terr. 16.2 ha (40 acres)/pair
DRPI	13	pileated woodpecker	L													3-5	terr. 121 ha (300 acres)/pair
ASLE	13	Lewis' woodpecker[10]	L													6-8	terr. 6.1 ha (15 acres)/pair
SPVA	13	yellow-bellied sapsucker	L													4-6	terr. 4 ha (10 acres)/pair
SPTH	13	Williamson's sapsucker	L													3-7	terr. 4 ha (10 acres)/pair
DEVI	13	hairy woodpecker[10]	L													3-6	terr. 10.1 ha (25 acres)/pair
DEPU	13	downy woodpecker	L													4-7	terr. 4 ha (10 acres)/pair
DEAL	13	white-headed woodpecker	L													3-5	terr. 8.1 ha (20 acres)/pair

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
common nighthawk[10]		● ■	■	■	● ■	● ■	● ■	● ■	■	● ■					■						○ ■		○		● ■	■	
black swift		● ■	■	● ■				■	■	● ■						■	■	■							● ■	■	
Vaux's swift			□								● ■	● ■	■	● ■		■	■	■			■	●			○ ■	■	
white-throated swift		■	■	■	■	■		■	■	● ■					● ■	■	■				■				● ■	■	
black-chinned hummingbird			■	□		● ■			● ■	□	● ■				○ □	● ■	● ■	● ■			■						
broad-tailed hummingbird			■	□		● ■			● ■	□	○ □					● ■	● ■	● ■									
rufous hummingbird		■	■	■		□			□	□	● ■	● ■	● ■	● ■	■	● ■	● ■	○ □			● ■						
calliope hummingbird		■	■	■	■	● ■			● ■	■	● ■			● ■	■	● ■	● ■	● ■			● ■						
belted kingfisher		■	■	■	■	■	■	■	■	■	■					● ■	● ■		■	■				●			
common flicker		□	□	□	□	□	□	● ■	● ■	● ■	● ■	● ■	○ □	○ □	□	● ■	● ■	● ■			■	● ■	■				
pileated woodpecker										● ■	● ■	● ■	□	□		○ □	○ □					● ■	■				
Lewis' woodpecker[10]			□	□		□			□	● ■	● ■					● ■	● ■	● ■			● ■	● ■	■				
yellow-bellied sapsucker						□		□	● ■	○ □	○ □	□	□	□		● ■	● ■	● ■			● ■	● □					
Williamson's sapsucker								□	□	● ■	● ■	● ■	□	● ■		○ □	○ □	□			■	● □					
hairy woodpecker[10]									□	● ■	● ■	● ■	● ■	● ■		□	□	□			□	● ■	■				
downy woodpecker						□			● ■	□	□					● ■	● ■	● ■			□	● ■	■				
white-headed woodpecker										● ■	● ■	○ □	□	○ □								● ■					

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BIRDS																	
PIAR	13	black-backed three-toed woodpecker	L													4-5	terr. 30.4 ha (75 acres)/pair
PITR	13	northern three-toed woodpecker[10]	L													4-5	terr. 30.4 ha (75 acres)/pair
TYTY	7	eastern kingbird	M													3-5	
TYVE	11	western kingbird	L													3-5	
MYCI	14	ash-throated flycatcher	L													4-5	
SASA	4	Say's phoebe	M													4-5	
EMTR	7	willow flycatcher	L													3-4	
EMHA	11	Hammond's flycatcher	M													3-4	
EMOB	8	dusky flycatcher	M													3-5	
EMWR	7	gray flycatcher	M													3-4	
EMDI	10	western flycatcher	M													3-4	
COVIR	9	eastern wood pewee[9]														3-4	
COSO	11	western wood pewee	M													3-4	
NUBO	10	olive-sided flycatcher	M													3	
ERAL	5	horned lark	L													3-5	
TATH	14	violet-green swallow	L													4-5	

L Low; M Medium; H High ■ Reproductive activity ■ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
black-backed three-toed woodpecker										□	● ■	● ■	● ■	● ■							□	● ■	■				
northern three-toed woodpecker[10]											□	○ □	● ■	● ■								● ■	■				
eastern kingbird					■	● ■		● ■	● ■							● ■	● ■	● ■			■						
western kingbird				□	□	● ■			● ■							● ■	● ■	● ■			■	□	□				
ash-throated flycatcher		■		■				● ■	● ■	● ■						● ■	● ■				■	●	□				
Say's phoebe		● ■	■	● ■	● ■	● ■	■	● ■	■	● ■						○ □	○ □				● ■		○ □		● ■	● ■	
willow flycatcher					■	■		■	● ■		○ ■	■	● ■	□		● ■	● ■				● ■		□				
Hammond's flycatcher									● ■	● ■	● ■	● ■	● ■	● ■		○ □	□	□			○ ■	□	■				
dusky flycatcher				■	■	● ■		● ■		● ■	● ■					● ■	● ■	● ■				□	■				
gray flycatcher		■		■	● ■	■		● ■	■	■						■	■								■	■	
western flycatcher											● ■	● ■	● ■	● ■		● ■	■	■			■	■	■				
eastern wood pewee[9]									■	■	■					■	■				■		■				
western wood pewee										● ■	● ■	● ■	● ■	● ■		● ■	● ■	■			● ■		■				
olive-sided flycatcher									■	● ■	● ■	● ■	■	■		○ ■	■	□			■	□	□				
horned lark		● ■	■	● ■	□																□						
violet-green swallow		□	■	□					● ■	● ■						● ■	● ■	● ■			● ■	●					

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Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year[4]	Home range (h.r.) or territory size (terr.)[5]
		BIRDS															
IRBI	14	tree swallow	L													4-6	
RIRI	16	bank swallow	L													4-5	
STRU	16	rough-winged swallow	L													4-8	
HIRU	4	barn swallow	L													4-6	
PEPY	4	cliff swallow[10]	L													4-6	
PECA	11	gray jay	L													3-5	
CYCR	9	blue jay[9]														3-5	
CYST	11	Steller's jay	M													3-5	
PIPI	7	black-billed magpie	H													6-9	
COCOR	4	common raven	H													4-7	
COBR	11	common crow	M													4-6	
GYCY	10	pinyon jay	L													3-4	
NUCO	10	Clark's nutcracker	L													2-4	
PAAT	14	black-capped chickadee	L													4-9	
PAGA	14	mountain chickadee	M													7-9	terr. 1.2-2 ha (3-5 acres)/pair
PARU	14	chestnut-backed chickadee[10]	L													5-7	
PSMI	8	bushtit	M													5-7	

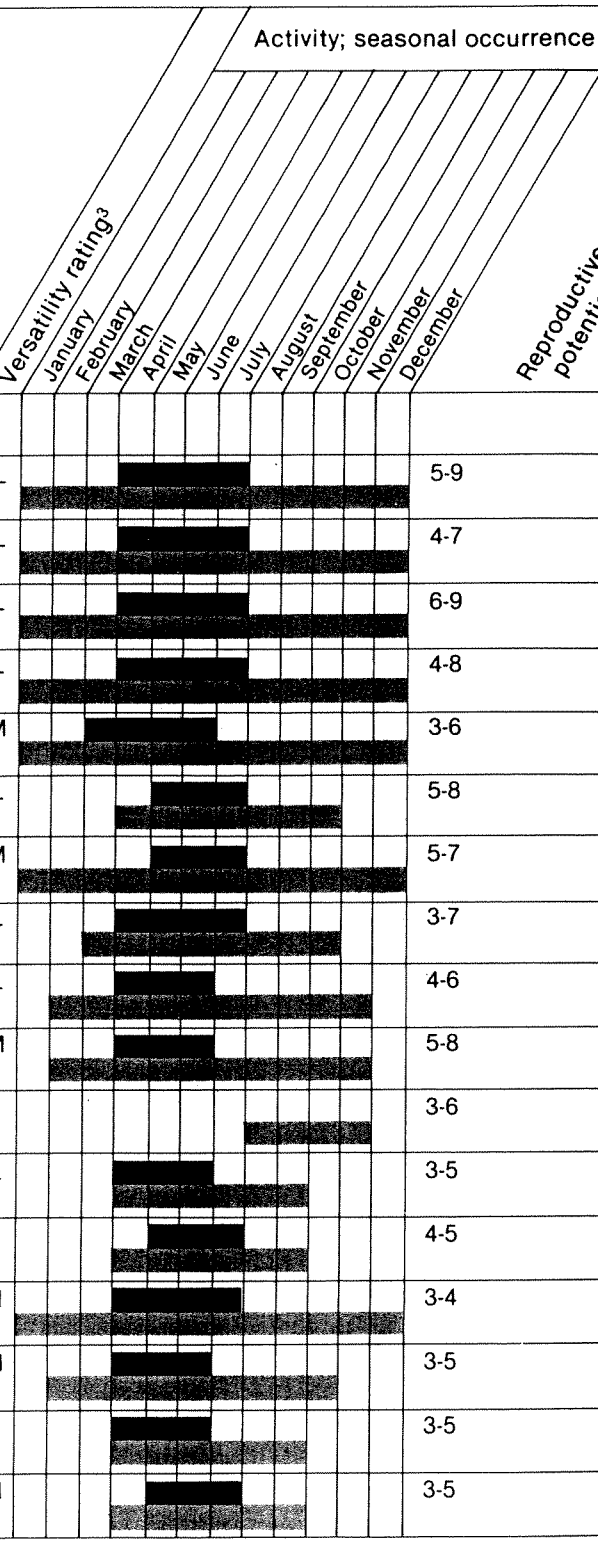
L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
tree swallow		□	■	□					● ■	● ■	●					● ■	● ■	● ■			● ■	●					
bank swallow		■	■	■		■										● ■	● ■	■			● ■			●			
rough-winged swallow		■	■	■		■										● ■	● ■	■			● ■			●			
barn swallow		● ■	● ■	● ■					■							■	■	■			● ■				● ■		
cliff swallow[10]		● ■	● ■	● ■					■							● ■	● ■	■							● ■	■	
gray jay									□	□	● ■	● ■	● ■	● ■	□	□											
blue jay[9]									■	■	■					■	■				■		□				
Steller's jay							■	■	■	● ■	● ■	● ■	□	□		● ■	● ■	■			● ■		□		■	■	
black-billed magpie		■	■	■	● ■	● ■	■	● ■	● ■	● ■	■	■	■	■	■	● ■	● ■	○ ■			● ■				■	■	
common raven		● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■				● ■				● ■	■	
common crow			□			■	■	■	● ■	■	● ■	● ■				● ■	● ■	●			● ■						
pinyon jay					■	■		● ■	■	■						■	■	□					□				
Clark's nutcracker										■	■			● ■								□	□		■		
black-capped chickadee						■		○ □	● ■	○ □						● ■	● ■	● ■			● ■	● □	○ □				
mountain chickadee						■		■	□	● ■	● ■	● ■	● ■	● ■		□	□	□			● ■	● □	○ □				
chestnut-backed chickadee[10]						■			□	□	● ■	● ■	● ■	□		○ ■	○ ■	■				● □	□				
bushtit					■	● ■	● ■	● ■		■						○ ■	○ ■	○ ■			● ■		□				

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		BIRDS				
SICA	13	white-breasted nuthatch	L		5-9	
SICAN	13	red-breasted nuthatch[10]	L		4-7	
SIPY	13	pygmy nuthatch	L		6-9	
CEFA	14	brown creeper	L		4-8	
CIME	3	dipper	M		3-6	
TRAE	14	house wren	L		5-8	
TRTR	3	winter wren	M		5-7	
TEPA	3	long-billed marsh wren	L		3-7	
CAMEX	4	canyon wren	L		4-6	
SAOB	4	rock wren	M		5-8	
MIPO	7	mockingbird[9 10]			3-6	
DUCA	7	gray catbird[10]	L		3-5	
ORMO	7	sage thrasher	L		4-5	
TUMI	7	American robin	H		3-4	
IXNA	11	varied thrush	M		3-5	
CAGU	5	hermit thrush[10]	L		3-5	
CAUS	7	Swainson's thrush	M		3-5	



L Low; M Medium; H High — Reproductive activity — Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
white-breasted nuthatch									□	● ■	● ■	□									■	● ■	□				
red-breasted nuthatch[10]									□	□	● ■	● ■	● ■	□		□	□				■	● ■	□				
pygmy nuthatch									■	● ■	○ ■	□	□			□	□				■	● ■					
brown creeper									□	● ■	● ■	□				■	■	■				● ■	□				
dipper										● ■	● ■	● ■				■				● ■			○		●		
house wren						■		○ □	● ■	● ■	● ■	○ □	○ □	○ □		● ■	● ■	● ■			● ■	● ■	● ■				
winter wren									□	□	● ■	● ■	● ■	● ■		○ ■						● ■	● ■				
long-billed marsh wren			● ■													□	□	● ■	● ■								
canyon wren		● ■		● ■	● ■	● ■				● ■											● ■				● ■	● ■	
rock wren		● ■		● ■	● ■	● ■	● ■			● ■	● ■	● ■									● ■				● ■	● ■	
mockingbird[9 10]						■					■	■				■	■				■						
gray catbird[10]						● ■			● ■							● ■	● ■	● ■									
sage thrasher					● ■	■		■	■							■		□							■	■	
American robin		■	■	■	● ■	● ■		● ■	● ■	● ■	● ■	● ■	● ■	● ■	■	● ■	● ■	● ■			● ■						
varied thrush											● ■	● ■	● ■	● ■		□	□				□						
hermit thrush[10]						□			□	■	● ■	● ■	● ■	● ■		□	□						○ □				
Swainson's thrush						● ■			● ■		● ■	● ■		● ■		● ■	● ■				● ■		● ■				

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
BIRDS																	
CAFU	5	veery[10]	L													3-5	
SIME	14	western bluebird[10]	M													4-6	
SICU	14	mountain bluebird[10]	M													4-6	
MYTO	6	Townsend's solitaire	M													3-5	
RESA	10	golden-crowned kinglet	M													5-9	
RECA	10	ruby-crowned kinglet	L													6-9	
ANSP	5	water pipit[10]	L													4-7	
BOGA	8	Bohemian waxwing[9 10]														4-6	
BOCE	9	cedar waxwing	L													3-6	
LAEX	7	northern shrike[9]														4-6	
LALU	7	loggerhead shrike[10]	M													4-7	
STVU	14	starling	L													4-6/clutch; 1-6 clutches	
VISO	11	solitary vireo	M													3-5	
VIOL	11	red-eyed vireo[10]	L													3-4	
VIGI	11	warbling vireo[10]	L													3-5	
VECE	6	orange-crowned warbler[10]	L													4-6	
VERU	6	Nashville warbler	L													3-5	

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
veery[10]						●			●							●	●	●			●		○				
						■			■							■	■	■			■		□				
western bluebird[10]								●	●	●	●							○			●	●	○				
		■	■	■	■	■	■	■		■					■	□	□	□			■		□		■	■	
mountain bluebird[10]								●	●	●	●							○			●	●	○				
		■	■	■	■	■	■	■		■					□	□	□	□			■		□		■	■	
Townsend's solitaire		●		●				●													●		○		●		
		■		■	□	□		■		■						□	□				■		■		■		
golden-crowned kinglet											●	●	●	●													
									■	■	■	■	■	■		□	□										
ruby-crowned kinglet											●	●	●	●		○	○	○									
									■	■	■	■	■	■		□	□	□			□						
water pipit[10]															●		○	○									
			■	■											■		□	□									
Bohemian waxwing[9 10]									■	■	■					■	■				■						
cedar waxwing						●			●							●	●	●									
						■			■							■	■	■			■						
northern shrike[9]				■	■	■										■	■				■		□				
loggerhead shrike[10]					●	●		●													●						
		■	■	■	■	■	■	■	■	■						■	■	■			■		□		■	■	
starling								○	○	○	○		○			●	●	●			●	●	○		●		
		■	■	■												■	■	■			■				■		
solitary vireo										●	●	●	●			○	○										
									■	■	■	■	■	■		■	■	■									
red-eyed vireo[10]									●							●	●	●									
						■			■	■						■	■	■			■						
warbling vireo[10]									●							●	●	●									
						■			■	■						■	■	■			■						
orange-crowned warbler[10]						●										●	●	●			●						
						■										■	■	■			■						
Nashville warbler						●			●		●					●	●	●			●						
						■			■		■					■	■	■			■		□				

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		BIRDS															
PAAM	10	northern parula[9]														3-5	
DEPE	8	yellow warbler[10]	L													4-5	
DECO	10	yellow-rumped warbler[10]	M													3-5	
DENI	10	black-throated gray warbler[10]	M													3-5	
DETO	10	Townsend's warbler	L													3-5	
SENO	3	northern waterthrush[10]	L													4-5	
OPTO	7	MacGillivray's warbler[10]	M													3-5	
GETR	3	common yellowthroat[10]	L													3-5	
ICVI	8	yellow-breasted chat[10]	L													3-5	
WIPU	5	Wilson's warbler	L													3-6	
SERUT	9	American redstart[10]	L													3-5	
PADO	14	house sparrow	L													5-6/clutch; 1-3 clutches	
DOOR	5	bobolink[10]	L													4-7	
STNEG	5	western meadowlark[10]	L													3-7	
XAXA	7	yellow-headed blackbird	L													3-5	
AGPH	7	red-winged blackbird	L													3-5	
ICSP	9	orchard oriole[9]														4-5	

Activity; seasonal occurrence

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
northern parula[9]									■		■					■	■										
yellow warbler[10]						● □			● ■							● ■	● ■	● ■			■						
yellow-rumped warbler[10]						□			■	■	● ■	● ■	● ■	● ■		○ ■	○ ■	○ ■			■						
black-throated gray warbler[10]						● ■		● ■		● ■	● ■					○ □	○ □	□									
Townsend's warbler										■	● ■	● ■	■	● ■		○ □	□	□									
northern waterthrush[10]			■			■					■					● ■	● ■	● ■			■		■				
MacGillivray's warbler[10]						● ■			● ■		● ■	● ■	● ■			● ■	● ■	● ■			■						
common yellowthroat[10]			■	● ■		● ■										■	■	● ■			■						
yellow-breasted chat[10]						● ■			■		■					● ■	● ■	● ■			● ■		□				
Wilson's warbler						● ■			● ■		● ■					● ■	● ■	● ■			● ■		○ ■				
American redstart[10]						□			● ■							● ■	● ■	● ■			■						
house sparrow		■	■	■												● ■	● ■	● ■			● ■	○					
bobolink[10]			● ■	□		□										□	□	● ■			● ■						
western meadowlark[10]		● ■	□	● ■	● ■	● ■												□			□						
yellow-headed blackbird	0.4-2 ha (1-5 acres) alkali marsh/population	■	■	■	■											□	■	● ■			■						
red-winged blackbird		■	● ■	■		■										● ■	● ■	● ■			● ■						
orchard oriole[9]						■			■							■	■	■									

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		BIRDS															
ICGA	9	northern oriole	L													3-6	
EUCY	7	Brewer's blackbird	M													4-6	
QUQU	7	common grackle[9]														4-6	
MOAT	7	brown-headed cowbird	M													4-6	
PILU	10	western tanager	M													3-5	
PHME	11	black-headed grosbeak	M													3-4	
PAAMO	7	lazuli bunting[10]	M													3-4	
HEVE	11	evening grosbeak	M													3-4	
CAPU	11	purple finch	M													4-5	
CACAS	11	Cassin's finch	M													4-5	
CAMEXI	9	house finch	M													4-5	
PIEN	11	pine grosbeak[10]	L													3-4	
LETE	4	gray-crowned rosy finch[10]	L													3-5	
LEAT	4	black rosy finch[10]	L														
SPPI	11	pine siskin	M													3-6	
SPTR	8	American goldfinch	M													3-6	
SPPS	7	lesser goldfinch[10]	L													4-5	

Activity; seasonal occurrence

L Low; M Medium; H High — Reproductive activity — Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
northern oriole						□			● ■	■	■					● ■	● ■	● ■			● ■						
Brewer's blackbird		■	■	■	■	● ■			● ■	● ■	● ■					● ■	● ■	● ■			● ■						
common grackle[9]			■	■												■	■	■			■						
brown-headed cowbird		□	● ■	■	□	● ■			● ■	● ■	● ■					● ■	● ■	● ■									
western tanager									● ■	● ■	● ■	● ■	● ■	● ■		● ■	● ■	● ■			● ■						
black-headed grosbeak									● ■	● ■	● ■	● ■	■	■		● ■	● ■	■			● ■						
lazuli bunting[10]					● ■	● ■		● ■	● ■							● ■	● ■	● ■			● ■						
evening grosbeak									■	● ■	● ■	● ■	● ■	● ■		● ■	● ■	■			● ■						
purple finch		■	■						□	● ■	● ■					● ■	● ■	■			● ■						
Cassin's finch		■	■						□	● ■	● ■	● ■	● ■	● ■		● ■	● ■				● ■						
house finch		□	□	□		● ■			● ■	● ■	■					● ■	● ■	● ■			● ■						
pine grosbeak[10]										● ■	● ■	● ■	● ■	● ■							● ■						
gray-crowned rosy finch[10]		■	■	■										● ■	● ■										● ■	■	
black rosy finch[10]		■	■	■										● ■	● ■										● ■	■	
pine siskin		■	□	□		■			■	● ■	● ■	● ■	● ■	● ■	□	■	■	■			● ■				■	■	
American goldfinch		■	□	■		● ■			○ □	● ■						● ■	● ■	● ■			● ■						
lesser goldfinch[10]		■	□	■		● ■		● ■								□		□			● ■				■	■	

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
				Activity; seasonal occurrence													
		BIRDS															
LOCUR	10	red crossbill	L													3-5	
LOLE	10	white-winged crossbill[9]														3-4	
CHCH	7	green-tailed towhee	M													4	
PIER	7	rufous-sided towhee	L													3-6	
PASA	5	savannah sparrow	L													4-5	
AMSA	5	grasshopper sparrow[10]	L													4-5	
POGRA	5	vesper sparrow[10]	L													4-6	
CHGR	5	lark sparrow	L													3-5	
AMBE	7	sage sparrow	L													3-4	
JUHY	5	dark-eyed junco[10]	M													4-5	
SPAR	7	tree sparrow[9 10]														4-5	
SPPA	7	chipping sparrow	M													3-5	
SPBR	7	Brewer's sparrow	M													3-4	
ZOLE	7	white-crowned sparrow	M													3-5	
ZOAT	5	golden-crowned sparrow[9]														4-5	
ZOAL	5	white-throated sparrow[9]														4-5	
PAIL	7	fox sparrow[10]	L													4-5	

L Low; M Medium; H High — Reproductive activity — Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
red crossbill										● ■	● ■	● ■	● ■	● ■		□	□	□			□						
white-winged crossbill[9]										■	■	■	■	■							□						
green-tailed towhee				□	● ■	○ □		● ■		■						■	■	□			● ■		○ ■		■	■	
rufous-sided towhee						● ■			● ■		○ □	□				● ■	● ■	○ □			● ■		○ ■				
savannah sparrow		● ■		● ■																							
grasshopper sparrow[10]		● ■																									
vesper sparrow[10]		● ■	● ■	● ■																							
lark sparrow		■	■	● ■	■	■															● ■						
sage sparrow					● ■	■		● ■								□		□							■	■	
dark-eyed junco[10]						● ■			● ■	● ■	● ■	● ■	● ■	● ■		● ■	● ■				● ■		○ □				
tree sparrow[9 10]						■										■	■				■						
chipping sparrow		■	■	■		● ■	● ■	● ■	● ■	● ■	● ■					● ■	● ■	○ □			● ■		○ □				
Brewer's sparrow		■		■	● ■	● ■		● ■								□	□	□			● ■						
white-crowned sparrow			□	□		■			■					● ■	● ■	■	■	■			● ■		□				
golden-crowned sparrow[9]			□	□		■			□					■	■	■	■	■			■		□				
white-throated sparrow[9]			□	□		■			□					■	■	■	■	■			■		□				
fox sparrow[10]						● ■								● ■		● ■	● ■				● ■		■				

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		BIRDS															
MELI	6	Lincoln's sparrow	L													4-5	
MEMEL	7	song sparrow	L													3-5	
CALA	5	Lapland longspur[9]														4-7	
PLNI	5	snow bunting[9]														4-6	
		MAMMALS															
DIMA	5	opossum[10]	L													5-13; avg. 9; 2 litters	
SOPR	15	Malheur shrew[10]	L														
SOVA	15	vagrant shrew	M													2-9; avg. 4-6; 1 litter	372 m² (4,000 ft²)
SOOB	15	dusky shrew	L													4-6; avg. 4; 1 litter	
SOPA	16	northern water shrew	M													5-8; avg. 5-6; 1 litter	
SOME	15	Merriam shrew[10]	L													5-7; 1 litter	
SCOR	15	coast mole	H													3-4; 1 litter	
MYLU	14	little brown myotis	M													1 young	
MYYU	14	Yuma myotis	L													1 young	
MYEV	14	long-eared myotis[10]	M													1 young	
MYVO	14	long-legged myotis[10]	M													1 young	
MYCA	14	California myotis	M													1 young	

Activity; seasonal occurrence

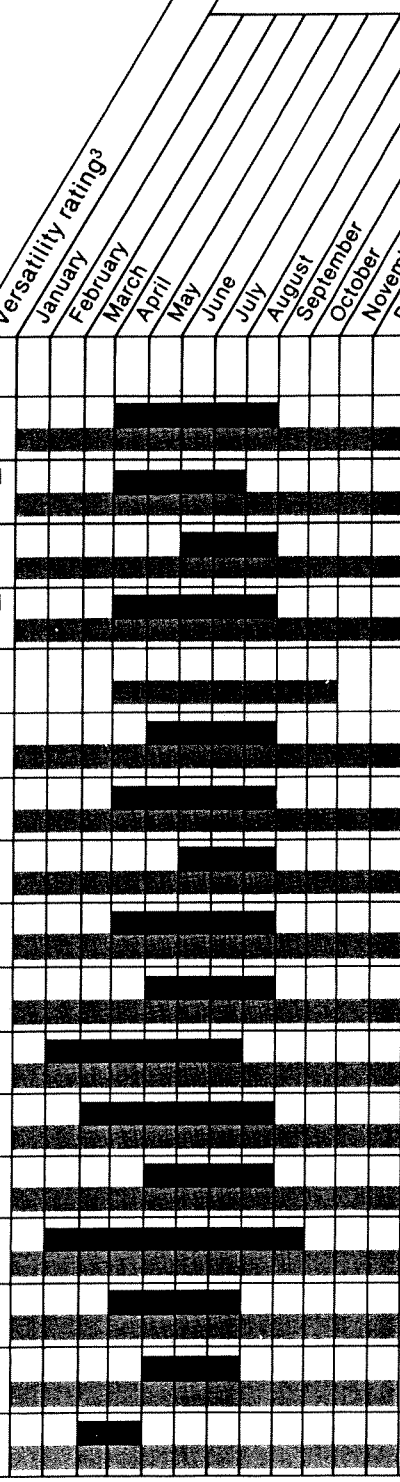
L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
BIRDS																											
Lincoln's sparrow						□			□					● ■	● ■	● ■	● ■	● ■			● ■		□				
song sparrow						● ■			□		■					● ■	● ■	● ■			● ■		○ ■				
Lapland longspur[9]		■	■	■												■	■				■						
snow bunting[9]		■	■	■												■	■				■						
MAMMALS																											
opossum[10]						□			□	□						● ■	● ■	● ■			■	○	●				
Malheur shrew[10]	≧2 ha (5 acres)/population		● ■								● ■					● ■	● ■	● ■					● ■	● □			
vagrant shrew	≧2 ha (5 acres)/population		● ■	● ■	● ■	● ■								● ■	● ■	● ■	● ■	● ■			● ■		● ■	● □		● ■	
dusky shrew	≧2 ha (5 acres)/population										● ■	● ■	● ■	● ■	○ □	○ □	○ □						● ■	● □			
northern water shrew	≧1.6 stream km (1 stream mi)/population								● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■		■	■			○ ■	●			
Merriam shrew[10]	≧8.1 ha (20 acres)/population			● ■	● ■	● ■										○ □	○ □				● ■			●			
coast mole	≧8.1 ha (20 acres)/population		● ■	● ■					● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■				● ■		■	● ■			
little brown myotis								● ■	■	● ■	● ■	■	■	■	■	■	■	○ ■			● ■	●			● ■	■	
Yuma myotis																● ■	● ■	● ■				●					
long-eared myotis[10]			■					● ■	■	● ■	● ■	■	■	■		○ ■	○ ■	○ ■				●					
long-legged myotis[10]			■					■	■	● ■	● ■	● ■	■	■		○ ■	○ ■	○ ■				●					
California myotis		■	■	■	■	■	■	● ■	■	● ■	● ■	■	■	■		■	■	○ ■				●			● ■		●

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)[4]
		MAMMALS				
MYLE	4	small-footed myotis[10]	L		1 young	
LANO	14	silver-haired bat[10]	M		2 young	
PIHE	4	western pipistrelle[10]	L		2 young	
EPFU	14	big brown bat	M		1 young	
LACI	11	hoary bat[10]	L		2 young	
EUMA	4	spotted bat[10]	L		1 young	
PLTO	4	western big-eared bat	M		1 young	
ANPA	4	pallid bat[10]	L		2 young	
OCPR	4	pika	L		2-5; 1 litter	
SYID	15	pygmy rabbit[10]	L		avg. 6; 1-2 litters	
SYNU	15	mountain cottontail	M		4-8; avg. 6; 1-2 litters	
LEAM	5	snowshoe hare	L		1-7; avg. 3-5; 2-3 litters	5.9 ha (14.5 acres)
LETO	5	whitetail jackrabbit[10]	L		3-6; 2-3 litters	
LECA	5	blacktail jackrabbit	L		1-6; avg. 2; 3-4 litters	
EUMI	15	least chipmunk	L		4-6; 1-2 litters	
EUAM	15	yellow pine chipmunk	H		5-7; 1 litter	
MAFL	4	yellow-bellied marmot	M		4-8; avg. 4-6; 1 litter	



L Low; M Medium; H High — Reproductive activity — Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
MAMMALS																											
small-footed myotis[10]		● ■			● ■											● ■	● ■	● ■							● ■	■	●
silver-haired bat[10]			■					● ■	■	● ■	● ■	■	■	■		■	■	○ ■				●					
western pipistrelle[10]		● ■			● ■											● ■	● ■	● ■							● ■	■	
big brown bat		■	■	■	■	■	■	■	■	● ■	● ■	■	■	■		■	■	○ ■				●			● ■	■	●
hoary bat[10]							■	■	■	■	■	■	■	■		■	■	■									
spotted bat[10]		■		■	● ■	■		■	■							■	■								■		
western big-eared bat		● ■	● ■	● ■	● ■			● ■	□	● ■						□	□	□							■	■	●
pallid bat[10]		● ■	● ■	● ■	● ■	■		□		● ■						□	□					○			● ■		●
pika	≧4 ha (10 acres)/ population		■	■							● ■			● ■	● ■											● ■	
pygmy rabbit[10]	≧243 ha (600 acres)/ population				● ■											□	□				■			●			
mountain cottontail	≧41 ha (100 acres)/ population	■	■	■	● ■	● ■	● ■	● ■	● ■	● ■						● ■	● ■	● ■			● ■		●	●		● ■	
snowshoe hare	65 ha (160 acres)/ population										● ■	● ■	● ■	● ■		○ □	○ □				● ■		●				
whitetail jackrabbit[10]	≧65 ha (160 acres)/ population	□	□	● ■	● ■	● ■	□	● ■								□	□				● ■						
blacktail jackrabbit	≧65 ha (160 acres)/ population	■	■	● ■	● ■	● ■	□	● ■	□	● ■						□	□				● ■						
least chipmunk	32 ha (80 acres)/ population				● ■	□										□	□				● ■			● □	● ■	● ■	
yellow pine chipmunk	32 ha (80 acres)/ population					□	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■		● ■	● ■	● ■			● ■	●	● ■	●	● ■	● ■	
yellow-bellied marmot		● ■	■	● ■	● ■	● ■	● ■	● ■								□	□	□			● ■			●	● ■	● ■	

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
MAMMALS																	
SPTO	15	Townsend ground squirrel	M													5-10; avg. 8-10; 1-2 litters	
SPWA	15	Washington ground squirrel[10]	L													5-11; 1 litter	
SPBE	15	Belding ground squirrel	L													6-7; 1 litter	
SPCO	15	Columbian ground squirrel	M													2-7; avg. 3-4; 1-2 litters	
SPLA	15	mantled ground squirrel	H													4-8; avg. 5-6; 1-2 litters	
SCGRI	10	western gray squirrel[10]	L													2-5; 1 litter	
SCNI	14	eastern fox squirrel[10]	L													1-6; avg. 3; 1 litter	
TAHU	10	red squirrel	M													3-7; avg. 5-6; 1 litter	± 41 ha (100 acres)
TADO	10	chickaree	M													2-8; avg. 4-6; 1 litter	± 41 ha (100 acres)
GLSA	14	northern flying squirrel	M													1-6; avg. 3-5; 1 litter	
THTO	15	Townsend pocket gopher	L													3-8; 1-2 litters	
THTA	15	northern pocket gopher	H													4-7; 1-2 litters	
PEPA	15	Great Basin pocket mouse	M													3-8; avg. 5-6; 1-2 litters	
DIOR	15	Ord kangaroo rat[10]	L													1-6; avg. 4; 1-2 litters	
CACAN	16	beaver	M													1-9; avg. 2-4; 1 litter	
REME	15	western harvest mouse	M													1-9; avg. 2-4; 1 + litters	
PECR	4	canyon mouse	L													3-5; 1 + litters	

L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
MAMMALS																											
Townsend ground squirrel	32 ha (80 acres)/ population	● ■		● ■	● ■			● ■								○ □	○ □				● ■			●			
Washington ground squirrel[10]	16 ha (40 acres)/ population	● ■	● ■	● ■												○ □	○ □							●			
Belding ground squirrel	16 ha (40 acres)/ population		● ■	● ■												○ □	○ □							●			
Columbian ground squirrel	32 ha (80 acres)/ population		● ■	■					● ■	● ■	● ■	● ■		● ■	● ■	○ ■	○ ■				● ■			●	○	○ □	
mantled ground squirrel	16 ha (40 acres)/ population	● ■		● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	■	■	● ■	● ■	■	■				● ■			●	● ■	● ■	
western gray squirrel[10]										● ■	● ■					○ ■	○ □	○ □				● ■	■				
eastern fox squirrel[10]																● ■	● ■					● ■					
red squirrel	259 ha (640 acres)/ population									● ■	● ■	● ■	● ■	● ■		○ ■					■	● ■	■				
chickaree	259 ha (640 acres)/ population									● ■	● ■	● ■	● ■	● ■		○ ■						●	■				
northern flying squirrel	146 ha (360 acres)/ population									● ■	● ■	● ■	● ■	● ■		■	■				● ■	● □	■				
Townsend pocket gopher	16 ha (40 acres)/ population		● ■	● ■	● ■											● ■	● ■							● ■			
northern pocket gopher	16 ha (40 acres)/ population	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■						● ■			
Great Basin pocket mouse	16 ha (40 acres)/ population				● ■	● ■	● ■	● ■		● ■						□	□				● ■			●		● ■	
Ord kangaroo rat[10]	32 ha (80 acres)/ population	□		□	● ■			● ■																●			
beaver	1.6 stream km (1 stream mi)/colony				■	● ■			■	■	■	■	■			● ■	● ■	● ■	● ■	● ■			□	●			
western harvest mouse	16 ha (40 acres)/ population	● ■	■	● ■	● ■	● ■		● ■								● ■	● ■							●		● ■	
canyon mouse	0.8 km (0.5 mi) cliff/ population	● ■		● ■	● ■	● ■																			● ■	● ■	●

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence: January	February	March	April	May	June	July	August	September	October	November	December	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
MAMMALS																	
PEMA	15	deer mouse	H													1-9; avg. 3-5; ±6 litters	1.2-1.6 ha (3-4 acres)
PETR	4	pinyon mouse[10]	L													3-6; 1+ litters	
ONLE	15	northern grasshopper mouse[10]	M													4-6; 1+ litters	
NECI	4	bushy-tailed woodrat	H													1-6; avg. 2-4; 1 litter	
CLGA	15	Gapper red-backed vole	L													3-8; avg. 4-6; 1+ litters	
PHIN	15	heather vole[10]	L													2-8; avg. 4-6; 2+ litters	
MIMO	15	mountain vole	M													2-8; avg. 5-6; 4+ litters	
MILO	15	long-tailed vole	H													2-10; avg. 3-6; 1+ litters	
MIRI	16	water vole	M													4-6; 1+ litters	
LACU	15	sagebrush vole[10]	L													2-13; avg. 4-6; 4+ litters	
ONZI	16	muskrat	M													2-16; avg. 6-8; 2 litters	
RANO	15	Norway rat	L													6-22; avg. 6-8; 6-8 litters	
MUMU	15	house mouse	L													3-16; avg. 4-7; ±6 litters	
ZAPR	3	western jumping mouse	M													2-7; 1 litter	
ERDO	6	porcupine	M													1 young	101-146 ha (250-360 acres)
MYCO	16	nutria	L													1-11; avg. 4-6; 1 litter	1 097-m (3,600-ft) radius
CALAT	15	coyote	H													4-19; avg. 5-7; 1 litter	

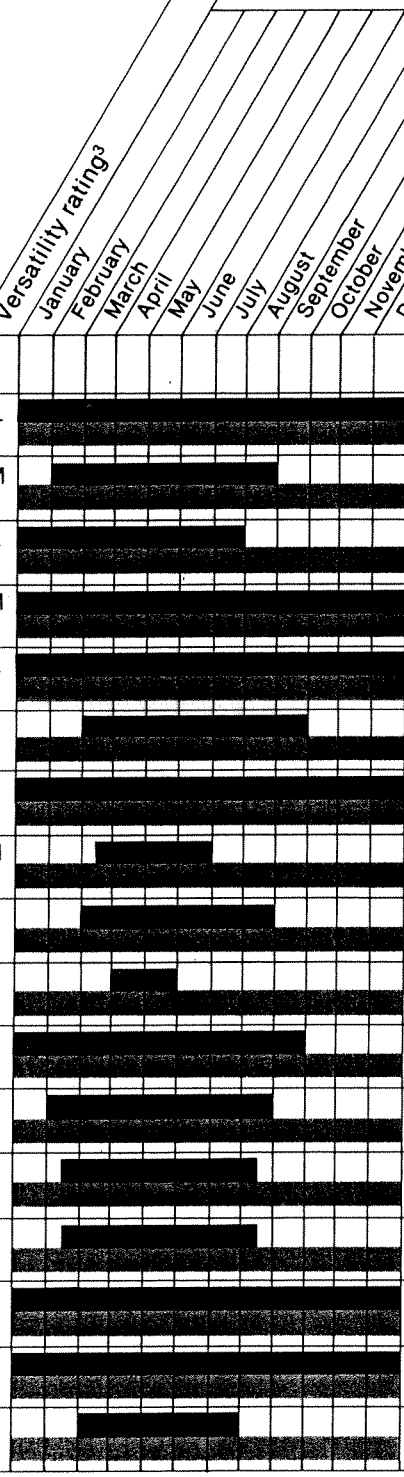
L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]										Unique habitats[6]		
																Riparian zones												
		Dry meadow	Moist meadow	Other grasses	Sagebrush–bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
MAMMALS																												
deer mouse	≧16 ha (40 acres)/ population	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■			●■	●■	●■	●□	●■	●■	●■
pinyon mouse[10]	0.8 km (0.5 mi) cliff/ population	●■		●■	●■	●■		●■															o		●■		●
northern grasshopper mouse[10]	32 ha (80 acres)/ population			●■	●■			●■								o□	o□				●■			●		●■	
bushy-tailed woodrat	32 ha (80 acres)/ population	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■					●■		●■	●■	●
Gapper red-backed vole	16 ha (40 acres)/ population										●■	●■	●■	●■		o□							●■	●■			
heather vole[10]	32 ha (80 acres)/ population													●■	●■	o□	o□						●	●			
mountain vole	8 ha (20 acres)/population		●■	●■	●■	●■			●■						●■	●■	●■						●	●		●■	
long-tailed vole	16 ha (40 acres)/ population	●■	●■	●■	●■	●■			●■	●■	●■	●■			●■	●■	●■						●	●			
water vole	0.8 stream km (0.5 stream mi)/population												●■	●■	●■	●■	●■	●■						●			
sagebrush vole[10]	16 ha (40 acres)/ population			●■	●■			●■													●■			●		●■	
muskrat	1.6 stream km (1 stream mi)/population		●■		●■	●■		●■								●■	●■	●■	●■					●			
Norway rat						●■										●■	●■	●■						●			
house mouse			●■			●■										●■	●■	●■						●□			
western jumping mouse	16 ha (40 acres)/ population		●■	●■						●■	●■	●■	●■	●■	●■	●■	●■	●■					●				
porcupine	2 590 ha (6,400 acres)/ population	■	■	■	●■	●■	●■	●■	■	●■	●■	■	■			●■	●■						●		●		●
nutria			●■													●■	●■	●■						●			
coyote		■	■	■	●■	●■	●■	●■	●■	●■	●■	●■	●■	●■	■	●■	●■	■					■	●	●■	■	●

Reproduction: ● Primary (≧40%); o Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
		MAMMALS				
CALU	15	gray wolf[10]	L		3-14; avg. 6-7; 1 litter	
VUVU	15	red fox[10]	M		2-10; avg. 5-6; 1 litter	259-777 ha (640-1,920 acres)
URCI	15	gray fox	L		2-7; avg. 3-4; 1 litter	
URAM	15	black bear	M		1-4; avg. 2-3; 1 litter every 2 years	414 to 1 010 ha (1,024-2,496 acres)
PRLO	14	raccoon	L		1-7; avg. 2-3; 1 litter	449 ha (1,110 acres)
MAAM	14	marten[10]	L		1-6; avg. 2-4; 1 litter	259 ha (640 acres)
MAPE	14	fisher[10]	L		1-4; avg. 3; 1 litter	1 036 to 1 295 ha (2,560-3,200 acres)
MUER	15	short-tailed weasel	M		4-13; avg. 6-7; 1 litter	
MUFR	15	long-tailed weasel	H		4-9; avg. 6-8; 1 litter	approx. 259 ha (640 acres)
MUVI	16	mink	H		2-10; avg. 4; 1 litter	1.6 stream km (1 stream mi)
GUGU	5	wolverine[10]	M		2-3; 1 litter every 2-3 years	
TATA	15	badger[10]	H		2-5; 1 litter	
SPPU	15	spotted skunk	L		1-5; 1 litter	≧259 ha (640 acres)
MEMEP	15	striped skunk	L		2-10; avg. 6-7; 1 litter	17-38 ha (43-95 acres)
LUCA	16	river otter[10]	M		1-5; avg. 2-3; 1 litter	80 stream km (50 stream mi)
FECO	4	puma[10]	H		1-5; avg. 3; 1 litter	6 475 ha (16,000 acres)
FECA	5	feral house cat	M		4-6; 1+ litters	



L Low; M Medium; H High ■ Reproductive activity ▒ Feeding activity

See footnotes at end of appendix.

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
MAMMALS																											
gray wolf[10]									■	■	■	■				□	□	□						●			
red fox[10]	518-777 ha (1,280-1,920 acres)/pair								● ■	● ■	● ■					○ □	○ □	○ □			● ■		■	●	■	■	
gray fox						● ■			● ■							○ □	○ □	□					■	●			●
black bear	1 295 ha (3,200 acres)/pair		■			■			■	■	● ■	● ■	■	● ■	■	○ ■	■	■			■		■	●	■	■	
raccoon	3.2 stream km (2 stream mi)/pair		■													● ■	● ■	● ■				●					
marten[10]	259 ha (640 acres)/pair										● ■	● ■	■	● ■	■							●	■		■	■	□
fisher[10]	1 295 ha (3,200 acres)/pair										● ■	● ■	■	● ■		● ■	● ■					●	● ■		■	■	□
short-tailed weasel										□	● ■	● ■	● ■	● ■	■	● ■	● ■	■			■	●	● ■	● ■	■	■	●
long-tailed weasel	259 ha (640 acres)/pair	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■	● ■				● ■	● ■	● ■	● ■	● ■	●
mink	1.6 stream km (1 stream mi)/pair		■		● ■	● ■			● ■	● ■	● ■	● ■	● ■	● ■		● ■	● ■	● ■					● ■	● □			
wolverine[10]									■	■	■	● ■	■	● ■	■	■	■	■						●	● ■	■	●
badger[10]		■	● ■	● ■	■	● ■	■	■	● ■	● ■	■	■	■	■	■	○ ■	○ ■	■						● ■	■	● ■	
spotted skunk	≧259 ha (640 acres)/pair					● ■			● ■	● ■	● ■					○ □						●	● ■	●	○ ■	■	●
striped skunk	≧259 ha (640 acres)/population		● ■			● ■										● ■	● ■	● ■			● ■		● ■	●	■	■	
river otter[10]	≧80 stream km (50 stream mi)/pair				● ■	● ■	○ □		● ■	● ■	● ■	● ■				● ■	● ■	● ■						● □			
puma[10]		■	■	■	■	■	■	■	■	● ■	● ■	● ■	● ■	● ■	■	■	■	■									●
feral house cat			● ■	● ■		● ■		● ■								● ■	● ■	● ■					■				

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

Letter code[1]	Life form[2]	Species	Versatility rating[3]	Activity; seasonal occurrence (January, February, March, April, May, June, July, August, September, October, November, December)	Reproductive capacity; potential per year	Home range (h.r.) or territory size (terr.)*
MAMMALS						
LYCA	5	lynx[10]	M		1-4; avg. 2; 1 litter	
LYRU	4	bobcat	H		1-6; avg. 3-4; 1 litter	518 ha (1,280 acres)
EQCA	5	feral horse	M		1-2; avg. 1 foal	
CEEL	5	elk	M		1-2 calves	
ODHE	5	mule deer	M		1-2 fawns	
ODVI	5	white-tailed deer[10]	L		1-3; avg. 2 fawns	
ANAME	5	pronghorn	M		1-3; avg. 2 kids	
ORAM	4	mountain goat[10]	L		1-2 kids	
OVCA	4	big-horned sheep[10]	L		1-2; avg. 1 lamb	

L Low; M Medium; H High ■ Reproductive activity ■ Feeding activity

Species	Minimum habitat required per individual, pair, colony, or population	Plant community groups (habitats)[4]														Special habitats (components)[6]									Unique habitats[6]		
																Riparian zones											
		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Ponderosa pine	Mixed conifer	White fir (grand fir)[5]	Lodgepole pine	Subalpine fir	Alpine meadow	Rivers, creeks, streams	Lakes, reservoirs, ponds	Marshes, bogs, swamps	Standing; slow-running water	Fast-running water	Edges (ecotones)	Snags[7]	Logs[8]	Burrows	Cliffs, rimrock	Talus	Caves
MAMMALS																											
lynx[10]						●					●	●	●	●		○							■		■	■	
						■					■	■	■	■		□											
bobcat					●	●					●	●	●	●											●	●	●
		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					■		■	■	
feral horse		●		●						●	●																
		■		■						■	■					□											
elk						●			●	●	●																
		■	■	■		■	■	■	■	■	■	■	■	■	■	■	■										
mule deer						●			●		●																
		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
white-tailed deer[10]						●			●		●					●	●	●									
			■			■			■	■	■					■	■	■									
pronghorn		●	●	●	●			●																			
		■	■	■	■	■		■								□											
mountain goat[10]														●	●										●		
														■	■										■	■	
big-horned sheep[10]														●	●										●		
										■	■			■	■										■	■	

Reproduction: ● Primary (≧40%); ○ Secondary (<40%) Feeding: ■ Primary (≧40%); □ Secondary (<40%)

*Absence of a home range or territory designation indicates that no differentiation has been made by the authors and/or in the literature.

[1]See appendix 2 for alphabetical listing of letter codes and scientific names of wildlife species.

[2]See appendix 7 for life form descriptions.

[3]See appendix 12 for versatility ratings. 326 species are given versatility ratings in appendix 12 and this appendix. 52 species are not given ratings: the bullfrog and the 51 species listed in appendix 3.

[4]See figure 10 of chapter 2 for plant communities associated with each habitat.

[5]Although "white fir" is common usage, this species is apparently grand fir *(Abies grandis)*. See appendix 5 for scientific names of plant species.

[6]See appendix 14 for information on special and unique habitats.

[7]See appendices 17 through 23 for more information on snags.

[8]See appendix 24 for more information on wildlife use of logs. Entries in this column denote extensive use only and imply neither primary nor secondary orientations for feeding or reproduction.

[9]Species found in the Blue Mountains only during migration or "accidental" in the area. See appendix 3.

[10]Species of special interest because of its rare or threatened status. See appendix 4.

Appendix 7

Life form descriptions

Life form	Reproduces	Feeds	No. of species[1]	Examples
1	in water	in water	1	bullfrog
2	in water	on the ground, in bushes, and/or in trees	9	long-toed salamander, western toad, Pacific treefrog
3	on the ground around water	on the ground, and in bushes, trees, and water	45	common garter snake, killdeer, western jumping mouse
4	in cliffs, caves, rimrock, and/or talus	on the ground or in the air	32	side-blotched lizard, common raven, pika
5	on the ground without specific water, cliff, rimrock, or talus association	on the ground	48	western fence lizard, dark-eyed junco, elk
6	on the ground	in bushes, trees, or the air	7	common nighthawk, Lincoln's sparrow, porcupine
7	in bushes	on the ground, in water, or the air	30	American robin, Swainson's thrush, chipping sparrow
8	in bushes	in trees, bushes, or the air	6	dusky flycatcher, yellow-breasted chat, American goldfinch
9	primarily in deciduous trees	in trees, bushes, or the air	4	cedar waxwing, northern oriole, house finch
10	primarily in conifers	in trees, bushes, or the air	14	golden-crowned kinglet, yellow-rumped warbler, red squirrel
11	in conifers or deciduous trees	in trees, in bushes, on the ground, or in the air	24	goshawk, evening grosbeak, hoary bat
12	on very thick branches	on the ground or in water	7	great blue heron, red-tailed hawk, great horned owl
13	in own hole excavated in tree	in trees, in bushes, on the ground, or in the air	13	common flicker, pileated woodpecker, red-breasted nuthatch
14	in a hole made by another species or in a natural hole	on the ground, in water, or the air	37	wood duck, American kestrel, northern flying squirrel
15	in a burrow underground	on the ground or under it	40	rubber boa, burrowing owl, Columbian ground squirrel
16	in a burrow underground	in the air or in the water	10	bank swallow, muskrat, river otter
		Total:	327	

[1]Species assignment to life form is based on predominant habitat-use patterns.

Appendix 8

Wildlife orientation to plant communities by life form

Life form 2. Reproduces in water and feeds on the ground, in bushes, and/or in trees (9 species)

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		• Reproduction and feeding									R Reproduction only				F Feeding only			
	AMPHIBIANS																		
AMTI	tiger salamander			•	•	•					•	•						5	5
AMMA	long-toed salamander			•	•	•	•		•		•						•	7	7
ASTR	tailed frog										•		•	•	•	•	•	6	6
SCIN	Great Basin spadefoot toad		•		•	•	•		•		•							6	6
BUBO	western toad			•		•	•	•	•	•	•	•	•	•	•	•		12	12
BUWO	Woodhouse toad		•	•	•	•	•		•		•							7	7
HYRE	Pacific treefrog		•	•	•	•	•	•	•	•	•	•	•	•	•	•		14	14
RAPR	spotted frog					•			•	•	•	•	•	•	•			8	8
RAPI	leopard frog			•							•							2	2
	No. of species using each community:	Reproduction	3	6	5	7	5	2	6	3	9	4	4	4	4	3	2		
		Feeding	3	6	5	7	5	2	6	3	9	4	4	4	4	3	2		

Life form 3. Reproduces on the ground around water (or in emergent vegetation, or on floating vegetation[1]) and feeds on the ground, and in bushes, trees and water (45 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: R	F
		• Reproduction and feeding							R Reproduction only					F Feeding only				
	REPTILES																	
CHPI	painted turtle									•							1	1
EUSK	western skink				•	•	•	•	•	•	•						7	7
DIPU	ringneck snake	•		•		•	•	•	•	•	•	•					9	9
THSI	common garter snake	•	•	•		•			•	•	•	•	•	•			10	10
	BIRDS																	
PONI	eared grebe									•							1	1
POPO	pied-billed grebe									R							1	0
PHAU	double-crested cormorant									R							1	0
BOLE	American bittern		F							•							1	2
BRCA	Canada goose	F	•	F						•							2	4
ANPL	mallard	F	•	F						•							2	4
ANST	gadwall		•	F						•							2	3
ANAC	pintail	F	•	F						•							2	4
ANCR	green-winged teal	F	•	F						•							2	4
ANDI	blue-winged teal		•	F						•							2	3
ANCY	cinnamon teal		•	F						•							2	3
ANAM	American wigeon	F	•	F						•							2	4
ANCL	northern shoveler	F	•	F						•							2	4
AYAM	redhead		•							•							2	2
AYCO	ring-necked duck	F	•	F						•							2	4
AYAF	lesser scaup	F	•	F						•							2	4
HIHI	harlequin duck									F		R	R	R	R		4	1
OXJA	ruddy duck		F							•							1	2
GRCA	sandhill crane	F	•	F						F							1	4
RALI	Virginia rail		F							•							1	2

See footnote at end of life form 3.

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
		● Reproduction and feeding							R Reproduction only				F Feeding only					
	BIRDS																	
POCA	sora									●							1	1
FUAM	American coot	F	F	F		●				●							2	5
CHAL	snowy plover	●	F	F	F					F							1	5
CHVO	killdeer	●	●	●						●							4	4
CAGA	common snipe		●	●						●							3	3
NUAM	long-billed curlew	F	F	●	●					F							2	5
ACMA	spotted sandpiper		●							●						●	3	3
CASE	willet	F	●	F						●							2	4
REAM	American avocet	F	●	●						●							3	4
STTR	Wilson's phalarope		●							●							2	2
LACA	California gull	●	F	●	●				F	●							4	6
LADE	ring-billed gull	●	F	●	●				F	F							3	6
LAPI	Franklin's gull	●	F	●	●				F	●							4	6
STFO	Forster's tern	●	F	R	R					●							4	3
CHNI	black tern	●	F	R						●							3	3
CIME	dipper									●	●	●	●				4	4
TRTR	winter wren									F		●	●	●	●		4	5
TEPA	long-billed marsh wren		●							●							2	2
SENO	northern waterthrush		F			F				●		F					1	4
GETR	common yellowthroat		F	●		●				●							3	4
	MAMMALS																	
ZAPR	western jumping mouse		●	●						●	●	●	●	●	●	●	9	9
	No. of species using each community: Reproduction	9	22	13	6	5	2	2	3	39	5	6	5	4	3	2		
	No. of species using each community: Feeding	22	35	26	6	6	2	2	6	43	5	6	4	3	2	2		

[1]A number of species in this life form are specifically oriented to water in emergent vegetation or on floating vegetation, for reproduction and/or feeding purposes; but from a management standpoint (i.e., potential for managed impacts) they fit this category.

Life form 4. Reproduces in cliffs, caves, rimrock, and/or talus and feeds on the ground or in the air (32 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	R	F
		● Reproduction and feeding							R Reproduction only					F Feeding only				
	REPTILES																	
UTST	side-blotched lizard	●		●	●	●		●		●							6	6
	BIRDS																	
CAAU	turkey vulture	●	F	●	F	F	F	●	F	F	●	F	F	F	F	F	4	15
BURE	ferruginous hawk	●	F	●	R			●			F						4	5
FAME	prairie falcon	●	F	●						F						F	2	5
FAPE	peregrine	F	F	F	F	F	F	F	F	F	F	●	●	●	●	●	5	15
LALE	white-tailed ptarmigan														F	●	1	2
ALCH	chukar					●	●	F									2	3
COLI	rock dove	●	F	●	R	F	F	F		F							3	7
CYNI	black swift	●	F	●				F	F	F	●						3	7
AESA	white-throated swift	F	F	F	F	F		F	F	F	●					●	2	10
SASA	Say's phoebe	●	F	●	●	●	F	●	F		●						6	9
HIRU	barn swallow	●	●	●					F	F							3	5
PEPY	cliff swallow	●	●	●					F	●							4	5
COCOR	common raven	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15	15
CAMEX	canyon wren	●		●	●	●					●						5	5
SAOB	rock wren	●		●	●	●	●				●	●	●				8	8
LETE	gray-crowned rosy finch	F	F	F											●	●	2	5
LEAT	black rosy finch	F	F	F											●	●	2	5
	MAMMALS																	
MYLE	small-footed myotis	●			●					●							3	3
PIHE	western pipistrelle	●			●					●							3	3
EUMA	spotted bat	F		F	●	F		F	F	F							1	7
PLTO	western big-eared bat	●	●	●	●			●			●						6	6
ANPA	pallid bat	●	●	●	●	F					●						5	6
																	Number of plant communities used by each species for:	

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		● Reproduction and feeding R Reproduction only F Feeding only																
	MAMMALS																		
OCPR	pika			F	F								●			●	●	3	5
MAFL	yellow-bellied marmot		●	F	●	●	●	●	●									6	7
PECR	canyon mouse		●		●	●	●											4	4
PETR	pinyon mouse		●		●	●	●		●									5	5
NECI	bushy-tailed woodrat		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15	15
FECO	puma		F	F	F	F	F	F	F	F	F	●	●	●	●	●	F	5	15
LYRU	bobcat		F	F	F	●	●	F	F	F	F	F	●	●	●	●	F	6	15
ORAM	mountain goat															●	●	2	2
OVCA	big-horned sheep											F	F			●	●	2	4
	No. of species using each community:	Reproduction	20	6	18	17	11	5	9	2	6	11	7	6	5	10	10		
		Feeding	27	20	26	19	18	11	17	12	16	15	9	7	6	12	14		

Life form 5. Reproduces on the ground without specific water, cliff, rimrock, or talus association and feeds on the ground (48 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	R	F
		● Reproduction and feeding							R Reproduction only				F Feeding only					
	REPTILES																	
SCOC	western fence lizard	●		●	●			●		●	●	●					7	7
SCGR	sagebrush lizard				●	●		●									3	3
PHDO	short-horned lizard	●		●	●	●	●	●			●						7	7
CNTI	western whiptail				●	●		●			●						4	4
COCO	yellow-bellied racer	●	F	●	●	●		●		●	F	F					6	9
MATA	striped whipsnake	●		●	●	●		●									5	5
PIME	gopher snake	●	●	●	●	●	●	●		●	●						9	9
THEL	western terrestrial garter snake		●	●		●		●	F	●							5	6
HYTO	night snake	F	F	●	●	F	F	●									3	7
CRVI	western rattlesnake	F	F	F	●	●		●	F	●	F	F					4	10
	BIRDS																	
CICY	marsh hawk	F	●	●		●											3	4
DEOB	blue grouse	F	F	F		●	F	F	●		●	●	F	F	F	F	4	13
CACA	Franklin's grouse					F							●	●	●		3	4
BOUM	ruffed grouse					●			●	●	●	●	F	F	F		5	8
PEPH	sharp-tailed grouse	●	F	●		●											3	4
CEUR	sage grouse			F	●	F		F									1	4
COVI	bobwhite					●				●							2	2
LOCA	California quail					●				●							2	2
ORPI	mountain quail					●				●	●						3	3
PEPE	gray partridge	●	●	●		●											4	4
PHCO	ring-necked pheasant			●		●											2	2
MEGA	turkey	F	F	F		●			●	F	●	●					4	8
BALO	upland sandpiper	F	●	F													1	3
																	Number of plant communities used by each species for:	

Life form 5. Continued

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	R	F
		• Reproduction and feeding							R Reproduction only				F Feeding only					
	BIRDS																	
ASFL	short-eared owl	F	•	F	F	F				•							2	6
ERAL	horned lark	•	F	•													2	3
CAGU	hermit thrush										F	•	•	•	•		4	5
CAFU	veery					•			•	•							3	3
ANSP	water pipit		F	F												•	1	3
WIPU	Wilson's warbler					•			•	•		•					4	4
DOOR	bobolink		•							•							2	2
STNEG	western meadowlark	•		•	•	•											4	4
PASA	savannah sparrow	•		•													2	2
AMSA	grasshopper sparrow	•															1	1
POGRA	vesper sparrow	•	•	•													3	3
CHGR	lark sparrow	F	F	•	F	F											1	5
JUHY	dark-eyed junco					•			•	•	•	•	•	•	•		8	8
	MAMMALS																	
DIMA	opossum									•							1	1
LEAM	snowshoe hare											•	•	•	•		4	4
LETO	whitetail jackrabbit			•	•	•		•									4	4
LECA	blacktail jackrabbit	F	F	•	•	•		•			•						5	7
GUGU	wolverine								F	F	F	F	•	F	•	F	2	8
FECA	feral house cat		•	•		•		•		•							5	5
LYCA	lynx					•						•	•	•	•		5	5
EQCA	feral horse	•		•							•	•					4	4
CEEL	elk	F	F	F		•	F	F	•	F	•	•	F	F	F	F	4	14

Number of plant communities used by each species for:

Life form 5. Continued

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		• Reproduction and feeding R Reproduction only F Feeding only																
	MAMMALS																		
ODHE	mule deer		F	F	F	F	•	F	F	•	F	F	•	F	F	F	F	3	15
ODVI	white-tailed deer			F			•			•	•	F	•					4	6
ANAME	pronghorn		•	•	•	•	F		•									5	6
	No. of species using each community:	Reproduction	14	10	21	14	29	2	14	9	17	12	13	6	5	6	1	Reproduction	Feeding
		Feeding	25	23	30	17	35	6	18	12	21	18	16	10	10	10	5		

Life form 6. Reproduces on the ground and feeds in bushes, trees, or the air (7 species)

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		● Reproduction and feeding							R Reproduction only				F Feeding only					
	BIRDS																		
PHNU	poorwill		F	F	F	●	F	F	F			●						2	8
CHMI	common nighthawk		●	F	F	●	●	●	●	F		●					F	6	10
MYTO	Townsend's solitaire		●		●				●			F						3	4
VECE	orange-crowned warbler						●				●							2	2
VERU	Nashville warbler						●			●	●		●					4	4
MELI	Lincoln's sparrow										●					●	●	3	3
	MAMMALS																		
ERDO	porcupine		F	F	F	●	●	●	●	F	●	●	●	F	F			7	13
	No. of species using each community:	Reproduction	2	0	1	3	4	2	3	1	4	3	2	0	0	1	1		
		Feeding	4	3	4	3	5	3	4	3	4	4	2	1	1	1	2		

Life form 7. Reproduces in bushes and feeds on the ground, in water, or the air (30 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	R	F
		• Reproduction and feeding R Reproduction only F Feeding only															Number of plant communities used by each species for:	
	BIRDS																	
NYNY	black-crowned night heron		F			•			•	•							3	4
BUSW	Swainson's hawk	•	F	•	•	•		•									5	6
TRSO	solitary sandpiper	F	•	F		•				•	F						3	6
ARAL	black-chinned hummingbird		F			•			•	•		•					4	5
SEPL	broad-tailed hummingbird		F			•			•	•							3	4
STCA	calliope hummingbird	F	F	F	F	•			•	•	F	•			•	F	5	11
TYTY	eastern kingbird				F	•		•	•	•							4	5
EMTR	willow flycatcher				F	F		F	•	•		F	F	•			3	8
EMWR	gray flycatcher	F		F	•	F		•	F	F	F						2	8
PIPI	black-billed magpie	F	F	F	•	•	F	•	•	•	•	F	F	F	F	F	6	15
DUCA	gray catbird					•			•	•							3	3
ORMO	sage thrasher				•	F		F	F	F							1	5
TUMI	American robin	F	F	F	•	•		•	•	•	•	•	•	•	•	F	10	14
CAUS	Swainson's thrush					•			•	•		•	•		•		6	6
LALU	loggerhead shrike	F	F	F	•	•	F	•	F	F	F						3	10
OPTO	MacGillivray's warbler					•			•	•		•	•	•			6	6
XAXA	yellow-headed blackbird	F	F	F	F					•							1	5
AGPH	red-winged blackbird	F	•	F		F				•							2	5
EUCY	Brewer's blackbird	F	F	F	F	•			•	•	•	•					5	9
MOAT	brown-headed cowbird		•	F		•			•	•	•	•					6	7
PAAMO	lazuli bunting				•	•		•	•	•							5	5
SPPS	lesser goldfinch	F		F		•		•									2	4
CHCH	green-tailed towhee				•			•		F	F						2	4
PIER	rufous-sided towhee					•			•	•							3	3
AMBE	sage sparrow				•	F		•									2	3

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		● Reproduction and feeding							R Reproduction only				F Feeding only					
	BIRDS																		
SPPA	chipping sparrow		F	F	F		●	●	●	●	●	●	●					7	10
SPBR	Brewer's sparrow		F		F	●	●		●									3	5
ZOLE	white-crowned sparrow						F			F	F					●	●	2	5
PAIL	fox sparrow						●				●					●		3	3
MEMEL	song sparrow						●				●		F					2	3
	No. of species using each community:	Reproduction	1	3	1	10	22	1	12	16	21	5	8	3	3	5	1	Reproduction	Feeding
		Feeding	13	14	14	15	28	3	14	20	26	10	11	5	4	6	4		

Life form 8. Reproduces in bushes and feeds in trees, bushes, or the air (6 species)

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		• Reproduction and feeding R Reproduction only F Feeding only																
	BIRDS																		
COAM	yellow-billed cuckoo						•			F	•							2	3
EMOB	dusky flycatcher				F	F	•		•		•	•	•					5	7
PSMI	bushtit					F	•	•	•		F	F						3	6
DEPE	yellow warbler									•	•							2	2
ICVI	yellow-breasted chat						•			F	•		F					2	4
SPTR	American goldfinch		F		F		•				•	•						3	5
	No. of species using each community:	Reproduction	0	0	0	0	5	1	2	1	5	2	1	0	0	0	0		
		Feeding	1	0	2	2	5	1	2	3	6	3	2	0	0	0	0		

Life form 9. Reproduces primarily in deciduous trees and feeds in trees, bushes, or the air (4 species)

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		● Reproduction and feeding R Reproduction only F Feeding only																
	BIRDS																		
BOCE	cedar waxwing						●			●	●							3	3
SERUT	American redstart									●	●							2	2
ICGA	northern oriole									●	●	F	F					2	4
CAMEXI	house finch						●			●	●	●	F					4	5
	No. of species using each community:	Reproduction	0	0	0	0	2	0	0	4	4	1	0	0	0	0	0		
		Feeding	0	0	0	0	2	0	0	4	4	2	2	0	0	0	0		

Life form 10. Reproduces primarily in conifers and feeds in trees, bushes, or the air (14 species)

Species			Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Reproduction	Feeding
			• Reproduction and feeding R Reproduction only F Feeding only																
	BIRDS																		
EMDI	western flycatcher										•		•	•	•	•		5	5
NUBO	olive-sided flycatcher									F	F	•	•	•	F	F		3	7
GYCY	pinyon jay					F	F		•	F	F	F						1	6
NUCO	Clark's nutcracker											F	F			•		1	3
RESA	golden-crowned kinglet									F		F	•	•	•	•		4	6
RECA	ruby-crowned kinglet									F		F	•	•	•	•		4	6
DECO	yellow-rumped warbler									F	F	F	•	•	•	•		4	7
DENI	black-throated gray warbler						•		•			•	•					4	4
DETO	Townsend's warbler											F	•	•	F	•		3	5
PILU	western tanager									•	•	•	•	•	•	•		7	7
LOCUR	red crossbill											•	•	•	•	•		5	5
	MAMMALS																		
SCGRI	western gray squirrel										F	•	•					2	3
TAHU	red squirrel										F	•	•	•	•	•		5	6
TADO	chickaree										F	•	•	•	•	•		5	6
Letter code	No. of species using each community:	Reproduction	0	0	0	0	1	0	2	1	2	7	12	10	8	10	0	Reproduction	Feeding
		Feeding	0	0	0	1	2	0	2	6	8	13	13	10	10	11	0		
																		Number of plant communities used by each species for:	

Life form 11. Reproduces in conifers or deciduous trees and feeds in trees, in bushes, on the ground, or in the air (24 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	R	F
		● Reproduction and feeding							R Reproduction only					F Feeding only				
	BIRDS																	
ACGE	goshawk								F	F	F	●	●	●	F		3	7
ACST	sharp-shinned hawk								F	F	F	●	●	●	F		3	7
ACCO	Cooper's hawk								F	●	●	●	●	F	F	F	4	8
FACO	merlin	F	F	F					F	F	F	●	●	●	●	F	4	11
ZEMA	mourning dove	F	F	F	●	●	R	R	R	R							6	5
ASOT	long-eared owl		F			F			●	●	F	●	●	●	●		6	9
SERU	rufous hummingbird	F	F	F						●		●	●	●	●	F	5	9
TYVE	western kingbird					●			●	●							3	3
EMHA	Hammond's flycatcher								●		●	●	●	●	●		6	6
COSO	western wood pewee									●	●	●	●	●	●		6	6
PECA	gray jay											●	●	●	●		4	4
CYST	Steller's jay						F	F	F	●	●	●	●				4	7
COBR	common crow					F	F	F	●	●	F	●	●				4	8
IXNA	varied thrush											●	●	●	●		4	4
VISO	solitary vireo								F	F	●	●	●	●	F		4	7
VIOL	red-eyed vireo					F			●	●	F						2	4
VIGI	warbling vireo					F			●	●	F						2	4
PHME	black-headed grosbeak								●	●	●	●	●	F	F		5	7
HEVE	evening grosbeak								F	●	●	●	●	●	●		6	7
CAPU	purple finch	F	F							●	●	●					3	5
CACAS	Cassin's finch	F	F							●	●	●	●	●	●		6	8
PIEN	pine grosbeak										●	●	●	●	●		5	5
SPPI	pine siskin	F				F			F	F	●	●	●	●	●		5	9
																Number of plant communities used by each species for:	R	F

Life form 11. Continued

Species			● Reproduction and feeding R Reproduction only F Feeding only																
MAMMALS																			
LACI	hoary bat							F	F	F	F	F	F	F	F	F		0	9
Letter code	No. of species using each community:	Reproduction	0	0	0	1	2	1	1	8	14	11	19	18	14	11	0	Repro-duction	Feeding
		Feeding	6	6	3	1	7	3	3	16	19	19	20	19	17	17	3		
			Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for:	

Life form 12. Reproduces on very thick branches and feeds on the ground or in water (7 species)

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		• Reproduction and feeding							R Reproduction only				F Feeding only					
	BIRDS																		
ARHE	great blue heron			F						R	•							2	2
BUJA	red-tailed hawk		F	F	F	F	F	F	•	•	•	•	•	F	F	F	F	5	15
AQCH	golden eagle		F	F	F	F	F	F	F	F	F	•	•	F	F	F	F	2	15
HALE	bald eagle		F	F	F				F	F	•	•	•	F				3	9
PAHA	osprey		F	F	F	F	F	F	F	F	•	•	•					3	11
BUVI	great horned owl		F	F	F	F	F	F	•	•	•	•	•	F	F	F	F	5	15
STNE	great gray owl			F									F		•			1	3
	No. of species using each community:	Reproduction	0	0	0	0	0	0	2	3	5	5	5	0	1	0	0		
		Feeding	5	7	5	4	4	4	5	5	6	5	6	4	4	3	3		

Life form 13. Reproduces in own hole excavated in tree and feeds in trees, in bushes, on the ground, or in the air (13 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
		• Reproduction and feeding R Reproduction only F Feeding only																
	BIRDS																	
COAU	common flicker							•	•	•	•	•	•				6	6
DRPI	pileated woodpecker										•	•	•				3	3
ASLE	Lewis' woodpecker									•	•	•					3	3
SPVA	yellow-bellied sapsucker								•	•							2	2
SPTH	Williamson's sapsucker										•	•	•		•		4	4
DEVI	hairy woodpecker										•	•	•	•	•		5	5
DEPU	downy woodpecker								•	•							2	2
DEAL	white-headed woodpecker										•	•					2	2
PIAR	black-backed three-toed woodpecker											•	•	•	•		4	4
PITR	northern three-toed woodpecker													•	•		2	2
SICA	white-breasted nuthatch										•	•					2	2
SICAN	red-breasted nuthatch											•	•	•			3	3
SIPY	pygmy nuthatch								F		•	F					1	3
	No. of species using each community: Reproduction	0	0	0	0	0	0	1	3	4	8	9	6	4	4	0		
	No. of species using each community: Feeding	0	0	0	0	0	0	1	4	4	8	10	6	4	4	0		

Life form 14. Reproduces in a hole made by another species or in a natural hole and feeds on the ground, in water, or the air (37 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: R	F
	● Reproduction and feeding R Reproduction only F Feeding only																	
	BIRDS																	
AISP	wood duck					F			F	●	F	F					1	5
BUIS	Barrow's goldeneye	F	F	F	F	F	F	F	F	●	F	F					1	11
BUAL	bufflehead	F	F	F	F	F	F	F	F	●	F	F	F	F	●	F	2	15
LOCU	hooded merganser	F	F	F	F	F	F	F	F	●	F	F					1	11
MEME	common merganser	F	F	F	F	F	F	F	F	●	●						2	10
FASP	American kestrel	F	F	F	F	F	F	●	●	R	●	R					5	9
TYAL	barn owl		F	F	F					●	●	●	●				4	7
OTAS	screech owl		F					●	F	●							2	4
OTFL	flammulated owl										●	●					2	2
GLGN	pygmy owl	F	F			F		●	●	●	●	●					5	8
STVA	barred owl									●	F	●	●				3	4
AEAC	saw-whet owl								F	●	●	●	●	F			4	6
CHVA	Vaux's swift									F		●	●	F	●		3	5
MYCI	ash-throated flycatcher	F		F				●	●	●	●						4	6
TATH	violet-green swallow		F						●	●	●						3	4
IRBI	tree swallow		F						●	●	●	R					4	4
PAAT	black-capped chickadee					F			●	●							2	3
PAGA	mountain chickadee					F		F			●	●	●	●	●		5	7
PARU	chestnut-backed chickadee					F				F		●	●	●			3	5
CEFA	brown creeper									F	●	●					2	3
TRAE	house wren					F			●	●	●	●					4	5
SIME	western bluebird	F	F	F	F	F	F	●	R		●	R				F	4	9
SICU	mountain bluebird	F	F	F	F	F	F	●	R		●	R					4	8
STVU	starling	F	F	F						●							1	4
PADO	house sparrow	F	F	F						●							1	4

Life form 14. Continued

Species			• Reproduction and feeding R Reproduction only F Feeding only																
	MAMMALS																		
MYLU	little brown myotis								•	F	F	•	•	F	F	F	F	3	9
MYYU	Yuma myotis										•							1	1
MYEV	long-eared myotis			F					•	F	F	•	•	F	F	F		3	9
MYVO	long-legged myotis			F					F	F	F	•	•	•	F	F		3	9
MYCA	California myotis		F	F	F	F	F	F	•	F	F	•	•	F	F	F		3	14
LANO	silver-haired bat			F					•	F	F	•	•	F	F	F		3	9
EPFU	big brown bat		F	F	F	F	F	F	F	F	F	•	•	F	F	F		2	14
SCNI	eastern fox squirrel										•							1	1
GLSA	northern flying squirrel										F	•	•	•	•	•		5	6
PRLO	raccoon			F							•							1	2
MAAM	marten												•	•	F	•	F	3	5
MAPE	fisher										•		•	•	F	•		4	5
Letter code	No. of species using each community:	Reproduction	0	0	0	0	0	0	10	9	22	21	23	10	3	6	0	Reproduction	Feeding
		Feeding	13	20	13	10	15	9	17	20	31	26	23	16	14	12	4		
			Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for:	

Life form 15. Reproduces in a burrow underground and feeds on the ground or under it (40 species)

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	R	F
		• Reproduction and feeding							R Reproduction only				F Feeding only				Number of plant communities used by each species for:	
	REPTILES																	
CHBO	rubber boa		•							F	F	•	•				3	5
	BIRDS																	
SPCU	burrowing owl	•		•	•			•									4	4
	MAMMALS																	
SOPR	Malheur shrew		•							•		•					3	3
SOVA	vagrant shrew		•	•	•	•				•					•	•	7	7
SOOB	dusky shrew											•	•	•	•		4	4
SOME	Merriam shrew			•	•	•											3	3
SCOR	coast mole		•	•					•	•	•	•	•	•	•	•	10	10
SYID	pygmy rabbit				•												1	1
SYNU	mountain cottontail	F	F	F	•	•	•	•	•	•	•						7	10
EUMI	least chipmunk				•												1	1
EUAM	yellow pine chipmunk						•	•	•	•	•	•	•	•	•		9	9
SPTO	Townsend ground squirrel	•		•	•			•									4	4
SPWA	Washington ground squirrel	•	•	•													3	3
SPBE	Belding ground squirrel		•	•													2	2
SPCO	Columbian ground squirrel		•	F					•	F	•	•	•		•	•	7	9
SPLA	mantled ground squirrel	•		•	•	•	•	•	•	F	•	•	F	F	•	•	11	14
THTO	Townsend pocket gopher		•	•	•					•							4	4
THTA	northern pocket gopher	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	15	15
PEPA	Great Basin pocket mouse				•	•	•	•			•						5	5
DIOR	Ord kangaroo rat				•			•									2	2
REME	western harvest mouse	•	F	•	•	•		•		•							6	7
PEMA	deer mouse	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	15	15
ONLE	northern grasshopper mouse			•	•			•									3	3

Life form 15. Continued

Letter code	Species	Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species	● Reproduction and feeding										R Reproduction only			F Feeding only			
	MAMMALS																	
CLGA	Gapper red-backed vole											●	●	●	●		4	4
PHIN	heather vole														●	●	2	2
MIMO	mountain vole		●	●	●	●			●	●						●	7	7
MILO	long-tailed vole	●	●	●	●	●			●	●	●	●	●			●	11	11
LACU	sagebrush vole			●	●			●									3	3
RANO	Norway rat					●				●							2	2
MUMU	house mouse		●			●				●							3	3
CALAT	coyote	F	F	F	●	●	●	●	●	●	●	●	●	●	●	F	11	15
CALU	gray wolf								F		F	F	F				0	4
VUVU	red fox								●		●	●					3	3
URCI	gray fox					●			●								2	2
URAM	black bear		F			F			F	F	F	●	●	F	●	F	3	10
MUER	short-tailed weasel									●		●	●	●	●	F	5	6
MUFR	long-tailed weasel	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15	15
TATA	badger	F	●	●	F	●	F	F	●	F	●	F	F	F	F	F	5	15
SPPU	spotted skunk					●			●		●	●					4	4
MEMEP	striped skunk		●			●				●							3	3
	No. of species using each community: Reproduction	9	16	18	20	18	8	14	15	17	14	17	13	9	14	10		
	No. of species using each community: Feeding	12	20	21	21	19	9	15	17	22	17	19	16	12	15	14		

Life form 16. Reproduces in a burrow underground and feeds in the air or in water (10 species)

Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for: Reproduction	Number of plant communities used by each species for: Feeding
	Species		● Reproduction and feeding							R Reproduction only				F Feeding only					
	BIRDS																		
MEAL	belted kingfisher		F	F	F	F	F	F	F	F	●	F	F					1	11
RIRI	bank swallow		F	F	F		F				●							1	5
STRU	rough-winged swallow		F	F	F		F				●							1	5
	MAMMALS																		
SOPA	northern water shrew									●	●	●	●	●	●	●	●	8	8
CACAN	beaver					F	●			F	●	F	F	F	F			2	8
MIRI	water vole										●				●	●	●	4	4
ONZI	muskrat			●		●	●		●		●							5	5
MYCO	nutria			●							●							2	2
MUVI	mink			F		●	●			●	●	●	●	●	●	●		9	10
LUCA	river otter					●	●			●	●	●	●	●				7	7
	No. of species using each community:	Reproduction	0	2	0	3	4	0	1	3	10	3	3	3	3	3	2		
		Feeding	3	6	3	5	7	1	2	5	10	5	5	4	4	3	2		

Appendix 9

Wildlife orientation to successional stages by life form

Life form 2. Reproduces in water and feeds on the ground, in bushes, and/or in trees (9 species)

Species			• Reproduction and feeding R Reproduction only F Feeding only							
	AMPHIBIANS									
AMTI	tiger salamander		•						1	1
AMMA	long-toed salamander		•			•			2	2
ASTR	tailed frog		•		•	•	•	•	5	5
SCIN	Great Basin spadefoot toad		•	•	•	•	•	•	6	6
BUBO	western toad		•	•	•	•	•	•	6	6
BUWO	Woodhouse toad		•	•					2	2
HYRE	Pacific treefrog		•	•	•	•	•	•	6	6
RAPR	spotted frog		•	•	•	•	•	•	6	6
RAPI	leopard frog		•						1	1
Letter code	No. of species using successional stage	Reproduction	9	5	5	6	5	5	Repro-duction	Feeding
		Feeding	9	5	5	6	5	5		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 3. Reproduces on the ground around water (or in emergent vegetation, or on floating vegetation[1]) and feeds on the ground, and in bushes, trees, and water (45 species)

Letter code	Species	Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	R	F
		● Reproduction and feeding		R Reproduction only		F Feeding only		No. of successional stages used	
	REPTILES								
CHPI	painted turtle	●	●	●	●	●		5	5
EUSK	western skink	●	●	●	●	●		5	5
DIPU	ringneck snake	●	●	●	●	●	●	6	6
THSI	common garter snake	●	●	●	●	●	●	6	6
	BIRDS								
PONI	eared grebe	●						1	1
POPO	pied-billed grebe	●						1	1
PHAU	double-crested cormorant	●						1	1
BOLE	American bittern	●	●					2	2
BRCA	Canada goose	●	●	●	●	●		5	5
ANPL	mallard	●	●	●	●	●		5	5
ANST	gadwall	●	●	●	●	●		5	5
ANAC	pintail	●	●					2	2
ANCR	green-winged teal	●	●	●	●	●		5	5
ANDI	blue-winged teal	●						1	1
ANCY	cinnamon teal	●						1	1
ANAM	American wigeon	●	●	●	●	●		5	5
ANCL	northern shoveler	●						1	1
AYAM	redhead	●						1	1
AYCO	ring-necked duck	●	●	●	●	●		5	5
AYAF	lesser scaup	●	●					2	2
HIHI	harlequin duck	F	F	F	●	●	●	3	6
OXJA	ruddy duck	●						1	1
GRCA	sandhill crane	●	F					1	2
RALI	Virginia rail	●	●	●	●	●		5	5

See footnote at end of life form 3.

Life form 3. Continued

Species		● Reproduction and feeding R Reproduction only F Feeding only							
	REPTILES								
POCA	sora		●	●	●	●		4	4
FUAM	American coot	F	●	●	●	●		4	5
CHAL	snowy plover	●						1	1
CHVO	killdeer	●						1	1
CAGA	common snipe	●						1	1
NUAM	long-billed curlew	●	●					2	2
ACMA	spotted sandpiper	●						1	1
CASE	willet	●						1	1
REAM	American avocet	●						1	1
STTR	Wilson's phalarope	●						1	1
LACA	California gull	●	●					2	2
LADE	ring-billed gull	●	●					2	2
LAPI	Franklin's gull	●	●					2	2
STFO	Forster's tern	●	●					2	2
CHNI	black tern	●						1	1
CIME	dipper	●	●	●	●	●	●	6	6
TRTR	winter wren		●	●	●	●	●	5	5
TEPA	long-billed marsh wren	●	●					2	2
SENO	northern waterthrush	●	●					2	2
GETR	common yellowthroat	●	●					2	2
	MAMMALS								
ZAPR	western jumping mouse	●	●			●	●	4	4
Letter code	No. of species using successional stage: Reproduction	41	27	15	16	17	6	Reproduction	Feeding
	No. of species using successional stage: Feeding	43	29	16	16	17	6		
		Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

[1]A number of species in this life form are specifically oriented to water in emergent vegetation or on floating vegetation, for reproduction and/or feeding purposes; but from a management standpoint (i.e., potential for managed impacts) they fit this category.

Life form 4. Reproduces in cliffs, caves, rimrock, and/or talus and feeds on the ground or in the air (32 species)

Letter code	Species	Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	R	F
		● Reproduction and feeding		R Reproduction only		F Feeding only			
	REPTILES								
UTST	side-blotched lizard	●	●					2	2
	BIRDS								
CAAU	turkey vulture	●	●				●	3	3
BURE	ferruginous hawk	●						1	1
FAME	prairie falcon	●						1	1
FAPE	peregrine	●	●	●	●	●	●	6	6
LALE	white-tailed ptarmigan	●						1	1
ALCH	chukar	●	●					2	2
COLI	rock dove	●						1	1
CYNI	black swift	●	F					1	2
AESA	white-throated swift	●	F					1	2
SASA	Say's phoebe	●	●	●	●	●	●	6	6
HIRU	barn swallow	●						1	1
PEPY	cliff swallow	●	F	F	F	F	F	1	6
COCOR	common raven	●	●				●	3	3
CAMEX	canyon wren	●	●					2	2
SAOB	rock wren	●	●					2	2
LETE	gray-crowned rosy finch	●						1	1
LEAT	black rosy finch	●						1	1
	MAMMALS								
MYLE	small-footed myotis	●	F					1	2
PIHE	western pipistrelle	●	F					1	2
EUMA	spotted bat	●	●					2	2
PLTO	western big-eared bat	●	●	F	F	F	F	2	6
ANPA	pallid bat	●	●				F	2	3
OCPR	pika	●						1	1
MAFL	yellow-bellied marmot	●	●					2	2

Life form 4. Continued

Letter code	Species		Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	
			• Reproduction and feeding R Reproduction only F Feeding only							
	MAMMALS									
PECR	canyon mouse		•	F					1	2
PETR	pinyon mouse		•	F					1	2
NECI	bushy-tailed woodrat		•	•	•	•	•	•	6	6
FECO	puma		F	•	•	•	•	•	5	6
LYRU	bobcat		F	•	•	•	•	•	5	6
ORAM	mountain goat		•						1	1
OVCA	big-horned sheep		•	F	F	F	F	F	1	6
	No. of species using successional stage	Reproduction	30	15	5	5	5	7	Reproduction	Feeding
		Feeding	32	23	8	8	8	11		

Life form 5. Reproduces on the ground without specific water, cliff, rimrock, or talus association and feeds on the ground (48 species)

Letter code	Species	Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	R	F
		● Reproduction and feeding		R Reproduction only		F Feeding only		No. of successional stages used	
	REPTILES								
SCOC	western fence lizard	●	●	●	●	●	●	6	6
SCGR	sagebrush lizard	●	●	●	●	●	●	6	6
PHDO	short-horned lizard	●	●	●	●	●	●	6	6
CNTI	western whiptail	●	●	●	●	●	●	6	6
COCO	yellow-bellied racer	●	●	●	●	●	●	6	6
MATA	striped whipsnake	●	●	●	●	●	●	6	6
PIME	gopher snake	●	●	●	●	●	●	6	6
THEL	western terrestrial garter snake	●	●	●	●	●	●	6	6
HYTO	night snake	●	●	●	●	●	●	6	6
CRVI	western rattlesnake	●	●	●	●	●	●	6	6
	BIRDS								
CICY	marsh hawk	●	●					2	2
DEOB	blue grouse	F	●	●	F	F	F	2	6
CACA	Franklin's grouse		F	●	●	●	F	3	5
BOUM	ruffed grouse		●	R	F	●	●	4	4
PEPH	sharp-tailed grouse	●	●					2	2
CEUR	sage grouse	F	●					1	2
COVI	bobwhite	F	●	●	●			3	4
LOCA	California quail	F	●	●	●			3	4
ORPI	mountain quail	F	●	●	●	F	F	3	6
PEPE	gray partridge	●						1	1
PHCO	ring-necked pheasant	●	●	F	F	F		2	5
MEGA	turkey	F	●	R	R	F	F	3	4
BALO	upland sandpiper	●						1	1
ASFL	short-eared owl	●	F					1	2
ERAL	horned lark	●						1	1

Life form 5. Continued

Species		● Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS								
CAGU	hermit thrush			F	F	●	●	2	4
CAFU	veery		●	●	●			3	3
ANSP	water pipit	●						1	1
WIPU	Wilson's warbler		●	●	●	●		4	4
DOOR	bobolink	●	F					1	2
STNEG	western meadowlark	●	F					1	2
PASA	savannah sparrow	●	F					1	2
AMSA	grasshopper sparrow	●						1	1
POGRA	vesper sparrow	●						1	1
CHGR	lark sparrow	●	F					1	2
JUHY	dark-eyed junco	●	●	●	●	●	●	6	6
	MAMMALS								
DIMA	opossum	●	●	●	●	●		5	5
LEAM	snowshoe hare	F	●	●	●	R		4	4
LETO	whitetail jackrabbit	●	●					2	2
LECA	blacktail jackrabbit	●	●					2	2
GUGU	wolverine	F	●	●	●	●	●	5	6
FECA	feral house cat	●	●	●	●	●		5	5
LYCA	lynx	F	●	●	●	●	●	5	6
EQCA	feral horse	●	●	●	F	F	F	3	6
CEEL	elk	F	●	●	F	F	F	2	6
ODHE	mule deer	F	●	●	F	F	F	2	6
ODVI	white-tailed deer	F	●	●				2	3
ANAME	pronghorn	●	●	●	●	●	●	6	6
Letter code	No. of species using successional stage: Reproduction	31	35	30	24	21	16	Reproduction	Feeding
	No. of species using successional stage: Feeding	43	41	30	30	27	23		
		Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 6. Reproduces on the ground and feeds in bushes, trees, or the air (7 species)

Species			● Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS									
PHNU	poorwill		●	●	F	F	F	F	2	6
CHMI	common nighthawk		●	●	F	F	●	●	4	6
MYTO	Townsend's solitaire		●	●	●	●	●	●	6	6
VECE	orange-crowned warbler			●	F	F			1	3
VERU	Nashville warbler			●	F	F			1	3
MELI	Lincoln's sparrow		●	●	F	F	F		2	5
	MAMMALS									
ERDO	porcupine		F	●	●	●	●		4	5
Letter code	No. of species using successional stage	Reproduction	4	7	2	2	3	2	Repro-duction	Feeding
		Feeding	5	7	7	7	5	3		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 7. Reproduces in bushes and feeds on the ground, in water, or the air (30 species)

Species		● Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS								
NYNY	black-crowned night heron	●	●	●	R	R		5	3
BUSW	Swainson's hawk	●	●	●	●	●	●	6	6
TRSO	solitary sandpiper	●	●	●				3	3
ARAL	black-chinned hummingbird	F	●	●	F	F	F	2	6
SEPL	broad-tailed hummingbird	F	●	●				2	3
STCA	calliope hummingbird	F	●	●	F	F	F	2	6
TYTY	eastern kingbird		●	●	●	●	●	5	5
EMTR	willow flycatcher		F	●	●			2	3
EMWR	gray flycatcher	F	●	●	●	●	●	5	6
PIPI	black-billed magpie	F	●	●	●	●	●	5	6
DUCA	gray catbird		●	●	●	●		4	4
ORMO	sage thrasher		●	●	●	●	●	5	5
TUMI	American robin	F	●	●	●	●	●	5	6
CAUS	Swainson's thrush		●	●	●	●	●	5	5
LALU	loggerhead shrike	F	●	●	●	●	●	5	6
OPTO	MacGillivray's warbler		●	●	●	●		4	4
XAXA	yellow-headed blackbird	F	R					1	1
AGPH	red-winged blackbird	●	●					2	2
EUCY	Brewer's blackbird	F	●	●	●	●	●	5	6
MOAT	brown-headed cowbird	●	●	●	●	●	F	5	6
PAAMO	lazuli bunting	F	●	●	●	●	●	5	6
SPPS	lesser goldfinch	F	●					1	2
CHCH	green-tailed towhee	F	●	●	●	●	●	5	6
PIER	rufous-sided towhee		●	●	●	●	●	5	5
AMBE	sage sparrow		●	●	●	●	●	5	5
SPPA	chipping sparrow	F	●	●	●	●	●	5	6
SPBR	Brewer's sparrow	F	●	●	●	●	●	5	6
Letter code		Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used: R	No. of successional stages used: F

Life form 7. Continued

Letter code	Species		● Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS									
ZOLE	white-crowned sparrow		●	●	●	●	●	●	6	6
PAIL	fox sparrow			●	●	●	●	●	5	5
MEMEL	song sparrow			●	●	●	●		4	4
	No. of species using successional stage	Reproduction	6	29	27	23	22	17	Repro-duction	Feeding
		Feeding	20	29	27	24	23	20		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 8. Reproduces in bushes and feeds in trees, bushes, or the air (6 species)

Species			● Reproduction and feeding R Reproduction only F Feeding only							
BIRDS										
COAM	yellow-billed cuckoo			●	●	●	●		4	4
EMOB	dusky flycatcher		F	●	●	●	●	●	5	6
PSMI	bushtit			●	●	●	●	●	5	5
DEPE	yellow warbler			●	●	●	●		4	4
ICVI	yellow-breasted chat			●	●	●	●	F	4	5
SPTR	American goldfinch		F	●	●	●	●		4	5
Letter code	No. of species using successional stage	Reproduction	0	6	6	6	6	2	Repro-duction	Feeding
		Feeding	2	6	6	6	6	3		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 9. Reproduces primarily in deciduous trees and feeds in trees, bushes, or the air (4 species)

Species			● Reproduction and feeding R Reproduction only F Feeding only							
BIRDS										
BOCE	cedar waxwing			●	●	●	●		4	4
SERUT	American redstart		F	●	●	●	●		4	5
ICGA	northern oriole			●	●	●	●		4	4
CAMEXI	house finch		F	●	●	●	●	F	4	6
Letter code	No. of species using successional stage	Reproduction	0	4	4	4	4	0	Repro-duction	Feeding
		Feeding	2	4	4	4	4	1		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 10. Reproduces primarily in conifers and feeds in trees, bushes, or the air (14 species)

Letter code	Species		Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used: Reproduction	No. of successional stages used: Feeding
			● Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS									
EMDI	western flycatcher			F	F	●	●	●	3	5
NUBO	olive-sided flycatcher		F	F	●	●	●	●	4	6
GYCY	pinyon jay			F	●	●	●	●	4	5
NUCO	Clark's nutcracker					F	●	●	2	3
RESA	golden-crowned kinglet			F	F	●	●	●	3	5
RECA	ruby-crowned kinglet				F	F	●	●	2	4
DECO	yellow-rumped warbler				F	●	●	●	3	4
DENI	black-throated gray warbler			●	●	●	●	●	5	5
DETO	Townsend's warbler					F	●	●	2	3
PILU	western tanager			F	F	●	●	●	3	5
LOCUR	red crossbill					F	●	●	2	3
	MAMMALS									
SCGRI	western gray squirrel				F	●	●	●	3	4
TAHU	red squirrel				●	●	●	●	4	4
TADO	chickaree				●	●	●	●	4	4
	No. of species using successional stage	Reproduction	0	1	5	10	14	14	Reproduction	Feeding
		Feeding	1	6	11	14	14	14		

Life form 11. Reproduces in conifers or deciduous trees and feeds in trees, in bushes, on the ground, or in the air (24 species)

Species		• Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS								
ACGE	goshawk		F		F	•	•	2	4
ACST	sharp-shinned hawk		F	•	•	•	F	3	5
ACCO	Cooper's hawk	F	F	F	•	•	F	2	6
FACO	merlin	F	F	F	F	•	•	2	6
ZEMA	mourning dove	•	•	R	R	R		5	2
ASOT	long-eared owl	F	F	F	•	•	•	3	6
SERU	rufous hummingbird	F	•	R	R	•	R	5	3
TYVE	western kingbird	F	•	•	•	•		4	5
EMHA	Hammond's flycatcher		F	F	F	•	•	2	5
COSO	western wood pewee		F	F	•	•	•	3	5
PECA	gray jay		F	•	•	•	F	3	5
CYST	Steller's jay	F	F	•	•	•	•	4	6
COBR	common crow	F	F	F	•	•	•	3	6
IXNA	varied thrush		F	•	•	•	•	4	5
VISO	solitary vireo			•	•	•	•	4	4
VIOL	red-eyed vireo		F	•	•	•	•	4	5
VIGI	warbling vireo		F	•	•	•	•	4	5
PHME	black-headed grosbeak	F		F	•	•	•	3	5
HEVE	evening grosbeak	F		F	F	•	•	2	5
CAPU	purple finch	F	F	•	•	•	•	4	6
CACAS	Cassin's finch	F	F	F	•	•	•	3	6
PIEN	pine grosbeak			F	F	•	•	2	4
SPPI	pine siskin	F	F	•	•	•	•	4	6
	MAMMALS								
LACI	hoary bat	F	F	F	F	F	F	0	6
Letter code	No. of species using successional stage: Reproduction	1	3	12	18	23	18	Reproduction	Feeding
	No. of species using successional stage: Feeding	14	20	21	22	23	21		
		Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 12. Reproduces on very thick branches and feeds on the ground or in water (7 species)

Species			● Reproduction and feeding R Reproduction only F Feeding only							
BIRDS										
ARHE	great blue heron		F				R		1	1
BUJA	red-tailed hawk		F	F	F	●	●	●	3	6
AQCH	golden eagle		F	F	F	F	●	●	2	6
HALE	bald eagle		F	F			●	●	2	4
PAHA	osprey		F	F	F	F	●	●	2	6
BUVI	great horned owl		F	F	F	●	●	●	3	6
STNE	great gray owl		F			●	F	F	1	4
Letter code	No. of species using successional stage	Reproduction	0	0	0	3	6	5	Repro-duction	Feeding
		Feeding	7	5	4	5	6	6		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 13. Reproduces in own hole excavated in tree and feeds in trees, in bushes, on the ground, or in the air (13 species)

Species			● Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS									
COAU	common flicker		F	F	F	●	●	●	3	6
DRPI	pileated woodpecker						●	●	2	2
ASLE	Lewis' woodpecker		F	F		●	●	●	3	5
SPVA	yellow-bellied sapsucker					●	●		2	2
SPTH	Williamson's sapsucker						●	●	2	2
DEVI	hairy woodpecker					●	●	●	3	3
DEPU	downy woodpecker					●	●	●	3	3
DEAL	white-headed woodpecker						●	●	2	2
PIAR	black-backed three-toed woodpecker					●	●	●	3	3
PITR	northern three-toed woodpecker					●	●	●	3	3
SICA	white-breasted nuthatch						●	●	2	2
SICAN	red-breasted nuthatch					●	●	●	3	3
SIPY	pygmy nuthatch						●	●	2	2
Letter code	No. of species using successional stage	Reproduction	0	0	0	8	13	12	Repro-duction	Feeding
		Feeding	2	2	1	8	13	12		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 14. Reproduces in a hole made by another species or in a natural hole and feeds on the ground, in water, or the air (37 species)

Species		● Reproduction and feeding R Reproduction only F Feeding only							
	BIRDS								
AISP	wood duck	F	F	F	F	●	●	2	6
BUIS	Barrow's goldeneye	F	F	F	F	●	●	2	6
BUAL	bufflehead	F	F	F	F	●	●	2	6
LOCU	hooded merganser	F	F	F	F	●	●	2	6
MEME	common merganser	F	F	F	F	●	●	2	6
FASP	American kestrel	F	F		R	R	●	3	3
TYAL	barn owl	F	F			●	●	2	4
OTAS	screech owl	F	F		R	●	●	3	4
OTFL	flammulated owl	F	F		R	●	●	3	4
GLGN	pygmy owl	F	F	F	●	●	●	3	6
STVA	barred owl	F	F			●	●	2	4
AEAC	saw-whet owl				R	●	●	3	2
CHVA	Vaux's swift					●	●	2	2
MYCI	ash-throated flycatcher	F	F			●	●	2	4
TATH	violet-green swallow	F	F		R	R	●	3	3
IRBI	tree swallow	F	F		R	R	●	3	3
PAAT	black-capped chickadee			●	●	●	●	4	4
PAGA	mountain chickadee			●	●	●	●	4	4
PARU	chestnut-backed chickadee			●	●	●	●	4	4
CEFA	brown creeper				F	●	●	2	3
TRAE	house wren	F	F	●	R	R	R	4	3
SIME	western bluebird	F	F		R	R	R	3	2
SICU	mountain bluebird	F	F		R	R	R	3	2
STVU	starling	F	F		R	R	R	3	2
PADO	house sparrow	F	F		R	R	R	3	2
Letter code		Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used: R	No. of successional stages used: F

Life form 14. Continued

Species			● Reproduction and feeding R Reproduction only F Feeding only							
	MAMMALS									
MYLU	little brown myotis		F	F			●	●	2	4
MYYU	Yuma myotis						●	●	2	2
MYEV	long-eared myotis		F	F	F	F	●	●	2	6
MYVO	long-legged myotis		F	F	F	F	●	●	2	6
MYCA	California myotis		F	F			●	●	2	4
LANO	silver-haired bat		F	F	F	F	●	●	2	6
EPFU	big brown bat		F	F	F	F	●	●	2	6
SCNI	eastern fox squirrel						●	●	2	2
GLSA	northern flying squirrel					●	●	●	3	3
PRLO	raccoon		F	F			●	●	2	4
MAAM	marten				F	F	●	●	2	4
MAPE	fisher				F	F	●	●	2	4
Letter code	No. of species using successional stage	Reproduction	0	0	4	16	37	37	Reproduction	Feeding
		Feeding	26	26	16	17	29	32		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 15. Reproduces in a burrow underground and feeds on the ground or under it (40 species)

Letter code	Species	Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used R	No. of successional stages used F
		● Reproduction and feeding		R Reproduction only		F Feeding only			
	REPTILES								
CHBO	rubber boa	●	●	F	F	●	●	4	6
	BIRDS								
SPCU	burrowing owl	●	●	●	●	●	●	6	6
	MAMMALS								
SOPR	Malheur shrew	●	●					2	2
SOVA	vagrant shrew	●	●	●	●	●	●	6	6
SOOB	dusky shrew				●	●	●	3	3
SOME	Merriam shrew	●	●					2	2
SCOR	coast mole	●	●	●	●	●	●	6	6
SYID	pygmy rabbit	●	●					2	2
SYNU	mountain cottontail	●	●	●	●	●	●	6	6
EUMI	least chipmunk	●	●					2	2
EUAM	yellow pine chipmunk	●	●	●	●	●	●	6	6
SPTO	Townsend ground squirrel	●	●	●	●	●	●	6	6
SPWA	Washington ground squirrel	●						1	1
SPBE	Belding ground squirrel	●						1	1
SPCO	Columbian ground squirrel	●	●			●	●	4	4
SPLA	mantled ground squirrel	●	●	●	●	●	●	6	6
THTO	Townsend pocket gopher	●	●					2	2
THTA	northern pocket gopher	●	●	●	●	●	●	6	6
PEPA	Great Basin pocket mouse	●	●	●	●	●	●	6	6
DIOR	Ord kangaroo rat	●	●	●	●	●	●	6	6
REME	western harvest mouse	●	●	●	●	●	●	6	6
PEMA	deer mouse	●	●	●	●	●	●	6	6
ONLE	northern grasshopper mouse	●	●	●	●	●	●	6	6
CLGA	Gapper red-backed vole			●	●	●	●	4	4
PHIN	heather vole	●	●				●	3	3

Life form 15. Continued

Species			● Reproduction and feeding R Reproduction only F Feeding only							
MAMMALS										
MIMO	mountain vole		●	●			●	●	4	4
MILO	long-tailed vole		●	●	●	●	●	●	6	6
LACU	sagebrush vole		●	●					2	2
RANO	Norway rat			●	●				2	2
MUMU	house mouse		●	●	●				3	3
CALAT	coyote		●	●	●	●	●	●	6	6
CALU	gray wolf		F	F	F	F	F	F	0	6
VUVU	red fox		F	●	●	●	●	●	5	6
URCI	gray fox		F	●	●	●	●	●	5	6
URAM	black bear		F	●	●	●	●	●	5	6
MUER	short-tailed weasel		F	●	●	●	●	●	5	6
MUFR	long-tailed weasel		●	●	●	●	●	●	6	6
TATA	badger		●	●	●	●	●	●	6	6
SPPU	spotted skunk		●	●	●				3	3
MEMEP	striped skunk		●	●					2	2
Letter code	No. of species using successional stage	Reproduction	32	35	25	23	26	27	Reproduction	Feeding
		Feeding	37	36	27	25	27	28		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Life form 16. Reproduces in a burrow underground and feeds in the air or in water (10 species)

Letter code	Species		● Reproduction and feeding R Reproduction only F Feeding only							
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	
	BIRDS								Reproduction	Feeding
MEAL	belted kingfisher		●	F	F	F	F	F	1	6
RIRI	bank swallow		●	F					1	2
STRU	rough-winged swallow		●	F					1	2
	MAMMALS									
SOPA	northern water shrew		●	●	●	●	●	●	6	6
CACAN	beaver		●	●	●	●	●	●	6	6
MIRI	water vole		●	●	●	●	●	●	6	6
ONZI	muskrat		●	●	●	●	●	●	6	6
MYCO	nutria		●	●	●	●	●		5	5
MUVI	mink		●	●	●	●	●	●	6	6
LUCA	river otter		●	●	●	●	●	●	6	6
	No. of species using successional stage	Reproduction	10	7	7	7	7	6		
		Feeding	10	10	8	8	8	7		

Appendix 10

Relative degree of use by the life form of indicated plant communities and successional stages

Life form 2. Reproduces in water and feeds on the ground, in bushes, and/or in trees (9 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 9 F 9	Shrub-seedling (0-10 years) R 5 F 5	Pole-sapling (11-39 years) R 5 F 5	Young (40-79 years) R 6 F 6	Mature (80-159 years) R 5 F 5	Old growth (160 + years) R 5 F 5
Dry meadow	R 3	R	3	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 3	F	3					
Moist meadow	R 6	R	6					
	F 6	F	6					
Other grasses	R 5	R	5					
	F 5	F	5					
Sagebrush-bitterbrush	R 7	R	7	5				
	F 7	F	7	5				
Other shrubs	R 5	R	5	4				
	F 5	F	5	4				
Curlleaf mountain-mahogany	R 2	R	2	2	2	2	2	2
	F 2	F	2	2	2	2	2	2
Western juniper	R 6	R	6	5	4	5	4	4
	F 6	F	6	5	4	5	4	4
Quaking aspen	R 3	R	3	3	3	3	3	*as above
	F 3	F	3	3	3	3	3	
Riparian (deciduous)	R 9	R	9	5	5	6	5	
	F 9	F	9	5	5	6	5	
Ponderosa pine	R 4	R	4	3	3	3	3	3
	F 4	F	4	3	3	3	3	3
Mixed conifer	R 4	R	4	3	4	4	4	4
	F 4	F	4	3	4	4	4	4
White fir (grand fir)	R 4	R	4	3	4	4	4	4
	F 4	F	4	3	4	4	4	4
Lodgepole pine	R 4	R	4	3	4	4	*as above	
	F 4	F	4	3	4	4		
Subalpine fir	R 3	R	3	2	3	3	3	3
	F 3	F	3	2	3	3	3	3
Alpine meadow	R 2	R	2	*as above				
	F 2	F	2					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 2 is equivalent to 10 units.

Life form 3. Reproduces on the ground around water (or in emergent vegetation, or on floating vegetation[2]) and feeds on the ground, and in bushes, trees, and water (45 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 41 F 43	Shrub-seedling (0-10 years) R 27 F 29	Pole-sapling (11-39 years) R 15 F 16	Young (40-79 years) R 16 F 16	Mature (80-159 years) R 17 F 17	Old growth (160 + years) R 6 F 6
Dry meadow	R 9	R	9	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 22	F	22					
Moist meadow	R 22	R	22					
	F 35	F	35					
Other grasses	R 13	R	13					
	F 26	F	26					
Sagebrush-bitterbrush	R 6	R	6	6				
	F 6	F	6	5				
Other shrubs	R 5	R	4	5				
	F 6	F	6	6				
Curlleaf mountain-mahogany	R 2	R	2	2	2	2	2	1
	F 2	F	2	2	2	2	2	1
Western juniper	R 2	2	2	2	2	2	2	1
	F 2	F	2	2	2	2	2	1
Quaking aspen	R 3	R	3	3	3	3	3	*as above
	F 6	F	6	6	3	3	3	
Riparian (deciduous)	R 39	R	37	24	14	14	15	
	F 43	F	41	29	16	16	17	
Ponderosa pine	R 5	R	5	5	4	4	5	4
	F 5	F	5	5	4	4	5	4
Mixed conifer	R 6	R	4	5	4	5	6	6
	F 6	F	5	6	4	4	5	5
White fir (grand fir)	R 5	R	3	4	3	4	5	5
	F 4	F	3	4	3	3	4	4
Lodgepole pine	R 4	R	2	3	2	3	*as above	
	F 3	F	2	3	2	2		
Subalpine fir	R 3	R	1	2	1	2	3	3
	F 2	F	1	2	1	1	2	2
Alpine meadow	R 2	R	2	*as above				
	F 2	F	2					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 3 is equivalent to 45 units.

[2]A number of species in this life form are specifically oriented to water in emergent vegetation or on floating vegetation, for reproduction and/or feeding purposes; but from a management standpoint (i.e., potential for managed impacts) they fit this category.

Life form 4. Reproduces in cliffs, caves, rimrock, and/or talus and feeds on the ground or in the air (32 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 30 F 32	Shrub-seedling (0-10 years) R 15 F 23	Pole-sapling (11-39 years) R 5 F 8	Young (40-79 years) R 5 F 8	Mature (80-159 years) R 5 F 8	Old growth (160 + years) R 7 F 11
Dry meadow	R 20	R	20	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 27	F	27					
Moist meadow	R 6	R	6					
	F 20	F	20					
Other grasses	R 18	R	18					
	F 26	F	26					
Sagebrush-bitterbrush	R 17	R	16	11				
	F 19	F	19	19				
Other shrubs	R 11	R	10	9				
	F 18	F	18	17				
Curlleaf mountain-mahogany	R 5	R	5	5	1	1	1	2
	F 11	F	11	10	5	5	5	7
Western juniper	R 9	R	9	7	2	2	2	4
	F 17	F	17	15	6	6	6	8
Quaking aspen	R 2	R	2	2	1	1	1	*as above
	F 12	F	12	11	6	6	6	
Riparian (deciduous)	R 6	R	6	3	1	1	1	
	F 16	F	16	13	5	5	5	
Ponderosa pine	R 11	R	10	9	3	3	3	5
	F 15	F	15	14	7	7	7	10
Mixed conifer	R 7	R	5	6	4	4	4	5
	F 9	F	9	8	5	5	5	7
White fir (grand fir)	R 6	R	4	6	4	4	4	5
	F 7	F	7	7	4	4	4	6
Lodgepole pine	R 5	R	3	5	4	4	*as above	
	F 6	F	6	6	4	4		
Subalpine fir	R 10	R	8	5	4	4	4	5
	F 12	F	12	7	5	5	5	7
Alpine meadow	R 10	R	10	*as above				
	F 14	F	14					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 4 is equivalent to 30 units.

Life form 5. Reproduces on the ground without specific water, cliff, rimrock, or talus association and feeds on the ground (48 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 31 F 43	Shrub-seedling (0-10 years) R 35 F 41	Pole-sapling (11-39 years) R 30 F 30	Young (40-79 years) R 24 F 30	Mature (80-159 years) R 21 F 27	Old growth (160 + years) R 16 F 23
Dry meadow	R 14	R	14	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 25	F	25					
Moist meadow	R 10	R	10					
	F 23	F	23					
Other grasses	R 21	R	21					
	F 30	F	30					
Sagebrush-bitterbrush	R 14	R	13	13				
	F 17	F	17	17				
Other shrubs	R 29	R	17	27				
	F 35	F	31	34				
Curlleaf mountain-mahogany	R 2	R	2	2	2	2	2	2
	F 6	F	6	6	6	6	6	6
Western juniper	R 14	R	14	14	12	12	12	11
	F 18	F	18	18	15	15	15	14
Quaking aspen	R 9	R	1	9	9	4	3	*as above
	F 12	F	9	12	10	10	10	
Riparian (deciduous)	R 17	R	10	15	15	13	10	
	F 21	F	18	21	17	17	15	
Ponderosa pine	R 12	R	7	12	11	7	6	6
	F 18	F	16	17	15	15	16	16
Mixed conifer	R 13	R	3	12	12	6	7	5
	F 16	F	13	15	14	14	14	13
White fir (grand fir)	R 6	R	1	4	5	5	6	4
	F 10	F	7	9	9	10	9	9
Lodgepole pine	R 5	R	1	3	4	4	*as above	
	F 10	F	7	9	9	10		
Subalpine fir	R 6	R	1	4	5	5	6	4
	F 10	F	7	9	9	10	9	9
Alpine meadow	R 1	R	1	*as above				
	F 5	F	5					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 5 is equivalent to 35 units.

Life form 6. Reproduces on the ground and feeds in bushes, trees, or the air (7 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 4 F 5	Shrub-seedling (0-10 years) R 7 F 7	Pole-sapling (11-39 years) R 2 F 7	Young (40-79 years) R 2 F 7	Mature (80-159 years) R 3 F 5	Old growth (160 + years) R 2 F 3
Dry meadow	R 2	R	2	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 4	F	4					
Moist meadow	R 0	R	0					
	F 3	F	3					
Other grasses	R 1	R	1					
	F 4	F	4					
Sagebrush-bitterbrush	R 3	R	2	3				
	F 3	F	3	3				
Other shrubs	R 4	R	1	4				
	F 5	F	3	5				
Curlleaf mountain-mahogany	R 2	R	1	2	1	1	2	1
	F 3	F	3	3	3	3	3	2
Western juniper	R 3	R	2	3	2	2	3	2
	F 4	F	4	4	4	4	4	3
Quaking aspen	R 1	R	0	1	0	0	0	*as above
	F 3	F	2	3	3	3	2	
Riparian (deciduous)	R 4	R	1	4	1	1	1	
	F 4	F	2	4	4	4	2	
Ponderosa pine	R 3	R	2	3	1	1	2	1
	F 4	F	4	4	4	4	4	3
Mixed conifer	R 2	R	0	2	1	1	1	0
	F 2	F	1	2	2	2	1	0
White fir (grand fir)	R 0	R	0	0	0	0	0	0
	F 1	F	1	1	1	1	1	0
Lodgepole pine	R 0	R	0	0	0	0	*as above	
	F 1	F	1	1	1	1		
Subalpine fir	R 1	R	1	1	0	0	0	0
	F 1	F	1	1	1	1	1	0
Alpine meadow	R 1	R	1	*as above				
	F 2	F	2					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 6 is equivalent to 5 units.

Life form 7. Reproduces in bushes and feeds on the ground, in water, or the air (30 species)

Plant community[1]		Function[1]	Successional stage[1]: Grass-forb R 6 F 20	Shrub-seedling (0-10 years) R 29 F 29	Pole-sapling (11-39 years) R 27 F 27	Young (40-79 years) R 23 F 24	Mature (80-159 years) R 22 F 23	Old growth (160 + years) R 17 F 20
Dry meadow	R 1	R	1	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 13	F	13					
Moist meadow	R 3	R	3					
	F 14	F	14					
Other grasses	R 1	R	1					
	F 14	F	14					
Sagebrush-bitterbrush	R 10	R	1	10				
	F 15	F	11	14				
Other shrubs	R 22	R	4	22				
	F 28	F	18	28				
Curlleaf mountain-mahogany	R 1	R	0	1	1	1	1	1
	F 3	F	3	3	3	3	3	3
Western juniper	R 12	R	1	12	11	11	11	11
	F 14	F	10	14	13	13	12	12
Quaking aspen	R 16	R	2	15	16	13	12	*as above
	F 20	F	13	20	20	18	17	
Riparian (deciduous)	R 21	R	4	20	19	15	14	
	F 26	F	17	25	24	21	20	
Ponderosa pine	R 5	R	1	5	5	5	5	4
	F 10	F	10	10	10	9	9	9
Mixed conifer	R 8	R	1	8	8	6	6	4
	F 11	F	7	11	11	11	10	8
White fir (grand fir)	R 3	R	0	3	3	3	3	2
	F 5	F	2	5	5	5	4	3
Lodgepole pine	R 3	R	0	2	3	3	*as above	
	F 4	F	2	4	4	4		
Subalpine fir	R 5	R	1	5	5	4	4	4
	F 6	F	4	6	6	6	6	6
Alpine meadow	R 1	R	1	*as above				
	F 4	F	4					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 7 is equivalent to 30 units.

Life form 8. Reproduces in bushes and feeds in trees, bushes, or the air (6 species)

Plant community[1]		Function[1]	Successional stage[1]: Grass-forb R0 F2	Shrub-seedling (0-10 years) R6 F6	Pole-sapling (11-39 years) R6 F6	Young (40-79 years) R6 F6	Mature (80-159 years) R6 F6	Old growth (160 + years) R2 F3
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 1	F	1					
Moist meadow	R 0	R	0					
	F 0	F	0					
Other grasses	R 0	R	0					
	F 2	F	2					
Sagebrush-bitterbrush	R 0	R	0	0				
	F 2	F	1	2				
Other shrubs	R 5	R	0	5				
	F 5	F	2	5				
Curlleaf mountain-mahogany	R 1	R	0	1	1	1	1	1
	F 1	F	0	1	1	1	1	1
Western juniper	R 2	R	0	2	2	2	2	2
	F 2	F	1	2	2	2	2	2
Quaking aspen	R 1	R	0	1	1	1	1	*as above
	F 3	F	0	3	3	3	3	
Riparian (deciduous)	R 5	R	0	5	5	5	5	
	F 6	F	2	6	6	6	6	
Ponderosa pine	R 2	R	0	2	2	2	2	1
	F 3	F	2	3	3	3	3	2
Mixed conifer	R 1	R	0	1	1	1	1	1
	F 2	F	1	2	2	2	2	2
White fir (grand fir)	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Lodgepole pine	R 0	R	0	0	0	0	*as above	
	F 0	F	0	0	0	0		
Subalpine fir	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Alpine meadow	R 0	R	0	*as above				
	F 0	F	0					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 8 is equivalent to 10 units.

Life form 9. Reproduces primarily in deciduous trees and feeds in trees, bushes, or the air (4 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 0 F 2	Shrub-seedling (0-10 years) R 4 F 4	Pole-sapling (11-39 years) R 4 F 4	Young (40-79 years) R 4 F 4	Mature (80-159 years) R 4 F 4	Old growth (160 + years) R 0 F 1
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 0	F	0					
Moist meadow	R 0	R	0					
	F 0	F	0					
Other grasses	R 0	R	0					
	F 0	F	0					
Sagebrush-bitterbrush	R 0	R	0	0				
	F 0	F	0	0				
Other shrubs	R 2	R	0	2				
	F 2	F	1	2				
Curlleaf mountain-mahogany	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Western juniper	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Quaking aspen	R 4	R	0	4	4	4	4	*as above
	F 4	F	2	4	4	4	4	
Riparian (deciduous)	R 4	R	0	4	4	4	4	
	F 4	F	2	4	4	4	4	
Ponderosa pine	R 1	R	0	1	1	1	1	0
	F 2	F	1	2	2	2	2	1
Mixed conifer	R 0	R	0	0	0	0	0	0
	F 2	F	1	2	2	2	2	1
White fir (grand fir)	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Lodgepole pine	R 0	R	0	0	0	0	*as above	
	F 0	F	0	0	0	0		
Subalpine fir	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Alpine meadow	R 0	R	0	*as above				
	F 0	F	0					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 9 is equivalent to 5 units.

Life form 10. Reproduces primarily in conifers and feeds in trees, bushes, or the air (14 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 0 F 1	Shrub-seedling (0-10 years) R 1 F 6	Pole-sapling (11-39 years) R 5 F 11	Young (40-79 years) R 10 F 14	Mature (80-159 years) R 14 F 14	Old growth (160 + years) R 14 F 14
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 0	F	0					
Moist meadow	R 0	R	0					
	F 0	F	0					
Other grasses	R 0	R	0					
	F 0	F	0					
Sagebrush-bitterbrush	R 0	R	0	0				
	F 1	F	0	1				
Other shrubs	R 1	R	0	1				
	F 2	F	0	2				
Curlleaf mountain-mahogany	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Western juniper	R 2	R	0	1	2	2	2	2
	F 2	F	0	2	2	2	2	2
Quaking aspen	R 1	R	0	0	0	1	1	*as above
	F 6	F	1	4	6	6	6	
Riparian (deciduous)	R 2	R	0	0	0	2	2	
	F 8	F	1	4	8	8	8	
Ponderosa pine	R 7	R	0	1	4	6	7	7
	F 13	F	1	5	10	13	13	13
Mixed conifer	R 12	R	0	1	4	9	12	12
	F 13	F	1	5	10	13	13	13
White fir (grand fir)	R 10	R	0	0	3	7	10	10
	F 10	F	1	4	8	10	10	10
Lodgepole pine	R 8	R	0	0	2	6	*as above	
	F 10	F	1	4	8	10		
Subalpine fir	R 10	R	0	0	2	6	10	10
	F 11	F	1	4	8	11	11	11
Alpine meadow	R 0	R	0	*as above				
	F 0	F	0					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 10 is equivalent to 15 units.

Life form 11. Reproduces in conifers or deciduous trees and feeds in trees, in bushes, on the ground, or in the air (24 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 1 F 14	Shrub-seedling (0-10 years) R 3 F 20	Pole-sapling (11-39 years) R 12 F 21	Young (40-79 years) R 18 F 22	Mature (80-159 years) R 23 F 23	Old growth (160 + years) R 18 F 21
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 6	F	6					
Moist meadow	R 0	R	0					
	F 6	F	6					
Other grasses	R 0	R	0					
	F 3	F	3					
Sagebrush-bitterbrush	R 1	R	1	1				
	F 1	F	1	1				
Other shrubs	R 2	R	1	2				
	F 7	F	5	7				
Curlleaf mountain-mahogany	R 1	R	1	1	1	1	1	0
	F 3	F	3	3	3	3	3	3
Western juniper	R 1	R	1	1	1	1	1	0
	F 3	F	3	3	3	3	3	3
Quaking aspen	R 8	R	1	2	4	7	8	*as above
	F 16	F	10	13	15	16	16	
Riparian (deciduous)	R 14	R	1	3	7	13	14	
	F 19	F	13	16	17	18	19	
Ponderosa pine	R 11	R	0	0	4	8	11	10
	F 19	F	11	15	18	19	19	19
Mixed conifer	R 19	R	0	1	8	14	19	19
	F 20	F	12	16	18	19	20	19
White fir (grand fir)	R 18	R	0	1	7	13	18	15
	F 19	F	11	15	17	18	19	18
Lodgepole pine	R 14	R	0	1	6	9	*as above	
	F 17	F	9	13	15	16		
Subalpine fir	R 11	R	0	1	4	7	11	10
	F 17	F	9	13	15	16	17	16
Alpine meadow	R 0	R	0	*as above				
	F 3	F	3					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 11 is equivalent to 20 units.

Life form 12. Reproduces on very thick branches and feeds on the ground or in water (7 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 0 F 7	Shrub-seedling (0-10 years) R 0 F 5	Pole-sapling (11-39 years) R 0 F 4	Young (40-79 years) R 3 F 5	Mature (80-159 years) R 6 F 6	Old growth (160 + years) R 5 F 6
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 5	F	5					
Moist meadow	R 0	R	0					
	F 7	F	7					
Other grasses	R 0	R	0					
	F 5	F	5					
Sagebrush-bitterbrush	R 0	R	0	0				
	F 4	F	4	4				
Other shrubs	R 0	R	0	0				
	F 4	F	4	4				
Curlleaf mountain-mahogany	R 0	R	0	0	0	0	0	0
	F 4	F	4	4	4	4	4	4
Western juniper	R 2	R	0	0	0	2	2	2
	F 5	F	5	5	4	4	5	5
Quaking aspen	R 3	R	0	0	0	2	3	*as above
	F 5	F	5	5	4	4	5	
Riparian (deciduous)	R 5	R	0	0	0	2	5	
	F 6	F	6	5	4	4	5	
Ponderosa pine	R 5	R	0	0	0	2	5	5
	F 5	F	5	5	4	4	5	5
Mixed conifer	R 5	R	0	0	0	2	5	5
	F 6	F	6	5	4	5	6	6
White fir (grand fir)	R 0	R	0	0	0	0	0	0
	F 4	F	4	4	3	3	4	4
Lodgepole pine	R 1	R	0	0	0	1	*as above	
	F 4	F	4	3	3	4		
Subalpine fir	R 0	R	0	0	0	0	0	0
	F 3	F	3	3	3	3	3	3
Alpine meadow	R 0	R	0	*as above				
	F 3	F	3					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 12 is equivalent to 10 units.

Life form 13. Reproduces in own hole excavated in tree and feeds in trees, in bushes, on the ground, or in the air (13 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 0 F 2	Shrub-seedling (0-10 years) R 0 F 2	Pole-sapling (11-39 years) R 0 F 1	Young (40-79 years) R 8 F 8	Mature (80-159 years) R 13 F 13	Old growth (160 + years) R 12 F 12
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 0	F	0					
Moist meadow	R 0	R	0					
	F 0	F	0					
Other grasses	R 0	R	0					
	F 0	F	0					
Sagebrush-bitterbrush	R 0	R	0	0				
	F 0	F	0	0				
Other shrubs	R 0	R	0	0				
	F 0	F	0	0				
Curlleaf mountain-mahogany	R 0	R	0	0	0	0	0	0
	F 0	F	0	0	0	0	0	0
Western juniper	R 1	R	0	0	0	1	1	1
	F 1	F	1	1	1	1	1	1
Quaking aspen	R 3	R	0	0	0	3	3	*as above
	F 4	F	1	1	1	3	4	
Riparian (deciduous)	R 4	R	0	0	0	4	4	
	F 4	F	2	2	1	4	4	
Ponderosa pine	R 8	R	0	0	0	3	8	8
	F 8	F	2	2	1	3	8	8
Mixed conifer	R 9	R	0	0	0	5	9	9
	F 10	F	2	2	1	5	10	10
White fir (grand fir)	R 6	R	0	0	0	4	6	6
	F 6	F	1	1	1	4	6	6
Lodgepole pine	R 4	R	0	0	0	4	*as above	
	F 4	F	0	0	0	4		
Subalpine fir	R 4	R	0	0	0	3	4	4
	F 4	F	0	0	0	3	4	4
Alpine meadow	R 0	R	0	*as above				
	F 0	F	0					

R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 13 is equivalent to 10 units.

Life form 14. Reproduces in a hole made by another species or in a natural hole and feeds on the ground, in water, or the air (37 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 0 F 26	Shrub-seedling (0-10 years) R 0 F 26	Pole-sapling (11-39 years) R 4 F 16	Young (40-79 years) R 16 F 17	Mature (80-159 years) R 37 F 29	Old growth (160 + years) R 37 F 32
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 13	F	13					
Moist meadow	R 0	R	0					
	F 20	F	20					
Other grasses	R 0	R	0					
	F 13	F	13					
Sagebrush-bitterbrush	R 0	R	0	0				
	F 10	F	10	10				
Other shrubs	R 0	R	0	0				
	F 15	F	12	12				
Curlleaf mountain-mahogany	R 0	R	0	0	0	0	0	0
	F 9	F	9	9	5	5	6	7
Western juniper	R 10	R	0	0	0	5	10	10
	F 17	F	16	16	10	10	14	15
Quaking aspen	R 9	R	0	0	2	8	9	*as above
	F 20	F	18	18	12	11	16	
Riparian (deciduous)	R 22	R	0	0	2	10	22	
	F 31	F	22	22	14	15	26	
Ponderosa pine	R 21	R	0	0	2	11	21	21
	F 26	F	22	22	12	13	20	23
Mixed conifer	R 23	R	0	0	3	11	23	23
	F 23	F	15	15	14	15	22	22
White fir (grand fir)	R 10	R	0	0	2	4	10	10
	F 16	F	9	9	9	10	16	16
Lodgepole pine	R 3	R	0	0	2	3	*as above	
	F 14	F	7	7	9	10		
Subalpine fir	R 6	R	0	0	1	2	6	6
	F 12	F	7	7	8	9	12	12
Alpine meadow	R 0	R	0	*as above				
	F 4	F	3					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 14 is equivalent to 35 units.

Life form 15. Reproduces in a burrow underground and feeds on the ground or under it (40 species)

Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 32 F 37	Shrub-seedling (0-10 years) R 35 F 36	Pole-sapling (11-39 years) R 25 F 27	Young (40-79 years) R 23 F 25	Mature (80-159 years) R 26 F 27	Old growth (160 + years) R 27 F 28
Dry meadow	R 9	R	9	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 12	F	12					
Moist meadow	R 16	R	16					
	F 20	F	20					
Other grasses	R 18	R	18					
	F 21	F	21					
Sagebrush-bitterbrush	R 20	R	20	20				
	F 21	F	21	21				
Other shrubs	R 18	R	16	18				
	F 19	F	18	19				
Curlleaf mountain-mahogany	R 8	R	8	8	8	8	8	8
	F 9	F	9	9	9	9	9	9
Western juniper	R 14	R	14	14	13	13	13	13
	F 15	F	15	15	14	14	14	14
Quaking aspen	R 15	R	13	15	13	12	14	*as above
	F 17	F	17	17	15	14	16	
Riparian (deciduous)	R 17	R	15	17	13	11	12	
	F 22	F	21	22	17	15	17	
Ponderosa pine	R 14	R	13	14	13	12	13	13
	F 17	F	17	17	16	15	16	16
Mixed conifer	R 17	R	12	15	13	13	15	15
	F 19	F	17	17	16	16	17	17
White fir (grand fir)	R 13	R	9	11	10	11	13	13
	F 16	F	14	14	14	15	16	16
Lodgepole pine	R 9	R	6	7	8	9	*as above	
	F 12	F	10	10	11	12		
Subalpine fir	R 14	R	10	12	11	12	13	14
	F 15	F	13	13	12	13	14	15
Alpine meadow	R 10	R	10	*as above				
	F 14	F	14					

[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 15 is equivalent to 25 units.

Life form 16. Reproduces in a burrow underground and feeds in the air or in water (10 species)

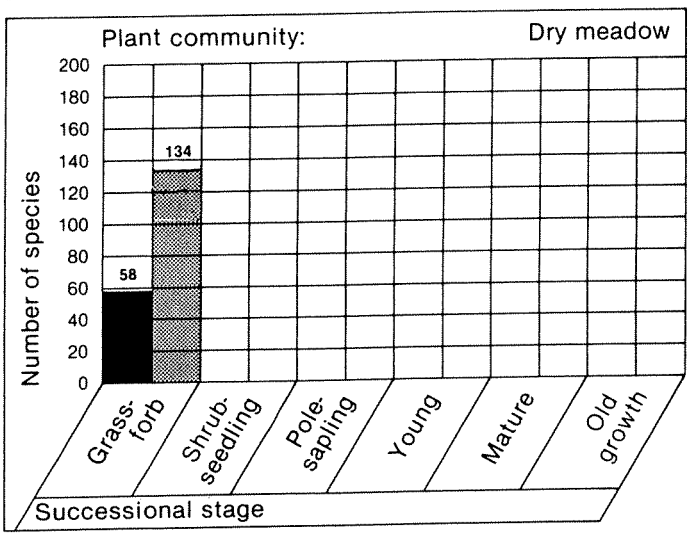
Plant community[1]		Function[1]	Successional stage[1]					
			Grass-forb R 10 F 10	Shrub-seedling (0-10 years) R 7 F 10	Pole-sapling (11-39 years) R 7 F 8	Young (40-79 years) R 7 F 8	Mature (80-159 years) R 7 F 8	Old growth (160 + years) R 6 F 7
Dry meadow	R 0	R	0	These plant communities do not achieve a habitat form like that characterized by these successional stages.*				
	F 3	F	3					
Moist meadow	R 2	R	2					
	F 6	F	6					
Other grasses	R 0	R	0					
	F 3	F	3					
Sagebrush-bitterbrush	R 3	R	3	3				
	F 5	F	5	5				
Other shrubs	R 4	R	4	4				
	F 7	F	7	7				
Curlleaf mountain-mahogany	R 0	R	0	0	0	0	0	0
	F 1	F	1	1	1	1	1	1
Western juniper	R 1	R	1	1	1	1	1	1
	F 2	F	2	2	2	2	2	2
Quaking aspen	R 3	R	3	3	3	3	3	*as above
	F 5	F	5	5	5	5	5	
Riparian (deciduous)	R 10	R	10	7	7	7	7	
	F 10	F	10	10	8	8	8	
Ponderosa pine	R 3	R	3	3	3	3	3	3
	F 5	F	5	5	5	5	5	5
Mixed conifer	R 3	R	3	3	3	3	3	3
	F 5	F	5	5	5	5	5	5
White fir (grand fir)	R 3	R	3	3	3	3	3	3
	F 4	F	4	4	4	4	4	4
Lodgepole pine	R 3	R	3	3	3	3	*as above	
	F 4	F	4	4	4	4		
Subalpine fir	R 3	R	3	3	3	3	3	3
	F 3	F	3	3	3	3	3	3
Alpine meadow	R 2	R	2	*as above				
	F 2	F	2					

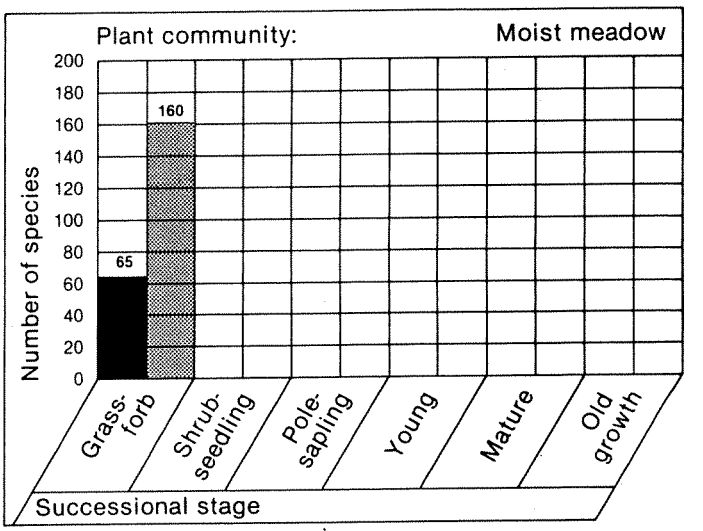
[1]R (reproduction) and F (feeding) refer to total species performing either function in the respective plant communities and successional stages. Vertical scale of each species-total box in life form 16 is equivalent to 10 units.

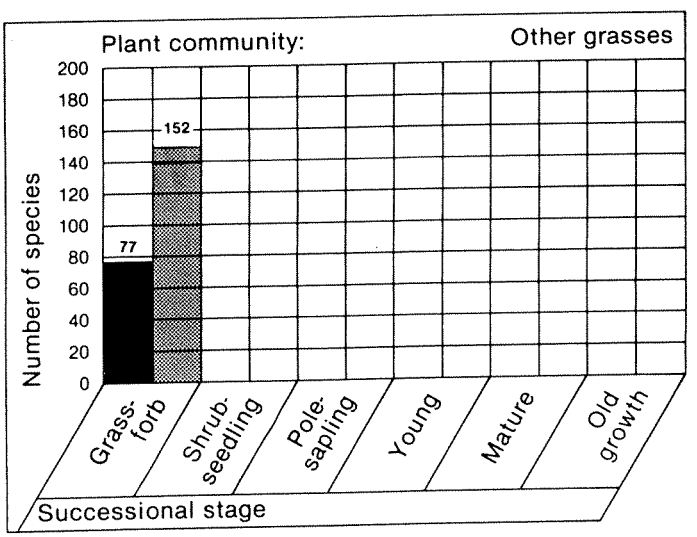
Appendix 11

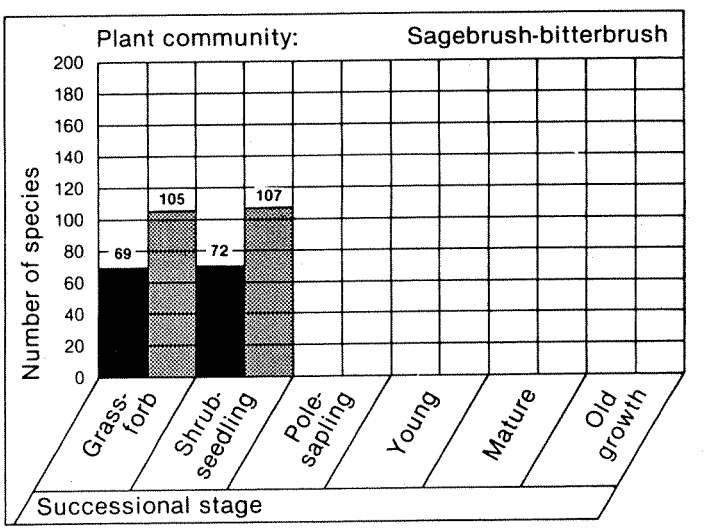
Summary of wildlife species associated with each successional stage by plant community

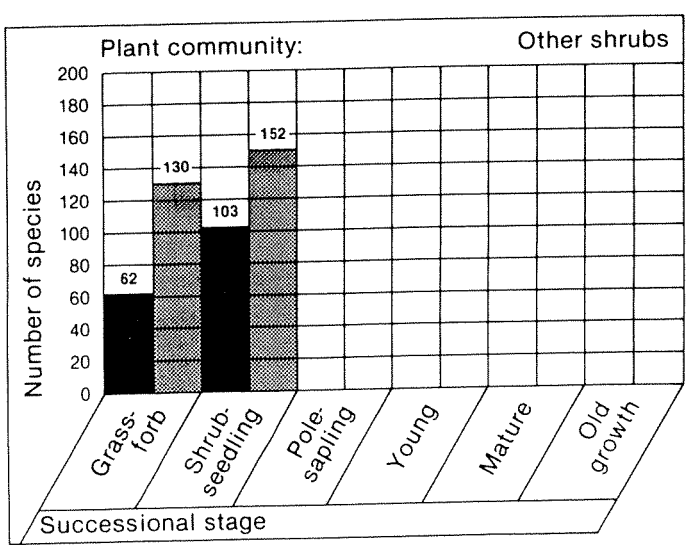
Reproduction Feeding

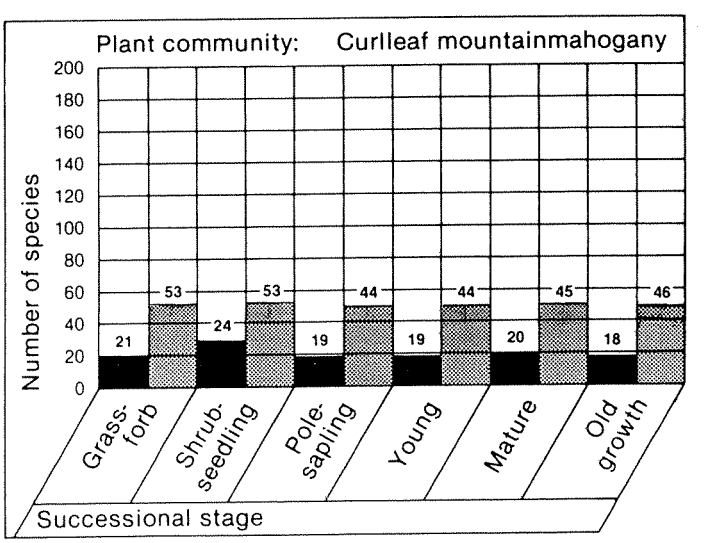




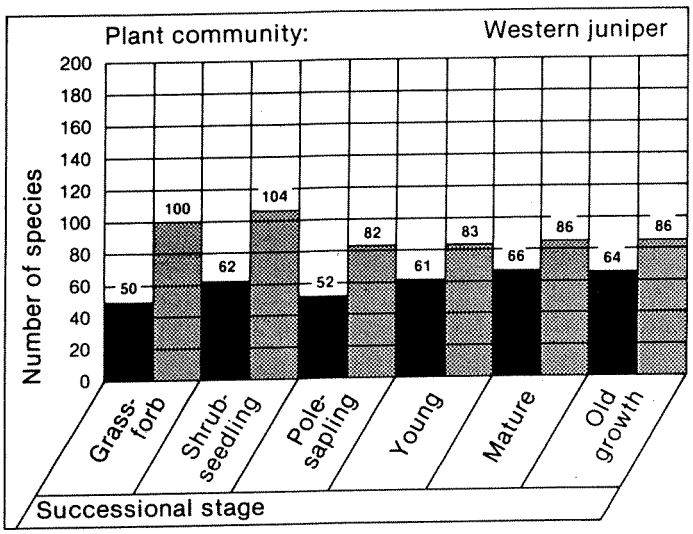


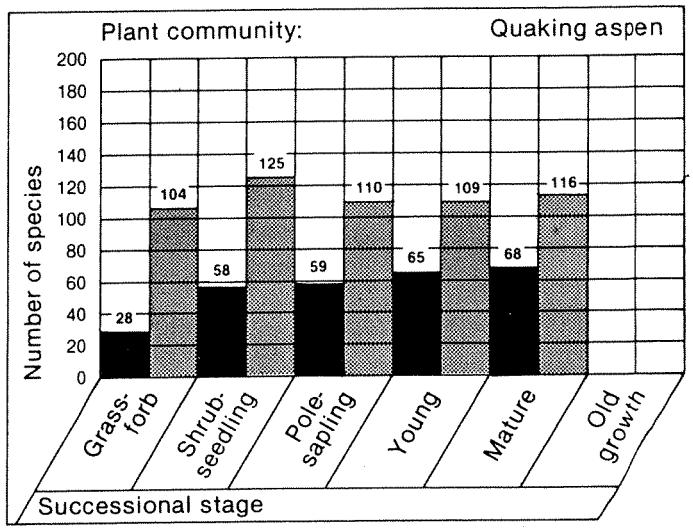


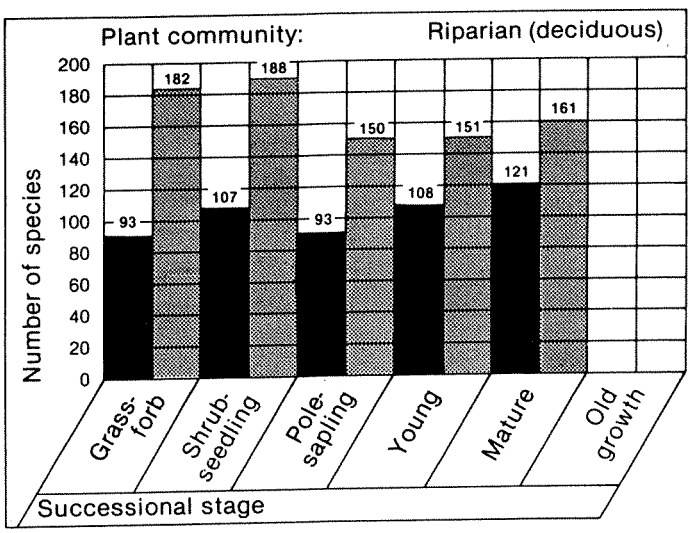


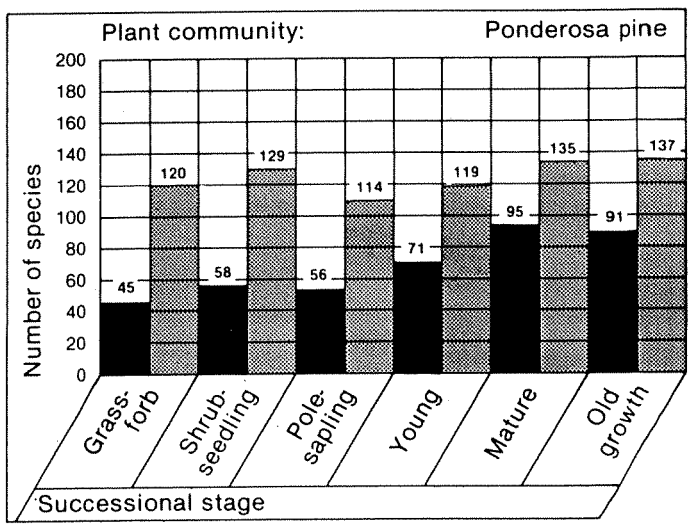


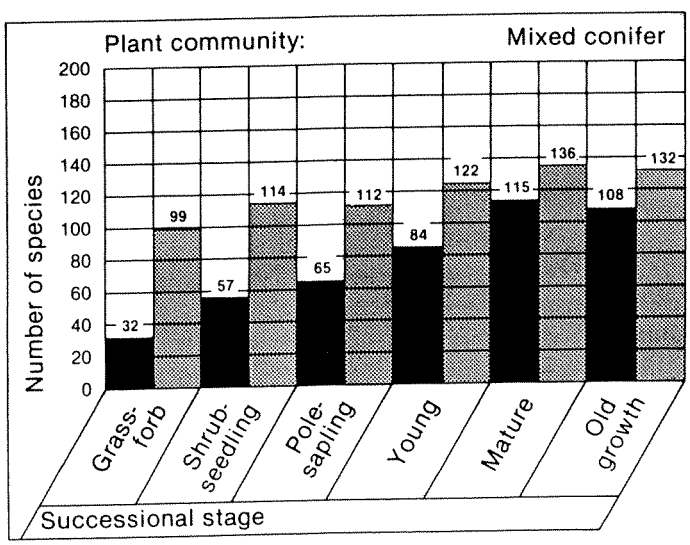
Reproduction Feeding

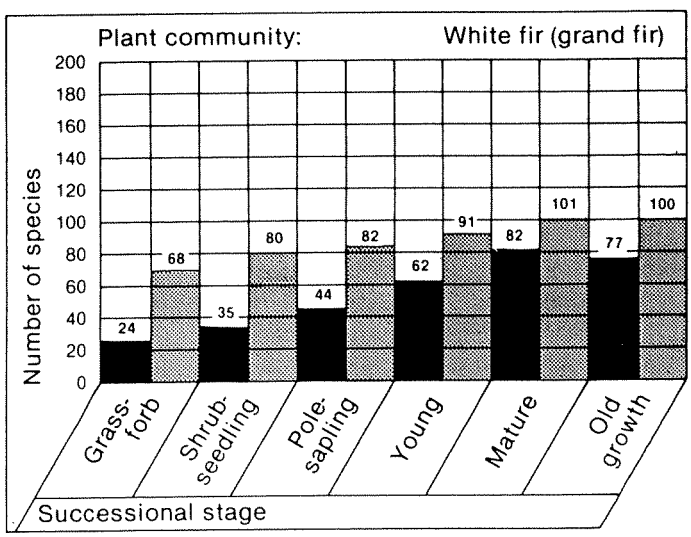


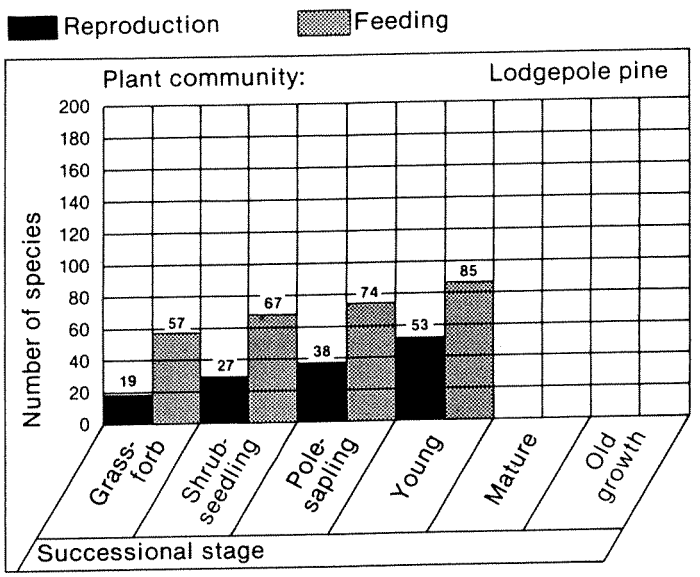


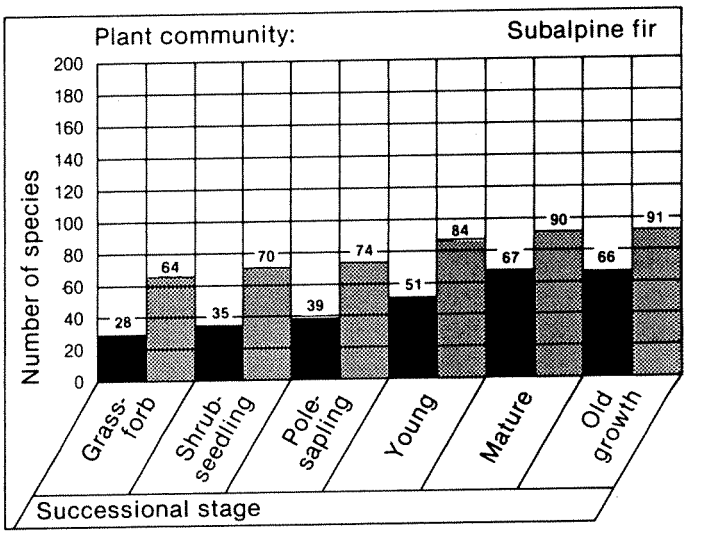


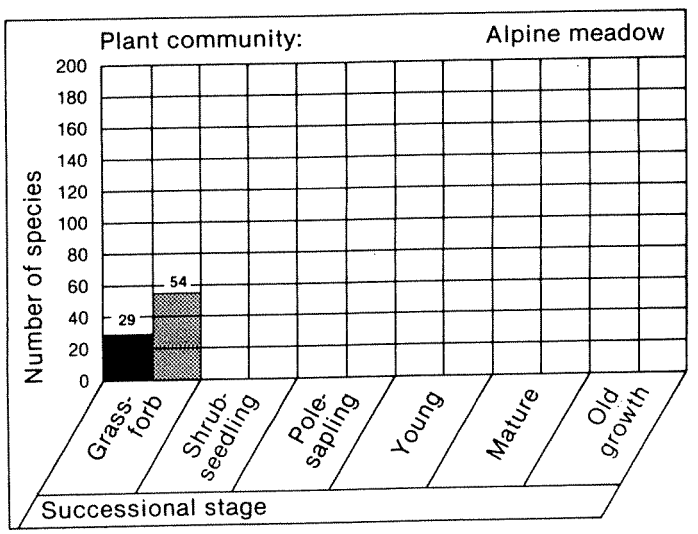







Reproduction
Feeding
Plant community:
Lodgepole pine
Number of species
200
180
160
140
120
100
80
60
40
20
0
19
57
27
67
38
74
53
85
Grass-forb
Shrub-seedling
Pole-sapling
Young
Mature
Old growth
Successional stage


Plant community:
Subalpine fir
Number of species
200
180
160
140
120
100
80
60
40
20
0
28
64
35
70
39
74
51
84
67
90
66
91
Grass-forb
Shrub-seedling
Pole-sapling
Young
Mature
Old growth
Successional stage

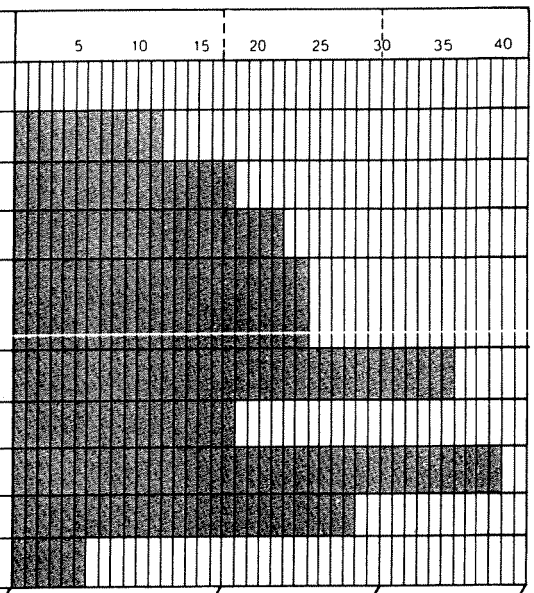

Plant community:
Alpine meadow
Number of species
200
180
160
140
120
100
80
60
40
20
0
29
54
Grass-forb
Shrub-seedling
Pole-sapling
Young
Mature
Old growth
Successional stage

Appendix 12

Versatility ratings of 326 wildlife species

Life form 2. Reproduces in water and feeds on the ground, in bushes, and/or in trees (9 species)

Letter code	Species	1	2	3	4	5	6	7
	AMPHIBIANS							
AMTI	tiger salamander	5	1	6	5	1	6	12
AMMA	long-toed salamander	7	2	9	7	2	9	18
ASTR	tailed frog[1]	6	5	11	6	5	11	22
SCIN	Great Basin spadefoot toad	6	6	12	6	6	12	24
BUBO	western toad	12	6	18	12	6	18	36
BUWO	Woodhouse toad	7	2	9	7	2	9	18
HYRE	Pacific treefrog	14	6	20	14	6	20	40
RAPR	spotted frog[1]	8	6	14	8	6	14	28
RAPI	leopard frog	2	1	3	2	1	3	6



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

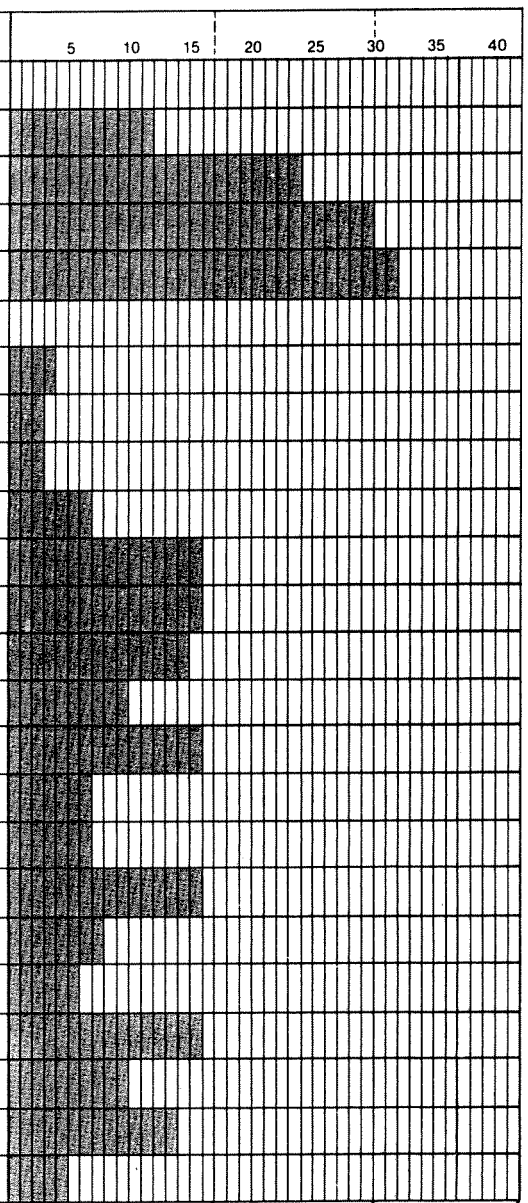
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 3. Reproduces on the ground around water (or in emergent vegetation, or on floating vegetation[2]) and feeds on the ground, and in bushes, trees, and water (45 species)

Letter code	Species	1	2	3	4	5	6	7
	REPTILES							
CHPI	painted turtle	1	5	6	1	5	6	12
EUSK	western skink	7	5	12	7	5	12	24
DIPU	ringneck snake	9	6	15	9	6	15	30
THSI	common garter snake	10	6	16	10	6	16	32
	BIRDS							
PONI	eared grebe	1	1	2	1	1	2	4
POPO	pied-billed grebe	1	1	2	0	1	1	3
PHAU	double-crested cormorant[1]	1	1	2	0	1	1	3
BOLE	American bittern[1]	1	2	3	2	2	4	7
BRCA	Canada goose[1]	2	5	7	4	5	9	16
ANPL	mallard	2	5	7	4	5	9	16
ANST	gadwall	2	5	7	3	5	8	15
ANAC	pintail	2	2	4	4	2	6	10
ANCR	green-winged teal	2	5	7	4	5	9	16
ANDI	blue-winged teal	2	1	3	3	1	4	7
ANCY	cinnamon teal	2	1	3	3	1	4	7
ANAM	American wigeon	2	5	7	4	5	9	16
ANCL	northern shoveler	2	1	3	4	1	5	8
AYAM	redhead	2	1	3	2	1	3	6
AYCO	ring-necked duck[1]	2	5	7	4	5	9	16
AYAF	lesser scaup[1]	2	2	4	4	2	6	10
HIHI	harlequin duck[1]	4	3	7	1	6	7	14
OXJA	ruddy duck	1	1	2	2	1	3	5



Letter code

1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation

Feeding orientation

Versatility rating (mean scale)

Low 1-16

Medium 17-29

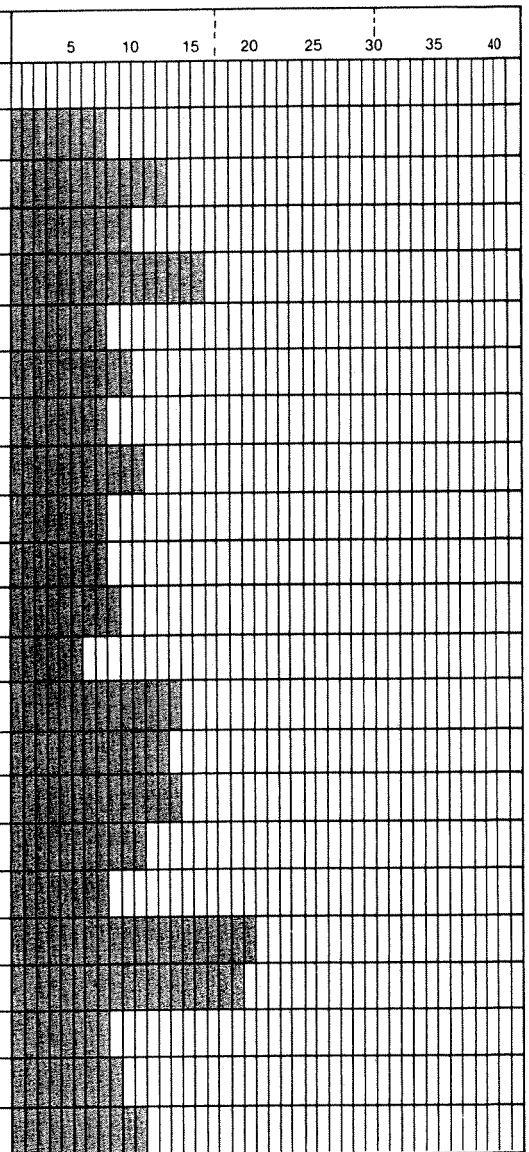
High 30-42

[1]Species of special interest; see appendix 4.

[2]See end of life form 3 for footnote.

Life form 3. Continued

	Species	1	2	3	4	5	6	7
	BIRDS							
GRCA	sandhill crane[1]	1	1	2	4	2	6	8
RALI	Virginia rail[1]	1	5	6	2	5	7	13
POCA	sora	1	4	5	1	4	5	10
FUAM	American coot	2	4	6	5	5	10	16
CHAL	snowy plover[1]	1	1	2	5	1	6	8
CHVO	killdeer	4	1	5	4	1	5	10
CAGA	common snipe	3	1	4	3	1	4	8
NUAM	long-billed curlew[1]	2	2	4	5	2	7	11
ACMA	spotted sandpiper	3	1	4	3	1	4	8
CASE	willet[1]	2	1	3	4	1	5	8
REAM	American avocet	3	1	4	4	1	5	9
STTR	Wilson's phalarope	2	1	3	2	1	3	6
LACA	California gull	4	2	6	6	2	8	14
LADE	ring-billed gull	3	2	5	6	2	8	13
LAPI	Franklin's gull[1]	4	2	6	6	2	8	14
STFO	Forster's tern	4	2	6	3	2	5	11
CHNI	black tern	3	1	4	3	1	4	8
CIME	dipper	4	6	10	4	6	10	20
TRTR	winter wren	4	5	9	5	5	10	19
TEPA	long-billed marsh wren	2	2	4	2	2	4	8
SENO	northern waterthrush[1]	1	2	3	4	2	6	9
GETR	common yellowthroat[1]	3	2	5	4	2	6	11



Letter code

1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

[2]See end of life form 3 for footnote.

Letter code	Species	1	2	3	4	5	6	7
	MAMMALS							
ZAPR	western jumping mouse	9	4	13	9	4	13	26

Columns: 1 = No. of plant communities used; 2 = No. of successional stages used; 3 = Columns 1 + 2; 4 = No. of plant communities used; 5 = No. of successional stages used; 6 = Columns 4 + 5; 7 = Versatility score: columns 3 + 6

Reproductive orientation: 1, 2, 3; Feeding orientation: 4, 5, 6; Versatility rating (mean scale): 7

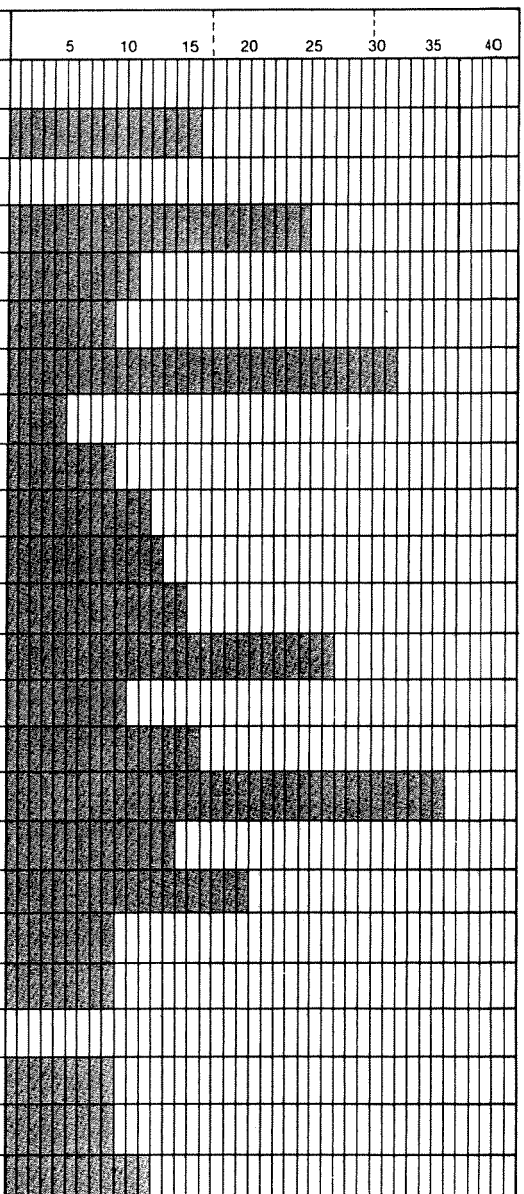
Versatility rating (mean scale): 5, 10, 15, 20, 25, 30, 35, 40

Low 1-16; Medium 17-29; High 30-42

[2]A number of species in this life form are specifically oriented to water in emergent vegetation or on floating vegetation, for reproduction and/or feeding purposes; but from a management standpoint (i.e., potential for managed impacts), they fit this category.

Life form 4. Reproduces in cliffs, caves, rimrock, and/or talus and feeds on the ground or in the air (32 species)

Letter code	Species	1	2	3	4	5	6	7
	REPTILES							
UTST	side-blotched lizard	6	2	8	6	2	8	16
	BIRDS							
CAAU	turkey vulture[1]	4	3	7	15	3	18	25
BURE	ferruginous hawk[1]	4	1	5	5	1	6	11
FAME	prairie falcon[1]	2	1	3	5	1	6	9
FAPE	peregrine[1]	5	6	11	15	6	21	32
LALE	white-tailed ptarmigan[1]	1	1	2	2	1	3	5
ALCH	chukar	2	2	4	3	2	5	9
COLI	rock dove	3	1	4	7	1	8	12
CYNI	black swift	3	1	4	7	2	9	13
AESA	white-throated swift	2	1	3	10	2	12	15
SASA	Say's phoebe	6	6	12	9	6	15	27
HIRU	barn swallow	3	1	4	5	1	6	10
PEPY	cliff swallow[1]	4	1	5	5	6	11	16
COCOR	common raven	15	3	18	15	3	18	36
CAMEX	canyon wren	5	2	7	5	2	7	14
SAOB	rock wren	8	2	10	8	2	10	20
LETE	gray-crowned rosy finch[1]	2	1	3	5	1	6	9
LEAT	black rosy finch[1]	2	1	3	5	1	6	9
	MAMMALS							
MYLE	small-footed myotis[1]	3	1	4	3	2	5	9
PIHE	western pipistrelle[1]	3	1	4	3	2	5	9
EUMA	spotted bat[1]	1	2	3	7	2	9	12

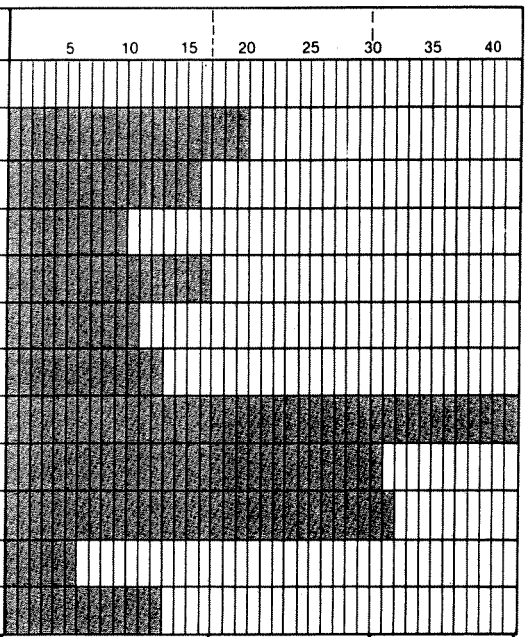


1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
Reproductive orientation
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
Feeding orientation
7 Versatility score: columns 3 + 6
Versatility rating (mean scale)
Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 4. Continued

Letter code	Species	1	2	3	4	5	6	7
	MAMMALS							
PLTO	western big-eared bat	6	2	8	6	6	12	20
ANPA	pallid bat[1]	5	2	7	6	3	9	16
OCPR	pika	3	1	4	5	1	6	10
MAFL	yellow-bellied marmot	6	2	8	7	2	9	17
PECR	canyon mouse	4	1	5	4	2	6	11
PETR	pinyon mouse[1]	5	1	6	5	2	7	13
NECI	bushy-tailed woodrat	15	6	21	15	6	21	42
FECO	puma[1]	5	5	10	15	6	21	31
LYRU	bobcat	6	5	11	15	6	21	32
ORAM	mountain goat[1]	2	1	3	2	1	3	6
OVCA	big-horned sheep[1]	2	1	3	4	6	10	13



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

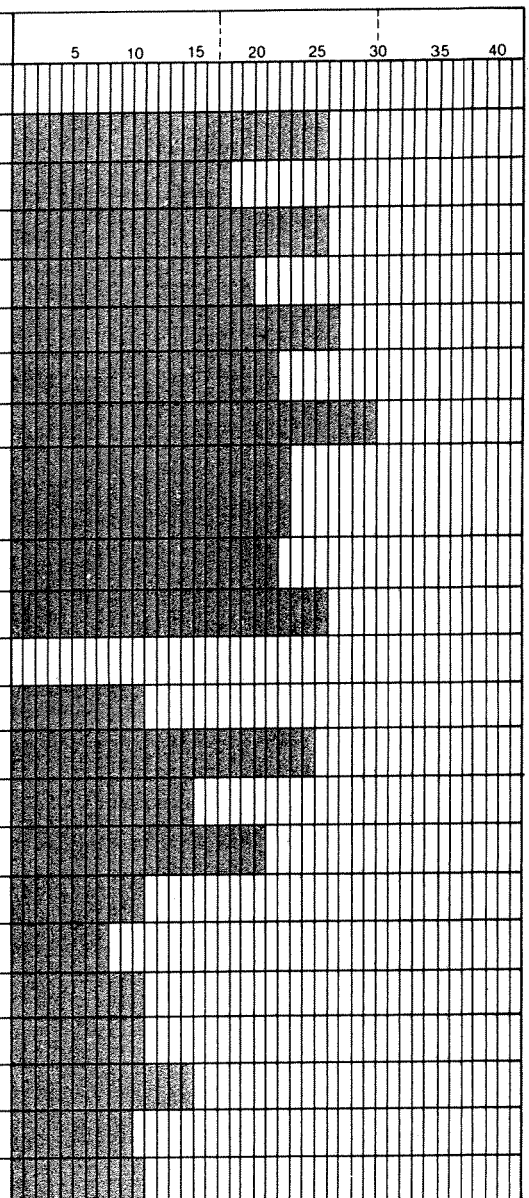
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 5. Reproduces on the ground without specific water, cliff, rimrock, or talus association and feeds on the ground (48 species)

Letter code	Species	1	2	3	4	5	6	7
	REPTILES							
SCOC	western fence lizard	7	6	13	7	6	13	26
SCGR	sagebrush lizard	3	6	9	3	6	9	18
PHDO	short-horned lizard[1]	7	6	13	7	6	13	26
CNTI	western whiptail[1]	4	6	10	4	6	10	20
COCO	yellow-bellied racer	6	6	12	9	6	15	27
MATA	striped whipsnake	5	6	11	5	6	11	22
PIME	gopher snake	9	6	15	9	6	15	30
THEL	western terrestrial garter snake	5	6	11	6	6	12	23
HYTO	night snake[1]	3	6	9	7	6	13	22
CRVI	western rattlesnake[1]	4	6	10	10	6	16	26
	BIRDS							
CICY	marsh hawk[1]	3	2	5	4	2	6	11
DEOB	blue grouse	4	2	6	13	6	19	25
CACA	Franklin's grouse[1]	3	3	6	4	5	9	15
BOUM	ruffed grouse	5	4	9	8	4	12	21
PEPH	sharp-tailed grouse[1]	3	2	5	4	2	6	11
CEUR	sage grouse[1]	1	1	2	4	2	6	8
COVI	bobwhite	2	3	5	2	4	6	11
LOCA	California quail	2	3	5	2	4	6	11
ORPI	mountain quail[1]	3	3	6	3	6	9	15
PEPE	gray partridge	4	1	5	4	1	5	10
PHCO	ring-necked pheasant	2	2	4	2	5	7	11



Letter code

1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation

Feeding orientation

Versatility rating (mean scale)

Low 1-16

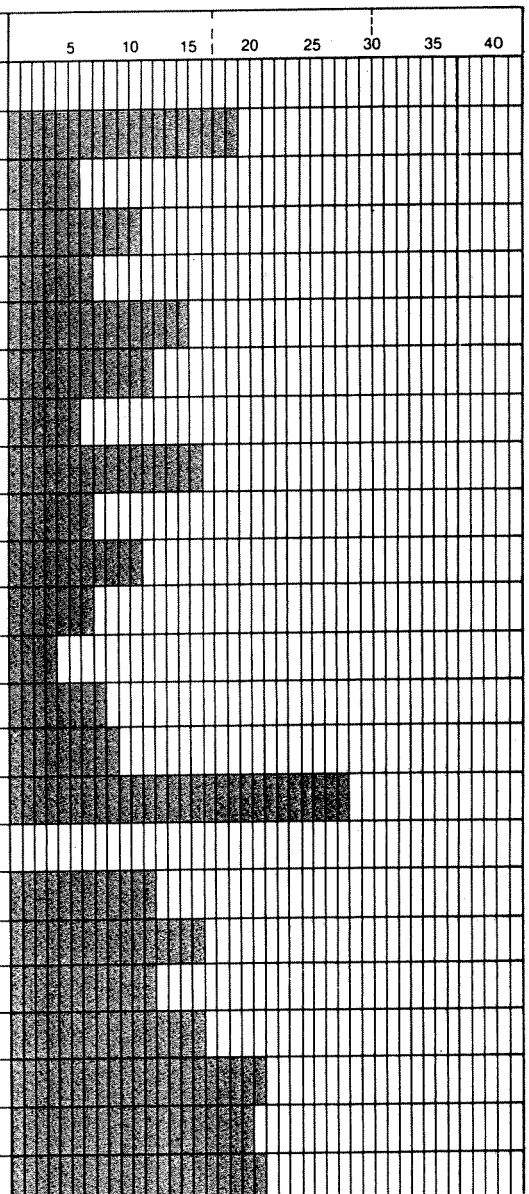
Medium 17-29

High 30-42

[1]Species of special interest; see appendix 4.

Life form 5. Continued

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
MEGA	turkey	4	3	7	8	4	12	19
BALO	upland sandpiper[1]	1	1	2	3	1	4	6
ASFL	short-eared owl[1]	2	1	3	6	2	8	11
ERAL	horned lark	2	1	3	3	1	4	7
CAGU	hermit thrush[1]	4	2	6	5	4	9	15
CAFU	veery[1]	3	3	6	3	3	6	12
ANSP	water pipit[1]	1	1	2	3	1	4	6
WIPU	Wilson's warbler	4	4	8	4	4	8	16
DOOR	bobolink[1]	2	1	3	2	2	4	7
STNEG	western meadowlark[1]	4	1	5	4	2	6	11
PASA	savannah sparrow	2	1	3	2	2	4	7
AMSA	grasshopper sparrow[1]	1	1	2	1	1	2	4
POGRA	vesper sparrow[1]	3	1	4	3	1	4	8
CHGR	lark sparrow	1	1	2	5	2	7	9
JUHY	dark-eyed junco[1]	8	6	14	8	6	14	28
	MAMMALS							
DIMA	opossum[1]	1	5	6	1	5	6	12
LEAM	snowshoe hare	4	4	8	4	4	8	16
LETO	whitetail jackrabbit[1]	4	2	6	4	2	6	12
LECA	blacktail jackrabbit	5	2	7	7	2	9	16
GUGU	wolverine[1]	2	5	7	8	6	14	21
FECA	feral house cat	5	5	10	5	5	10	20
LYCA	lynx[1]	5	5	10	5	6	11	21



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

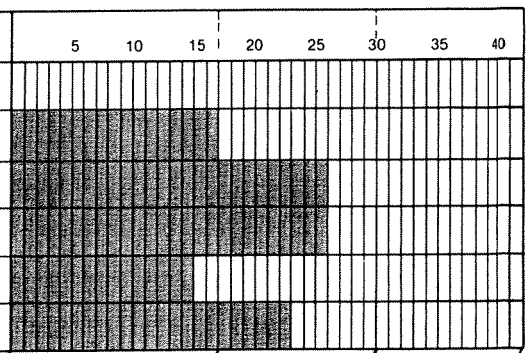
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 5. Continued

Species		1	2	3	4	5	6	7
MAMMALS								
EQCA	feral horse	4	3	7	4	6	10	17
CEEL	elk	4	2	6	14	6	20	26
ODHE	mule deer	3	2	5	15	6	21	26
ODVI	white-tailed deer[1]	4	2	6	6	3	9	15
ANAME	pronghorn	5	6	11	6	6	12	23



Letter code

1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation

Feeding orientation

Versatility rating (mean scale)

Low 1-16

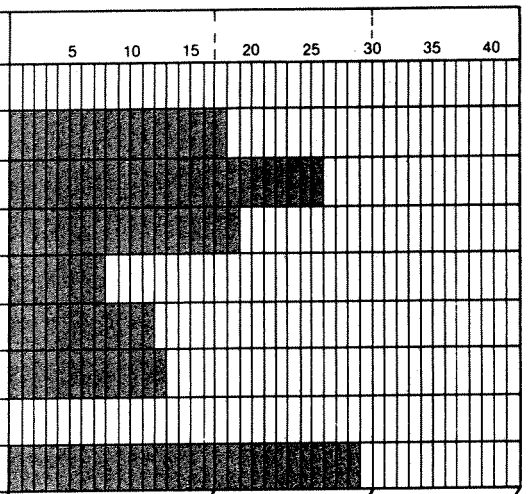
Medium 17-29

High 30-42

[1]Species of special interest; see appendix 4.

Life form 6. Reproduces on the ground and feeds in bushes, trees, or the air (7 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
PHNU	poorwill[1]	2	2	4	8	6	14	18
CHMI	common nighthawk[1]	6	4	10	10	6	16	26
MYTO	Townsend's solitaire	3	6	9	4	6	10	19
VECE	orange-crowned warbler[1]	2	1	3	2	3	5	8
VERU	Nashville warbler	4	1	5	4	3	7	12
MELI	Lincoln's sparrow	3	2	5	3	5	8	13
	MAMMALS							
ERDO	porcupine	7	4	11	13	5	18	29



Low 1-16

Medium 17-29

High 30-42

1 No. of plant communities used

2 No. of successional stages used

3 Columns 1 + 2

4 No. of plant communities used

5 No. of successional stages used

6 Columns 4 + 5

7 Versatility score: columns 3 + 6

Reproductive orientation

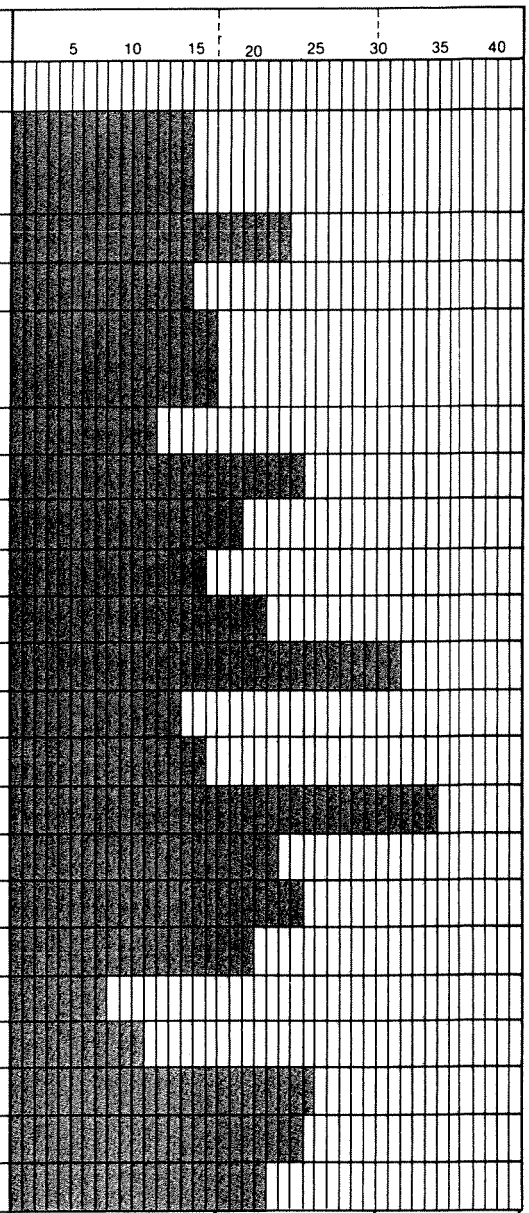
Feeding orientation

Versatility rating (mean scale)

Species of special interest; see appendix 4.

Life form 7. Reproduces in bushes and feeds on the ground, in water, or the air (30 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
NYNY	black-crowned night heron[1]	3	5	8	4	3	7	15
BUSW	Swainson's hawk[1]	5	6	11	6	6	12	23
TRSO	solitary sandpiper[1]	3	3	6	6	3	9	15
ARAL	black-chinned hummingbird	4	2	6	5	6	11	17
SEPL	broad-tailed hummingbird	3	2	5	4	3	7	12
STCA	calliope hummingbird	5	2	7	11	6	17	24
TYTY	eastern kingbird	4	5	9	5	5	10	19
EMTR	willow flycatcher	3	2	5	8	3	11	16
EMWR	gray flycatcher	2	5	7	8	6	14	21
PIPI	black-billed magpie	6	5	11	15	6	21	32
DUCA	gray catbird[1]	3	4	7	3	4	7	14
ORMO	sage thrasher	1	5	6	5	5	10	16
TUMI	American robin	10	5	15	14	6	20	35
CAUS	Swainson's thrush	6	5	11	6	5	11	22
LALU	loggerhead shrike[1]	3	5	8	10	6	16	24
OPTO	MacGillivray's warbler[1]	6	4	10	6	4	10	20
XAXA	yellow-headed blackbird	1	1	2	5	1	6	8
AGPH	red-winged blackbird	2	2	4	5	2	7	11
EUCY	Brewer's blackbird	5	5	10	9	6	15	25
MOAT	brown-headed cowbird	6	5	11	7	6	13	24
PAAMO	lazuli bunting[1]	5	5	10	5	6	11	21



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

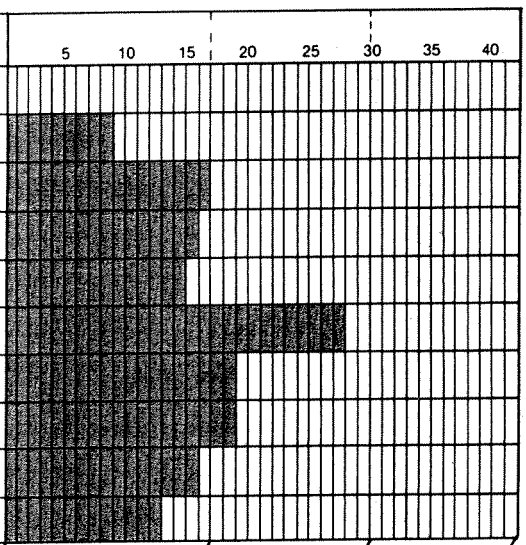
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 7. Continued

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
SPPS	lesser goldfinch[1]	2	1	3	4	2	6	9
CHCH	green-tailed towhee	2	5	7	4	6	10	17
PIER	rufous-sided towhee	3	5	8	3	5	8	16
AMBE	sage sparrow	2	5	7	3	5	8	15
SPPA	chipping sparrow	7	5	12	10	6	16	28
SPBR	Brewer's sparrow	3	5	8	5	6	11	19
ZOLE	white-crowned sparrow	2	6	8	5	6	11	19
PAIL	fox sparrow[1]	3	5	8	3	5	8	16
MEMEL	song sparrow	2	4	6	3	4	7	13



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

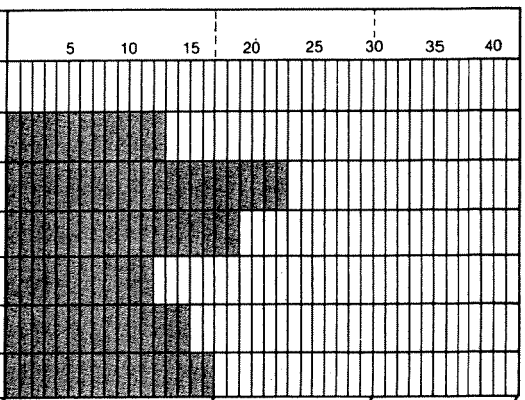
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 8. Reproduces in bushes and feeds in trees, bushes, or the air (6 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
COAM	yellow-billed cuckoo[1]	2	4	6	3	4	7	13
EMOB	dusky flycatcher	5	5	10	7	6	13	23
PSMI	bushtit	3	5	8	6	5	11	19
DEPE	yellow warbler[1]	2	4	6	2	4	6	12
ICVI	yellow-breasted chat[1]	2	4	6	4	5	9	15
SPTR	American goldfinch	3	4	7	5	5	10	17



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

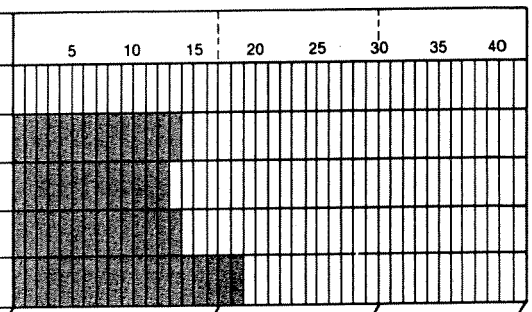
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 9. Reproduces primarily in deciduous trees and feeds in trees, bushes, or the air (4 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
BOCE	cedar waxwing	3	4	7	3	4	7	14
SERUT	American redstart[1]	2	4	6	2	5	7	13
ICGA	northern oriole	2	4	6	4	4	8	14
CAMEXI	house finch	4	4	8	5	6	11	19



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

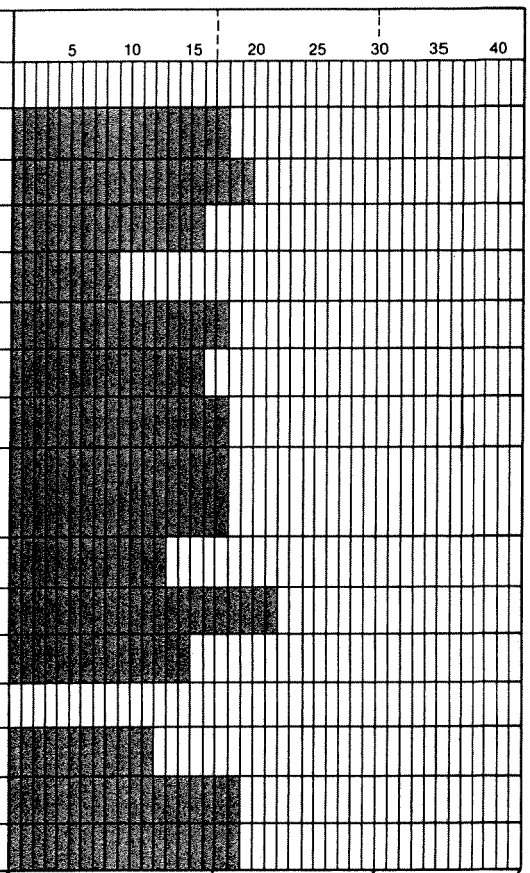
Reproductive orientation: 1, 2, 3
Feeding orientation: 4, 5, 6

Versatility rating (mean scale): Low 1-16; Medium 17-29; High 30-42

[1]Species of special interest; see appendix 4.

Life form 10. Reproduces primarily in conifers and feeds in trees, bushes, or the air (14 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
EMDI	western flycatcher	5	3	8	5	5	10	18
NUBO	olive-sided flycatcher	3	4	7	7	6	13	20
GYCY	pinyon jay	1	4	5	6	5	11	16
NUCO	Clark's nutcracker	1	2	3	3	3	6	9
RESA	golden-crowned kinglet	4	3	7	6	5	11	18
RECA	ruby-crowned kinglet	4	2	6	6	4	10	16
DECO	yellow-rumped warbler[1]	4	3	7	7	4	11	18
DENI	black-throated gray warbler[1]	4	5	9	4	5	9	18
DETO	Townsend's warbler	3	2	5	5	3	8	13
PILU	western tanager	7	3	10	7	5	12	22
LOCUR	red crossbill	5	2	7	5	3	8	15
	MAMMALS							
SCGRI	western gray squirrel[1]	2	3	5	3	4	7	12
TAHU	red squirrel	5	4	9	6	4	10	19
TADO	chickaree	5	4	9	6	4	10	19



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

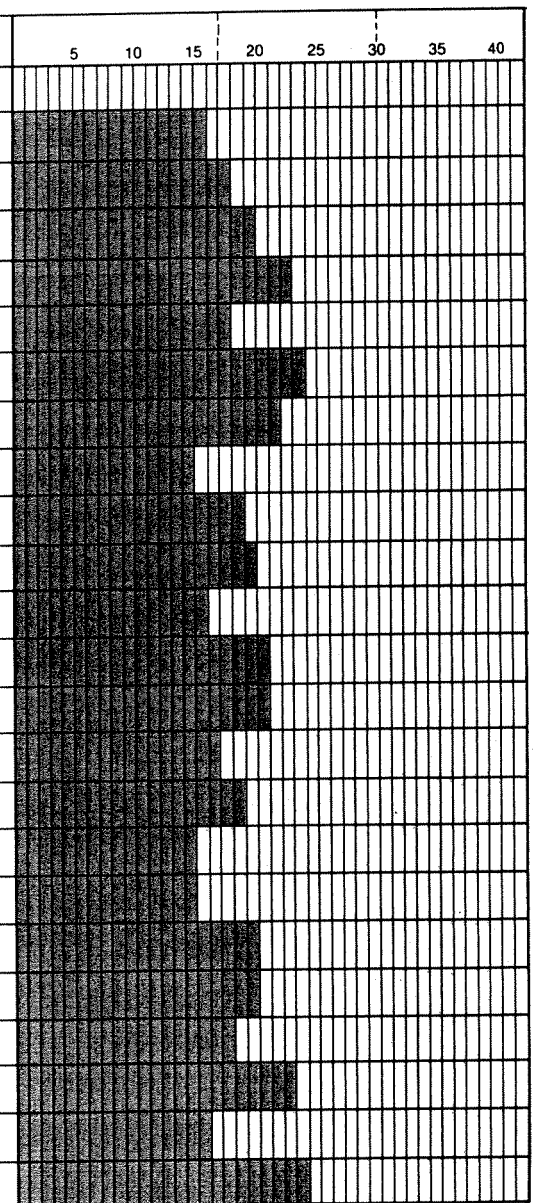
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 11. Reproduces in conifers or deciduous trees and feeds in trees, in bushes, on the ground, or in the air (24 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
ACGE	goshawk	3	2	5	7	4	11	16
ACST	sharp-shinned hawk[1]	3	3	6	7	5	12	18
ACCO	Cooper's hawk[1]	4	2	6	8	6	14	20
FACO	merlin[1]	4	2	6	11	6	17	23
ZEMA	mourning dove	6	5	11	5	2	7	18
ASOT	long-eared owl	6	3	9	9	6	15	24
SERU	rufous hummingbird	5	5	10	9	3	12	22
TYVE	western kingbird	3	4	7	3	5	8	15
EMHA	Hammond's flycatcher	6	2	8	6	5	11	19
COSO	western wood pewee	6	3	9	6	5	11	20
PECA	gray jay	4	3	7	4	5	9	16
CYST	Steller's jay	4	4	8	7	6	13	21
COBR	common crow	4	3	7	8	6	14	21
IXNA	varied thrush	4	4	8	4	5	9	17
VISO	solitary vireo	4	4	8	7	4	11	19
VIOL	red-eyed vireo[1]	2	4	6	4	5	9	15
VIGI	warbling vireo[1]	2	4	6	4	5	9	15
PHME	black-headed grosbeak	5	3	8	7	5	12	20
HEVE	evening grosbeak	6	2	8	7	5	12	20
CAPU	purple finch	3	4	7	5	6	11	18
CACAS	Cassin's finch	6	3	9	8	6	14	23
PIEN	pine grosbeak[1]	5	2	7	5	4	9	16
SPPI	pine siskin	5	4	9	9	6	15	24



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 11. Continued

	Species	1	2	3	4	5	6	7
	MAMMALS							
LACI	hoary bat[1]	0	0	0	9	6	15	15

Letter code

1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

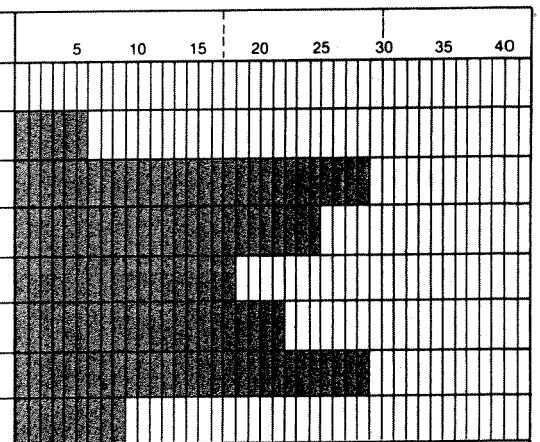
5 10 15 20 25 30 35 40

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 12. Reproduces on very thick branches and feeds on the ground or in water (7 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
ARHE	great blue heron	2	1	3	2	1	3	6
BUJA	red-tailed hawk[1]	5	3	8	15	6	21	29
AQCH	golden eagle[1]	2	2	4	15	6	21	25
HALE	bald eagle[1]	3	2	5	9	4	13	18
PAHA	osprey[1]	3	2	5	11	6	17	22
BUVI	great horned owl	5	3	8	15	6	21	29
STNE	great gray owl[1]	1	1	2	3	4	7	9



Low 1-16

Medium 17-29

High 30-42

1 No. of plant communities used

2 No. of successional stages used

3 Columns 1 + 2

4 No. of plant communities used

5 No. of successional stages used

6 Columns 4 + 5

7 Versatility score: columns 3 + 6

Reproductive orientation

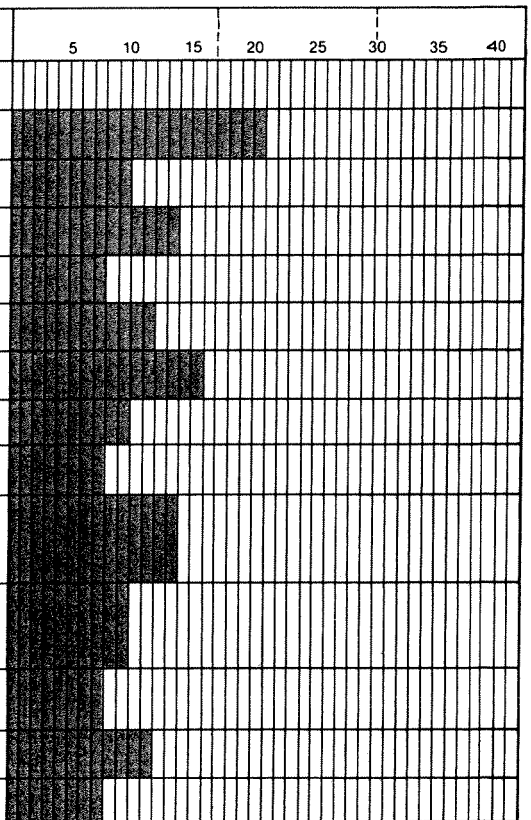
Feeding orientation

Versatility rating (mean scale)

[1]Species of special interest; see appendix 4.

Life form 13. Reproduces in own hole excavated in tree and feeds in trees, in bushes, on the ground, or in the air (13 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
COAU	common flicker	6	3	9	6	6	12	21
DRPI	pileated woodpecker	3	2	5	3	2	5	10
ASLE	Lewis' woodpecker[1]	3	3	6	3	5	8	14
SPVA	yellow-bellied sapsucker	2	2	4	2	2	4	8
SPTH	Williamson's sapsucker	4	2	6	4	2	6	12
DEVI	hairy woodpecker[1]	5	3	8	5	3	8	16
DEPU	downy woodpecker	2	3	5	2	3	5	10
DEAL	white-headed woodpecker	2	2	4	2	2	4	8
PIAR	black-backed three-toed woodpecker	4	3	7	4	3	7	14
PITR	northern three-toed woodpecker[1]	2	3	5	2	3	5	10
SICA	white-breasted nuthatch	2	2	4	2	2	4	8
SICAN	red-breasted nuthatch[1]	3	3	6	3	3	6	12
SIPY	pygmy nuthatch	1	2	3	3	2	5	8



Letter code

1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation

Feeding orientation

Versatility rating (mean scale)

Low 1-16

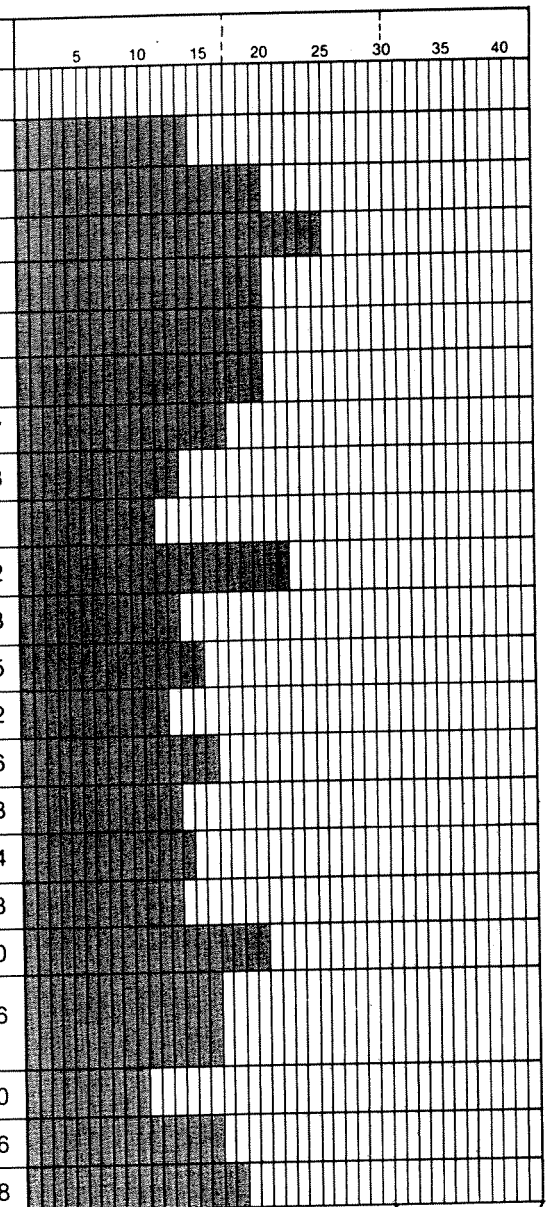
Medium 17-29

High 30-42

[1]Species of special interest; see appendix 4.

Life form 14. Reproduces in a hole made by another species or in a natural hole and feeds on the ground, in water, or the air (37 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
AISP	wood duck	1	2	3	5	6	11	14
BUIS	Barrow's goldeneye[1]	1	2	3	11	6	17	20
BUAL	bufflehead[1]	2	2	4	15	6	21	25
LOCU	hooded merganser	1	2	3	11	6	17	20
MEME	common merganser	2	2	4	10	6	16	20
FASP	American kestrel[1]	5	3	8	9	3	12	20
TYAL	barn owl[1]	4	2	6	7	4	11	17
OTAS	screech owl[1]	2	3	5	4	4	8	13
OTFL	flammulated owl[1]	2	3	5	2	4	6	11
GLGN	pygmy owl	5	3	8	8	6	14	22
STVA	barred owl[1]	3	2	5	4	4	8	13
AEAC	saw-whet owl	4	3	7	6	2	8	15
CHVA	Vaux's swift	3	2	5	5	2	7	12
MYCI	ash-throated flycatcher	4	2	6	6	4	10	16
TATH	violet-green swallow	3	3	6	4	3	7	13
IRBI	tree swallow	4	3	7	4	3	7	14
PAAT	black-capped chickadee	2	4	6	3	4	7	13
PAGA	mountain chickadee	5	4	9	7	4	11	20
PARU	chestnut-backed chickadee[1]	3	4	7	5	4	9	16
CEFA	brown creeper	2	2	4	3	3	6	10
TRAE	house wren	4	4	8	5	3	8	16
SIME	western bluebird[1]	4	3	7	9	2	11	18



Letter code

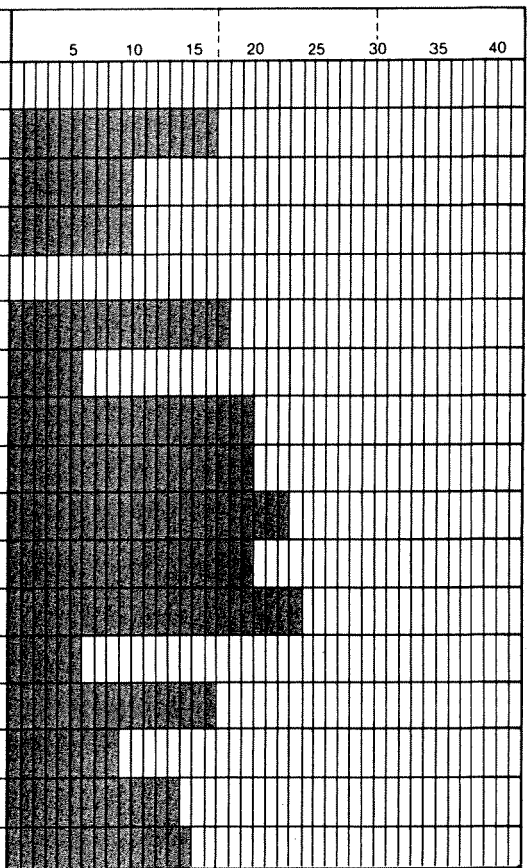
1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2 — Reproductive orientation
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5 — Feeding orientation
7 Versatility score: columns 3 + 6 — Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 14. Continued

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
SICU	mountain bluebird[1]	4	3	7	8	2	10	17
STVU	starling	1	3	4	4	2	6	10
PADO	house sparrow	1	3	4	4	2	6	10
	MAMMALS							
MYLU	little brown myotis	3	2	5	9	4	13	18
MYYU	Yuma myotis	1	2	3	1	2	3	6
MYEV	long-eared myotis[1]	3	2	5	9	6	15	20
MYVO	long-legged myotis[1]	3	2	5	9	6	15	20
MYCA	California myotis	3	2	5	14	4	18	23
LANO	silver-haired bat[1]	3	2	5	9	6	15	20
EPFU	big brown bat	2	2	4	14	6	20	24
SCNI	eastern fox squirrel[1]	1	2	3	1	2	3	6
GLSA	northern flying squirrel	5	3	8	6	3	9	17
PRLO	raccoon	1	2	3	2	4	6	9
MAAM	marten[1]	3	2	5	5	4	9	14
MAPE	fisher[1]	4	2	6	5	4	9	15



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

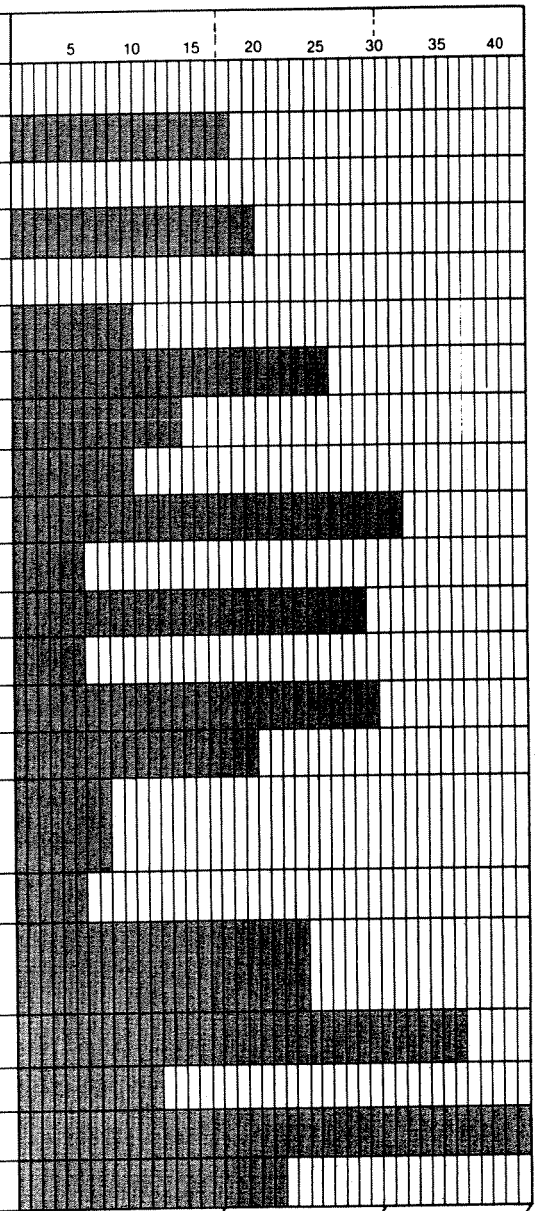
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 15. Reproduces in a burrow underground and feeds on the ground or under it (40 species)

Letter code	Species	1	2	3	4	5	6	7
	REPTILES							
CHBO	rubber boa	3	4	7	5	6	11	18
	BIRDS							
SPCU	burrowing owl[1]	4	6	10	4	6	10	20
	MAMMALS							
SOPR	Malheur shrew[1]	3	2	5	3	2	5	10
SOVA	vagrant shrew	7	6	13	7	6	13	26
SOOB	dusky shrew	4	3	7	4	3	7	14
SOME	Merriam shrew[1]	3	2	5	3	2	5	10
SCOR	coast mole	10	6	16	10	6	16	32
SYID	pygmy rabbit[1]	1	2	3	1	2	3	6
SYNU	mountain cottontail	7	6	13	10	6	16	29
EUMI	least chipmunk	1	2	3	1	2	3	6
EUAM	yellow pine chipmunk	9	6	15	9	6	15	30
SPTO	Townsend ground squirrel	4	6	10	4	6	10	20
SPWA	Washington ground squirrel[1]	3	1	4	3	1	4	8
SPBE	Belding ground squirrel	2	1	3	2	1	3	6
SPCO	Columbian ground squirrel	7	4	11	9	4	13	24
SPLA	mantled ground squirrel	11	6	17	14	6	20	37
THTO	Townsend pocket gopher	4	2	6	4	2	6	12
THTA	northern pocket gopher	15	6	21	15	6	21	42
PEPA	Great Basin pocket mouse	5	6	11	5	6	11	22



Low 1-16 | Medium 17-29 | High 30-42

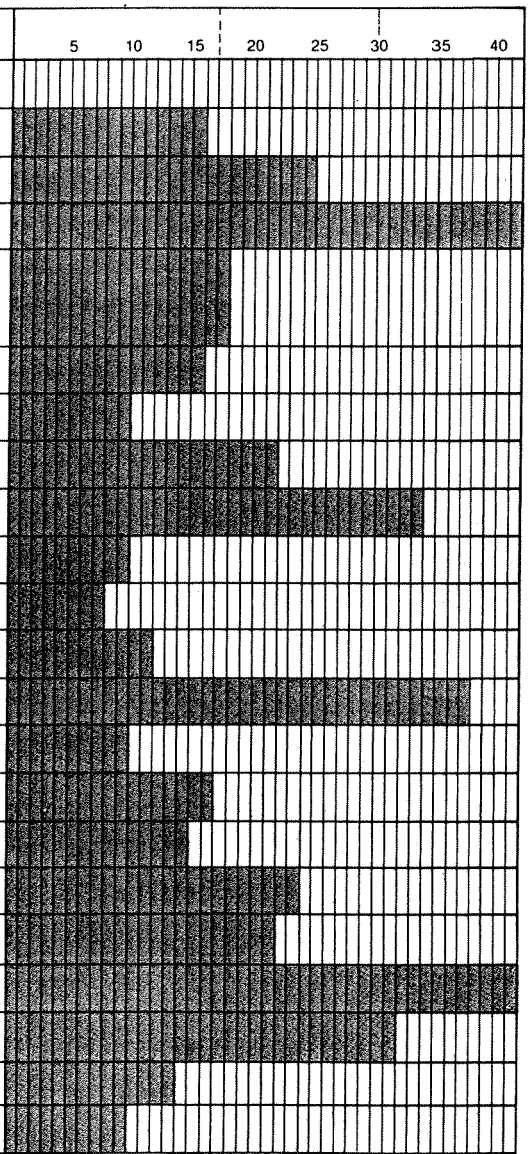
1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation | Feeding orientation | Versatility rating (mean scale)

[1]Species of special interest; see appendix 4.

Life form 15. Continued

Letter code	Species	1	2	3	4	5	6	7
	MAMMALS							
DIOR	Ord kangaroo rat[1]	2	6	8	2	6	8	16
REME	western harvest mouse	6	6	12	7	6	13	25
PEMA	deer mouse	15	6	21	15	6	21	42
ONLE	northern grasshopper mouse[1]	3	6	9	3	6	9	18
CLGA	Gapper red-backed vole	4	4	8	4	4	8	16
PHIN	heather vole[1]	2	3	5	2	3	5	10
MIMO	mountain vole	7	4	11	7	4	11	22
MILO	long-tailed vole	11	6	17	11	6	17	34
LACU	sagebrush vole[1]	3	2	5	3	2	5	10
RANO	Norway rat	2	2	4	2	2	4	8
MUMU	house mouse	3	3	6	3	3	6	12
CALAT	coyote	11	6	17	15	6	21	38
CALU	gray wolf[1]	0	0	0	4	6	10	10
VUVU	red fox[1]	3	5	8	3	6	9	17
URCI	gray fox	2	5	7	2	6	8	15
URAM	black bear	3	5	8	10	6	16	24
MUER	short-tailed weasel	5	5	10	6	6	12	22
MUFR	long-tailed weasel	15	6	21	15	6	21	42
TATA	badger[1]	5	6	11	15	6	21	32
SPPU	spotted skunk	4	3	7	4	3	7	14
MEMEP	striped skunk	3	2	5	3	2	5	10



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

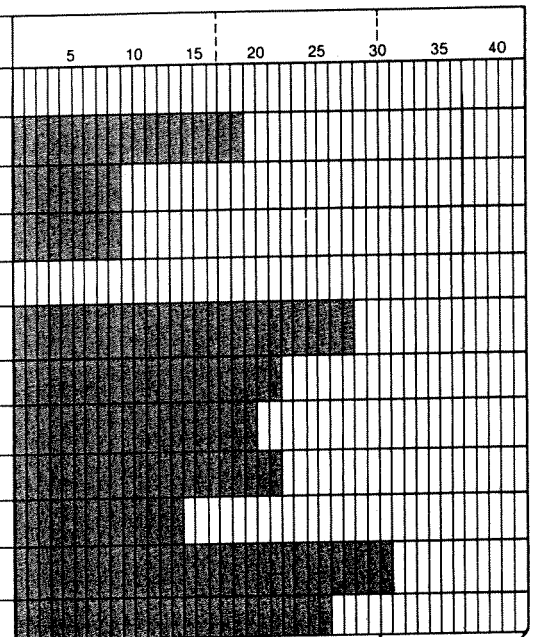
Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Life form 16. Reproduces in a burrow underground and feeds in the air or in water (10 species)

Letter code	Species	1	2	3	4	5	6	7
	BIRDS							
MEAL	belted kingfisher	1	1	2	11	6	17	19
RIRI	bank swallow	1	1	2	5	2	7	9
STRU	rough-winged swallow	1	1	2	5	2	7	9
	MAMMALS							
SOPA	northern water shrew	8	6	14	8	6	14	28
CACAN	beaver	2	6	8	8	6	14	22
MIRI	water vole	4	6	10	4	6	10	20
ONZI	muskrat	5	6	11	5	6	11	22
MYCO	nutria	2	5	7	2	5	7	14
MUVI	mink	9	6	15	10	6	16	31
LUCA	river otter[1]	7	6	13	7	6	13	26



1 No. of plant communities used
2 No. of successional stages used
3 Columns 1 + 2
4 No. of plant communities used
5 No. of successional stages used
6 Columns 4 + 5
7 Versatility score: columns 3 + 6

Reproductive orientation
Feeding orientation
Versatility rating (mean scale)

Low 1-16
Medium 17-29
High 30-42

[1]Species of special interest; see appendix 4.

Appendix 13

Life form versatility rating summary

Life form[1]	Number species[2]	Range of versatility scores[3]	Mean versatility score	Life form versatility rating[4] (median scale)
1	1	Not developed[5]		
2	9	6 to 40 (34)	22.67	High
3	45	3 to 32 (29)	12.11	Low
4	32	5 to 42 (37)	16.53	Medium
5	48	4 to 30 (26)	16.25	Medium
6	7	8 to 29 (21)	17.86	Medium
7	30	8 to 35 (27)	18.87	Medium
8	6	12 to 23 (11)	16.50	Medium
9	4	13 to 19 (6)	15.00	Low
10	14	9 to 22 (13)	16.64	Medium
11	24	15 to 24 (9)	18.96	Medium
12	7	6 to 29 (23)	19.71	High
13	13	8 to 21 (13)	11.62	Low
14	37	6 to 25 (19)	15.86	Medium
15	40	6 to 42 (36)	20.23	High
16	10	9 to 31 (22)	20.00	High
Total:	327			

[1]See appendix 7 for life form descriptions.

[2]Refers to the total number of species in the life form.

[3]Numbers are lowest and highest scores in the life form; number in parentheses is the range of scores in the life form.

[4]Life form versatility rating (median) scale: 11.62 to 15.30 low; 15.31 to 18.99 medium; 19.00 to 22.67 high.

[5]No versatility rating has been developed for life form 1 because it contains only one species—the bullfrog, which is considered semi-terrestrial. The bullfrog has only a negligible orientation to plant communities or successional stages for reproduction or feeding.

Appendix 14

Wildlife orientation to special and unique habitats (components)*

Life form 2. Reproduces in water and feeds on the ground, in bushes, and/or trees (9 species)

	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
	SPECIES	● Reproduction and feeding									R Reproduction only								F Feeding only							
	AMPHIBIANS																									
AMTI	tiger salamander			●		●	●		●	●	●	●	●	●						F					9	10
AMMA	long-toed salamander			●	●	●	●	●	●	●	●	●	●	●						F			F		11	13
ASTR	tailed frog[1]		●												●										2	2
SCIN	Great Basin spadefoot toad			●			●	●		F	F	F		R							F				4	7
BUBO	western toad	●	●	●	●	●	●	●	●	●	●	●	●	R		F	F	F		F	F		F		13	18
BUWO	Woodhouse toad	●	●	●	●	●	●		●	●	●	●	●	●								F	F		12	14
HYRE	Pacific treefrog	●	●	●	●	●	●	●	●	●	●	●	●	●						F		F	F		13	16
RAPR	spotted frog[1]	●	●		●	●	●		●	●	●	●	●	●	●										12	12
RAPI	leopard frog			●			●		●		●	●	●	●	F										7	8
Letter code	Reproduction	4	5	7	5	6	8	4	7	6	7	7	7	8	2	0	0	0	0	0	0	0	0	0	Reproduction	Feeding
	Feeding	4	5	7	5	6	8	4	7	7	8	8	7	6	3	1	1	1	0	4	2	2	4	0		
	Number of species using each habitat for:																								Number of habitats used by each species for:	
	Special habitats (components)										Marshes				Edges (ecotones)					Unique habitats						

*Except for the logs column, use of these habitats by the species includes both primary and secondary reproduction and feeding orientations as defined in appendix 6. See appendix 24 for more information on species that use logs.

[1]Species of special interest; see appendix 4.

Life form 3. Reproduces on the ground around water (or in emergent vegetation, or on floating vegetation[2]) and feeds on the ground, and in bushes, trees and water (45 species)

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
		Special habitats (components)							Marshes						Edges (ecotones)						Unique habitats				Number of habitats used by each species for:	
	REPTILES																									
CHPI	painted turtle	•		•		•	•							•											5	5
EUSK	western skink	•	•			•	•													•		F	•		6	7
DIPU	ringneck snake	•	•		•	•	•						•							•					7	7
THSI	common garter snake	•	•	•	•	•	•		•	•	•	•	•			F									11	12
	BIRDS																									
PONI	eared grebe	R		R	•	•			•		•	•		•	F										8	7
POPO	pied-billed grebe			R			R		R	R	R	R		•	F										7	2
PHAU	double-crested cormorant[1]	R				R								•	F										3	2
BOLE	American bittern[1]	F	F	F	•	F			•		•	•	•	F											5	10
BRCA	Canada goose[1]	•		•	•	•			•		•	•		F						R		R			9	8
ANPL	mallard	•	•	•	•	•	•	F	•	•	•	•		F	F					R					11	13
ANST	gadwall	•	•	•	•	•			•		•	•	•	F											9	10
ANAC	pintail			•	•	•			•		•	•		F											6	7
ANCR	green-winged teal			•	•	•	•	F	•	F	•	•	F	F											7	11
ANDI	blue-winged teal			•	•	•	•			•	•	•		F											7	8
ANCY	cinnamon teal			•	F	•	•	F	F	•	•	•		F											6	10
ANAM	American wigeon	•	F	•	•	•	•	F	•	•	•	•	•	F											10	13
ANCL	northern shoveler			•	•	•	F	F	•	F	•	•		F											6	10
AYAM	redhead			•	•	•			F		F	F		F											3	7
AYCO	ring-necked duck[1]	•	F	•	•	•	F	F	F	F	F	F	F	F	F										4	14

• Reproduction and feeding R Reproduction only F Feeding only

[2]A number of species in this life form are specifically oriented to water in emergent vegetation or on floating vegetation, for reproduction and/or feeding purposes; but from a management standpoint (i.e., potential for managed impacts) they fit this category.

Life form 3. Continued

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
	BIRDS																									
AYAF	lesser scaup[1]	●	F	●	●	●	F	F	●	F	●	●		F											7	12
HIHI	harlequin duck[1]	●	●											F	●					R					4	4
OXJA	ruddy duck			●	●	●			●	●	●	●		F											7	8
GRCA	sandhill crane[1]		F		F				●	F	●	●				F									3	7
RALI	Virginia rail[1]	F		F					●	●			●	●		F									4	7
POCA	sora	●	●	●	●	●	●		●	●			●	●	F	F									10	12
FUAM	American coot	●	●	●	●	●	F		●	●	●	●	●	●		●									12	13
CHAL	snowy plover[1]	F			F	F		F	F	F	F	F		F		F									0	10
CHVO	killdeer	●	●	F	●	●	●	F	●	●	F	●													8	11
CAGA	common snipe	F	●	F	●	F	F		●	●		●		F	F										5	11
NUAM	long-billed curlew[1]	F		F	F	F	F	F	F	F		F		F		●									1	11
ACMA	spotted sandpiper	●	●	●	●	●	●	F	●	●	●	●		●	●	F									12	14
CASE	willet[1]	F	F	F	●	●	●	●	●	●		●		●											8	11
REAM	American avocet	●		●	●	●	●	F	●	F	F	●		●											8	11
STTR	Wilson's phalarope			F			●	●	●	●		●		●											6	7
LACA	California gull	●	F	F	●	F			●	F	●	●		●											6	10
LADE	ring-billed gull	●	F	F	●	F			●	F	●	●		●											6	10
LAPI	Franklin's gull[1]	●	F	F	●	F			●	F	●	●		●											6	10
STFO	Forster's tern	F		F	●	●	F		●		●	●		●	F										6	10
CHNI	black tern	F		F	●	●	F		●		●	●		●											6	9

Special habitats (components): Marshes; Edges (ecotones); Unique habitats

[1]Species of special interest; see appendix 4.

Life form 3. Continued

	SPECIES	● Reproduction and feeding R Reproduction only F Feeding only																								
	BIRDS																									
CIME	dipper	●	●												●					R		R			5	3
TRTR	winter wren	●	●																R	●					4	3
TEPA	long-billed marsh wren	F		F					●	●	●	●		●											5	7
SENO	northern waterthrush[1]	●	●	●	●	●	●			●			●			F				F					8	10
GETR	common yellowthroat[1]		F	F		F			●	●	●		F			F									3	8
	MAMMALS																									
ZAPR	western jumping mouse	●	●	●	●	●	●	●	●	●	●	●	●							R					13	12
Letter code	Reproduction	25	15	23	30	29	18	3	30	19	26	30	10	17	3	2	0	0	1	8	0	2	1	0	Reproduction	Feeding
	Feeding	32	25	35	34	36	25	15	35	29	30	33	13	35	11	10	0	0	0	4	0	1	1	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)							Marshes						Edges (ecotones)					Unique habitats						

[1]Species of special interest; see appendix 4.

Life form 4. Reproduces in cliffs, caves, rimrock, and/or talus and feeds on the ground or in the air (32 species)

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
	● Reproduction and feeding R Reproduction only F Feeding only																									
	REPTILES																									
UTST	side-blotched lizard	●	●		●	●										●						●	●		7	7
	BIRDS																									
CAAU	turkey vulture[1]	F		F	F	F										F	F	F		R		R	F		2	8
BURE	ferruginous hawk[1]															F	F	F				R	F		1	4
FAME	prairie falcon[1]	F	F	F	F	F	F	F	F	F	F	F	F									●	F		1	14
FAPE	peregrine[1]	F	F	F	F	F	F	F	F	F	F	F	F			F	F	F				●	F		1	17
LALE	white-tailed ptarmigan[1]																						●		1	1
ALCH	chukar	●	●													●	F			R		●	●		6	6
COLI	rock dove	F			F	F										F						R			1	4
CYNI	black swift	F	F	F	F	F	F	F	F	F	F	F	F									●	F		1	14
AESA	white-throated swift	F	F	F	F	F										F	F	F				●	F		1	10
SASA	Say's phoebe	●	●		●	●											●	●		●		●	●		9	9
HIRU	barn swallow	F	F	F	F	F	F		F	F	F	F	F			●	●	●				●			4	15
PEPY	cliff swallow[1]	●	F	F	●	●			F		F	F										●	F		4	10
COCOR	common raven	●	F	F	●	●										●	●	●				●	F		7	10
CAMEX	canyon wren															●						●	●		3	3
SAOB	rock wren															●						●	●		3	3
LETE	gray-crowned rosy finch[1]																					●	F		1	2
LEAT	black rosy finch[1]																					●	F		1	2

Special habitats (components): Rivers, Streams, Sloughs, Lakes, Reservoirs ≥0.8 ha (≥2 acres), Reservoirs <0.8 ha (<2 acres), Intermittent ponds, Large ≥0.8 ha (≥2 acres), Small <0.8 ha (<2 acres), Rush, cattail, Sedge, Deciduous vegetation, Standing or slow-running water, Fast-running water, Grass-shrub, Shrub-forest, Grass-forest, Snags, Logs, Burrows, Cliffs, rimrock, Talus, Caves

Marshes

Edges (ecotones)

Unique habitats

Number of habitats used by each species for: Reproduction, Feeding

Species of special interest; see appendix 4.

Life form 4. Continued

	SPECIES	● Reproduction and feeding R Reproduction only F Feeding only																								
	MAMMALS																									
MYLE	small-footed myotis[1]	●	●	●	●	●	●	●		●	●	●	●									●	F	R	13	13
PIHE	western pipistrelle[1]	●	●	●	●	●	●	●		●	●	●	●									●	F		12	13
EUMA	spotted bat[1]	F	F	F	F	F	F	F														●			1	8
PLTO	western big-eared bat	F	F	F	F	F	F	F	F	F	F	F	F									F	F	R	1	14
ANPA	pallid bat[1]	F	F	F	F	F	F	F											R			●		R	3	8
OCPR	pika																						●		1	1
MAFL	yellow-bellied marmot	F	F	F	F	F	F									●		●			R	●	●		5	10
PEOR	canyon mouse																					●	●	R	3	2
PETR	pinyon mouse[1]																			R		●		R	3	1
NECI	bushy-tailed woodrat	●	●	●	●	●	●	●	●	●			●							●		●	●	R	14	13
FECO	puma[1]	F	F	F	F	F	F	F	F	F			F											R	1	10
LYRU	bobcat	F	F	F	F	F	F	F	F	F	F	F	F							F		●	●	R	3	15
ORAM	mountain goat[1]																					●	F		1	2
OVCA	big-horned sheep[1]																					●	F		1	2
Letter code	Reproduction	8	6	3	7	7	3	3	1	3	2	2	3	0	0	7	3	4	1	5	1	28	11	8	Reproduction	Feeding
	Feeding	21	19	17	20	20	13	11	9	10	9	9	10	0	0	12	8	8	0	3	0	26	26	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)							Marshes							Edges (ecotones)						Unique habitats				

[1]Species of special interest; see appendix 4.

Life form 5. Reproduces on the ground without specific water, cliff, rimrock, or talus association and feeds on the ground (48 species)

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≧0.8 ha (≧2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≧0.8 ha (≧2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
		● Reproduction and feeding									R Reproduction only					F Feeding only										
	REPTILES																									
SCOC	western fence lizard	●	●													●	●	●		●		●	●		8	8
SCGR	sagebrush lizard															●									1	1
PHDO	short-horned lizard[1]															●									1	1
CNTI	western whiptail[1]		●													●							●		3	3
COCO	yellow-bellied racer		●			F	F									●	F						●		3	6
MATA	striped whipsnake	●	●													●						F	●		4	5
PIME	gopher snake	●	●	●	●	●	●									●	F	F		●		F	●		9	12
THEL	western terrestrial garter snake	●	●	●	●	●	●		F	F	F	F	F			●	●						●		9	14
HYTO	night snake[1]															F					●	F	●		2	4
CRVI	western rattlesnake[1]	●	●	●	●	●				●	●	●	●			F	F	F		●		F	●		11	15
	BIRDS																									
CICY	marsh hawk[1]			F	F	F			●	●	F	●				F									3	8
DEOB	blue grouse		F				F									●	●	F		●					3	6
CACA	Franklin's grouse[1]		F														F			●					1	3
BOUM	ruffed grouse	●	●	●		●	●			F			F			●	●			●					8	10
PEPH	sharp-tailed grouse[1]			F			F	F																	0	3
CEUR	sage grouse[1]			F			F	F								●									1	4
COVI	bobwhite	●	●	●	●	●				F			F			●	F			●					7	10
LOCA	California quail	●	●	●	●	●				F			F			●	●			●					8	10

Special habitats (components): Marshes; Edges (ecotones); Unique habitats

[1]Species of special interest; see appendix 4.

Life form 5. Continued

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
	BIRDS																									
ORPI	mountain quail[1]	●	●		●	●										●	●			●					7	7
PEPE	gray partridge	F	●	F												●									2	4
PHCO	ring-necked pheasant	●	●	●	●	●			●		●		●			●	●			R					11	10
MEGA	turkey	F	●													●	●	●		●			F		5	7
BALO	upland sandpiper[1]	●	●	●		●	●	●		F		F				F									6	9
ASFL	short-eared owl[1]	●	●	●	●	●			●	●	F	●				●									9	10
ERAL	horned lark																								0	0
CAGU	hermit thrush[1]	F	F	F	F	F	F													●					1	7
CAFU	veery[1]	●	F	●	●	●	●		●	●			●				●			●					10	11
ANSP	water pipit[1]				●	●	●			●		●													5	5
WIPU	Wilson's warbler	●	●	●	●	●			●	●			●			F	●			●					10	11
DOOR	bobolink[1]		F	F			F		F	●	F	●				●									3	8
STNEG	western meadowlark[1]								F	F	F	F	F			F									0	6
PASA	savannah sparrow																								0	0
AMSA	grasshopper sparrow[1]																								0	0
POGRA	vesper sparrow[1]																								0	0
CHGR	lark sparrow															●									1	1
JUHY	dark-eyed junco[1]		●				●	●									●	●		●					6	6

Special habitats (components): Rivers, Streams, Sloughs, Lakes, Reservoirs ≥0.8 ha (≥2 acres), Reservoirs <0.8 ha (<2 acres), Intermittent ponds, Large ≥0.8 ha (≥2 acres), Small <0.8 ha (<2 acres), Rush, cattail, Sedge, Deciduous vegetation, Standing or slow-running water, Fast-running water, Grass-shrub, Shrub-forest, Grass-forest, Snags, Logs, Burrows, Cliffs, rimrock, Talus, Caves

Marshes

Edges (ecotones)

Unique habitats

Number of habitats used by each species for: Reproduction, Feeding

● Reproduction and feeding R Reproduction only F Feeding only

[1]Species of special interest; see appendix 4.

	SPECIES	● Reproduction and feeding R Reproduction only F Feeding only																								
	MAMMALS																									
DIMA	opossum[1]	●	●	●	●	●			●	●			●			F	F	F	R	R					10	11
LEAM	snowshoe hare	F	●				●									●	●			R					5	5
LETO	whitetail jackrabbit[1]	F				F	F	F								●									1	5
LECA	blacktail jackrabbit	F					F	F								●									1	4
GUGU	wolverine[1]	F	F		F	F	F	F	F		F	F	F								R	●	F	R	3	12
FECA	feral house cat	●	●	●	●	●	●		●	●	●	●	●							F					11	12
LYCA	lynx[1]	●	●																	F		F	F		2	5
EQCA	feral horse	F	F																						0	2
CEEL	elk	F	F				F																		0	3
ODHE	mule deer	F	F	F	F	F	F	F																	0	7
ODVI	white-tailed deer[1]	●	●	●	●	●			●	●	F	F	●												8	10
ANAME	pronghorn	F	F																						0	2
Letter code	Reproduction	18	23	14	14	16	9	2	8	10	3	6	7	0	0	23	12	3	1	17	2	2	8	1	Reproduction	Feeding
	Feeding	29	33	21	18	22	20	8	12	16	10	11	13	0	0	30	18	7	0	16	1	7	11	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)						Marshes						Edges (ecotones)							Unique habitats					

Species of special interest; see appendix 4.

Life form 6. Reproduces on the ground and feeds in bushes, trees, or the air (7 species)

	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
		● Reproduction and feeding R Reproduction only F Feeding only																								
	BIRDS																									
PHNU	poorwill[1]	●	●			●	●	●	●	●	●	●				●	F	F				F	F		10	14
CHMI	common nighthawk[1]															●	●	●		R		●	F		5	5
MYTO	Townsend's solitaire	F	F	F	F	F										●	●			●		●			4	9
VECE	orange-crowned warbler[1]	●	●	●	●				●	●			●			●	●								9	9
VERU	Nashville warbler	●	●	●	●	●	●		●				●				●			F					9	10
MELI	Lincoln's sparrow	●	●	F	●	F	F	F	●	●			●			●	●			F					8	13
	MAMMALS																									
ERDO	porcupine	●	●	●	●															R		R		R	7	4
Letter code	Reproduction	5	5	3	4	2	2	1	4	3	1	1	3	0	0	5	5	1	0	3	0	3	0	1	Reproduction	Feeding
	Feeding	6	6	5	5	4	3	2	4	3	1	1	3	0	0	5	6	2	0	3	0	3	2	0		
	Number of species using each habitat for:																									
	Special habitats (components)								Marshes						Edges (ecotones)					Unique habitats						
	Number of habitats used by each species for:																									

[1]Species of special interest; see appendix 4.

Life form 7. Reproduces in bushes and feeds on the ground, in water, or the air (30 species)

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
	BIRDS																									
NYNY	black-crowned night heron[1]	●	●	●	●				●				●	F											6	7
BUSW	Swainson's hawk[1]															●	●	●				F	F		3	5
TRSO	solitary sandpiper[1]	●	●	●	F	F	●	F		●			●			●	●								8	11
ARAL	black-chinned hummingbird	●	●	●	●	●				●			●			F	F	F							7	10
SEPL	broad-tailed hummingbird	●	●	●	●	●				●			●												7	7
STCA	calliope hummingbird	●	●		●					●			●			F	●								6	7
TYTY	eastern kingbird	●	●	●	●	●	●			●			●			F	F								8	10
EMTR	willow flycatcher	●	●	F	F	F	●									F	●			F					4	9
EMWR	gray flycatcher	F	F	F	F	F	F															F	F		0	8
PIPI	black-billed magpie	●	●	●	●	●	●	F	●	●	F	F	●			●	●	F				F	F		11	17
DUCA	gray catbird[1]	●	●	●	●	●	●		●	●			●												9	9
ORMO	sage thrasher	F	F						F	F			F									F	F		0	7
TUMI	American robin	●	●	●	●	●	●	●	●	●	F	F	●				●	●							12	14
CAUS	Swainson's thrush	●	●	●	●												●			●					6	6
LALU	loggerhead shrike[1]	F	F				F			F			F			●	●			F		F	F		2	10
OPTO	MacGillivray's warbler[1]	●	●	●	●	●	●		●	●			●				F								9	10
XAXA	yellow-headed blackbird			F	F	F	F		●	●	F	●				F									3	9
		Special habitats (components)									Marshes				Edges (ecotones)					Unique habitats				Number of habitats used by each species for:		

● Reproduction and feeding R Reproduction only F Feeding only

[1]Species of special interest; see appendix 4.

Life form 7. Continued

SPECIES		● Reproduction and feeding R Reproduction only F Feeding only																								
BIRDS																										
AGPH	red-winged blackbird	●	●	●	●	●	●		●	●	●	●	●			●	F	F							12	14
EUCY	Brewer's blackbird	●	●	●	●	●	●		●	●	●	●	●			●	●								13	13
MOAT	brown-headed cowbird	●	●	●	●	●	●		●	●	●	●	●												11	11
PAAMO	lazuli bunting[1]	●	●	F			●		●	●			●			●	●								8	9
SPPS	lesser goldfinch[1]		F						F	F			F			●						F	F		1	7
CHCH	green-tailed towhee	F	F		F	F			F	F			F			●				●		F	F		2	11
PIER	rufous-sided towhee	●	●	●	●	●			●	●			●			●	●			●					11	11
AMBE	sage sparrow	F	F						F	F			F									F	F		0	7
SPPA	chipping sparrow	●	●				●		●	●			●			●	●			●					9	9
SPBR	Brewer's sparrow		F				F		F	F			F			●									1	6
ZOLE	white-crowned sparrow	F	F	F	F	F	F		F	F			F			●		●		F					2	12
PAIL	fox sparrow[1]	●	●	●	●	●	●										●	●		F					8	9
MEMEL	song sparrow	●	●	●	●	●	●		●	●			●			●	●			●					12	12
Letter code	Reproduction	20	20	16	16	13	14	1	13	17	3	4	17	0	0	14	14	4	0	5	0	0	0	0	Reproduction	Feeding
	Feeding	26	28	21	22	19	19	3	19	24	6	6	24	1	0	19	18	7	0	9	0	8	8	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)						Marshes						Edges (ecotones)					Unique habitats							

[1]Species of special interest; see appendix 4.

Life form 8. Reproduces in bushes and feeds in trees, bushes, or the air (6 species)

	SPECIES	● Reproduction and feeding R Reproduction only F Feeding only																								
	BIRDS																									
COAM	yellow-billed cuckoo[1]	●	●	●	●	●			●	●			●			●	●	●		F					11	12
EMOB	dusky flycatcher	●	●	●	●	●			●	●			●						F	F					8	10
PSMI	bushtit	●	●	●	●	●			●	●			●			●	●			F					10	11
DEPE	yellow warbler[1]	●	●	●	●	●			●	●			●			F	F								8	10
ICVI	yellow-breasted chat	●	●	●	●	●			●	●			●			F	●			F					9	11
SPTR	American goldfinch	●	●	●	●	●			●	●			●			●	●	F							10	11
Letter code	Reproduction	6	6	6	6	6	0	0	6	6	0	0	6	0	0	3	4	1	0	0	0	0	0	0	Reproduction	Feeding
	Feeding	6	6	6	6	6	0	0	6	6	0	0	6	0	0	5	5	2	1	4	0	0	0	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≧0.8 ha (≧2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≧0.8 ha (≧2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)							Marshes						Edges (ecotones)					Unique habitats						

[1]Species of special interest; see appendix 4.

Life form 9. Reproduces primarily in deciduous trees and feeds in trees, bushes, or the air (4 species)

SPECIES		● Reproduction and feeding R Reproduction only F Feeding only																								
BIRDS																										
BOCE	cedar waxwing	●	●	●	●	●				●			●			F	F								7	9
SERUT	American redstart[1]	●	●	●	●	●				●			●			F	F								7	9
ICGA	northern oriole	●	●	●	●	●				●			●			●	F								8	9
CAMEXI	house finch	●				●				●			●			●	●	F							6	7
Letter code	Reproduction	4	3	3	3	4	0	0	0	4	0	0	4	0	0	2	1	0	0	0	0	0	0	0	Reproduction	Feeding
	Feeding	4	3	3	3	4	0	0	0	4	0	0	4	0	0	4	4	1	0	0	0	0	0	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
	Special habitats (components)							Marshes							Edges (ecotones)					Unique habitats						

[1]Species of special interest; see appendix 4.

Life form 10. Reproduces primarily in conifers and feeds in trees, bushes, or the air (14 species)

	SPECIES	● Reproduction and feeding R Reproduction only F Feeding only																								
	BIRDS																									
EMDI	western flycatcher	●	●	F	F	F	F		F	F			F				F		F	F					2	12
NUBO	olive-sided flycatcher	●	●	F	F	F	F		F	F			F				F	F	F	F					2	13
GYCY	pinyon jay	F	F	F	F	F	F		F	F			F							F					0	10
NUCO	Clark's nutcracker																		F	F		F			0	3
RESA	golden-crowned kinglet	F	F		F	F																			0	4
RECA	ruby-crowned kinglet	●	●	●	●	●			●	●			●			F	F								8	10
DECO	yellow-rumped warbler[1]	●	●	●	●	●	●		●	●			●			F	F								9	11
DENI	black-throated gray warbler[1]	●	●	●	●	●	●		F	F			F												6	9
DETO	Townsend's warbler	●	●	F	F	F	F		F	F			F												2	9
PILU	western tanager	●	●	●	●	●	●		●	●			●				●	●							11	11
LOCUR	red crossbill	F	F	F	F	F	F		F	F			F				F	F							0	11
	MAMMALS																									
SCGRI	western gray squirrel[1]	●	●	●	●	●				●			●						●	F					8	9
TAHU	red squirrel	●	●														F		●	F					3	5
TADO	chickaree	●	●																R	F					3	3
Letter code	Reproduction	10	10	5	5	5	3	0	3	4	0	0	4	0	0	0	1	1	3	0	0	0	0	0	Reproduction	Feeding
	Feeding	13	13	10	11	11	8	0	9	10	0	0	10	0	0	2	7	3	5	7	0	1	0	0		
		Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≧0.8 ha (≧2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≧0.8 ha (≧2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
			Special habitats (components)						Marshes						Edges (ecotones)						Unique habitats					

Species of special interest; see appendix 4.

Life form 11. Reproduces in conifers or deciduous trees and feeds in trees, in bushes, on the ground, or in the air (24 species)

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
	BIRDS																									
ACGE	goshawk	F	F						F	F			F						F	F		F	F		0	9
ACST	sharp-shinned hawk[1]	F	F						F	F			F			F	F	F	F	F					0	10
ACCO	Cooper's hawk[1]	●	●	F	F	F	F	F	F	F			F			F	F	F	F	F					2	15
FACO	merlin[1]	●	●		●				F	F	F	F	F				F	F							3	10
ZEMA	mourning dove	R	R	R	R	R	R		R	R			R			●	R	●							12	2
ASOT	long-eared owl	●	●	●	●	●	●	●	●	●			●			F	F	F							10	13
SERU	rufous hummingbird	●	●	●	●	●	F	F	●	●	●		●			F	●								10	13
TYVE	western kingbird	●	●	●	●	●	●		●	●			●			F	F	F	F	F					9	14
EMHA	Hammond's flycatcher	●	●	F	F	F	F		F	F			F				●		F	F					3	12
COSO	western wood pewee	●	●	F	●	F	F			F			F				●	●		F					5	11
PECA	gray jay	F	F																						0	2
CYST	Steller's jay	●	●	●	F	F	●	F	F	F			F				●	F		F		F	F		5	15
COBR	common crow	●	●	●	●	●			R	R			R			F	●	●							10	8
IXNA	varied thrush	F	F	F	F	F	F										F								0	7
VISO	solitary vireo	F	●		F	F	●		F				F												2	7
VIOL	red-eyed vireo[1]	●	●	●	●	●	●	●	●	●			●			F	F								10	12
VIGI	warbling vireo[1]	●	●	●	●	●	●		●	●			●			F	F								9	11

Special habitats (components): Rivers, Streams, Sloughs, Lakes, Reservoirs ≥0.8 ha (≥2 acres), Reservoirs <0.8 ha (<2 acres), Intermittent ponds, Large ≥0.8 ha (≥2 acres), Small <0.8 ha (<2 acres), Rush, cattail, Sedge, Deciduous vegetation, Standing or slow-running water, Fast-running water, Grass-shrub, Shrub-forest, Grass-forest, Snags, Logs, Burrows, Cliffs, rimrock, Talus, Caves

Marshes; Edges (ecotones); Unique habitats

Number of habitats used by each species for: Reproduction, Feeding

● Reproduction and feeding R Reproduction only F Feeding only

[1]Species of special interest; see appendix 4.

	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for: Reproduction	Feeding
		● Reproduction and feeding									R Reproduction only					F Feeding only										
	BIRDS																									
PHME	black-headed grosbeak	●	●	●	●	●			F	F			F				●	●							7	10
HEVE	evening grosbeak	●	●	●	●	●			F	F			F				●	●							7	10
CAPU	purple finch	●	●	●	●	●			F	F			F			F	●	●							7	11
CACAS	Cassin's finch	●	●		●											F	●	●							5	6
PIEN	pine grosbeak[1]																●	●							2	2
SPPI	pine siskin	F	F	F	F	F	F	F	F	F	F	F	F			F	●	●				F	F		2	17
	MAMMALS																									
LACI	hoary bat[1]	F	F	F	F	F	F		F	F			F												0	9
Letter code	Reproduction	16	17	11	13	10	7	2	7	7	1	0	7	0	0	1	12	9	0	0	0	0	0	0	Reproduction	Feeding
	Feeding	22	22	16	19	17	13	6	17	17	3	2	18	0	0	12	19	15	5	7	0	3	3	0		
	Number of species using each habitat for:																									
	Special habitats (components)							Marshes						Edges (ecotones)							Unique habitats					

[1]Species of special interest; see appendix 4.

Life form 12. Reproduces on very thick branches and feeds on the ground or in water (7 species)

	SPECIES	● Reproduction and feeding R Reproduction only F Feeding only																								
	BIRDS																									
ARHE	great blue heron	●	F	●	●	●	F		●	●	F	F	●	F	F										7	13
BUJA	red-tailed hawk[1]	●	F	F	●	●			●	●			●			F	F	F	F			R	F		7	13
AQCH	golden eagle[1]	F	F	F	F	F	F	F	F	F	F	F	F			F	F	F	F			●	F		1	18
HALE	bald eagle[1]	●		●	●	●			F	F	F	F	F						F						4	10
PAHA	osprey[1]	●		●	●	●								F	F				R						5	6
BUVI	great horned owl	●	F	F	●	●	F	F	●	●	F	F	●			F	F	F	●			●	F		8	18
STNE	great gray owl[1]																	●	R						2	1
Letter code	Reproduction	5	0	3	5	5	0	0	3	3	0	0	3	0	0	0	0	1	3	0	0	3	0	0	Reproduction	Feeding
	Feeding	6	4	6	6	6	3	2	5	5	4	4	5	2	2	3	3	4	4	0	0	2	3	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)							Marshes					Edges (ecotones)						Unique habitats						

[1]Species of special interest; see appendix 4.

Life form 13. Reproduces in own hole excavated in tree and feeds in trees, in bushes, on the ground, or in the air (13 species)

	SPECIES	● Reproduction and feeding R Reproduction only F Feeding only																								
	BIRDS																									
COAU	common flicker	●	●	●	●	●	●		●	●			●				F	F	●	F					10	13
DRPI	pileated woodpecker	●	●		●	●													●	F					5	6
ASLE	Lewis' woodpecker[1]	●	●	●	●	●			●	●			●				●	●	●	F					11	12
SPVA	yellow-bellied sapsucker	●	●	●	●	●	●		●	●			●				●		●						11	11
SPTH	Williamson's sapsucker	●	●				●		F	F			F				F	F	●						4	9
DEVI	hairy woodpecker[1]	F	F		F	F	F		F	F			F				F	F	●	F					1	12
DEPU	downy woodpecker	●	●	●	●	●	●		●	●			●				F	F	●	F					10	13
DEAL	white-headed woodpecker																		●						1	1
PIAR	black-backed three-toed woodpecker																F	F	●	F					1	4
PITR	northern three-toed woodpecker[1]																		●	F					1	2
SICA	white-breasted nuthatch																F	F	●	F					1	4
SICAN	red-breasted nuthatch[1]	F	F			F	F										F	F	●	F					1	8
SIPY	pygmy nuthatch	F	F			F	F										F	F	●						1	7
Letter code	Reproduction	6	6	4	5	5	4	0	4	4	0	0	4	0	0	0	2	1	13	0	0	0	0	0	Reproduction	Feeding
	Feeding	9	9	4	6	8	7	0	6	6	0	0	6	0	0	0	10	9	13	9	0	0	0	0		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)						Marshes						Edges (ecotones)							Unique habitats					

Species of special interest; see appendix 4.

Life form 14. Reproduces in a hole made by another species or in a natural hole and feeds on the ground, in water, or the air (37 species)

SPECIES		Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
		● Reproduction and feeding										R Reproduction only						F Feeding only								
	BIRDS																									
AISP	wood duck	●	●			●			●				●	F	F		R		R	R					8	7
BUIS	Barrow's goldeneye[1]	●	●	●	●	F	F		●				●	F					R	R					8	9
BUAL	bufflehead[1]	●	●	●	●	F	F		●	●			●	F					R						8	10
LOCU	hooded merganser	●	●	●	●	F	F		●	●			●	F					R	R					9	10
MEME	common merganser	●	●	●	●	●			●				●	F					R	R					9	8
FASP	American kestrel[1]	●	●	●	●	●	●		●	●			●			F	F	●	R			●	F		12	14
TYAL	barn owl[1]	●		●		●			●	●	F	F	●				●	●	●			●	F	R	11	13
OTAS	screech owl[1]	●	●	●	●	●			●	●			●				●	●	R			●	F	R	13	12
OTFL	flammulated owl[1]																●	●	●						3	3
GLGN	pygmy owl	●	●	●	●	●			●	●			●			F	●	F	●				F		10	13
STVA	barred owl[1]	●	●	●	●	●	●		●				●						●	F					9	10
AEAC	saw-whet owl	●	●	●	●	●			●	●			●				●	●	R						11	10
CHVA	Vaux's swift	F	F	F	F	F	F	F		F	F	F	F				F	F	R			●	F		2	15
MYCI	ash-throated flycatcher	●	●				●									F	F	F	R	F					4	7
TATH	violet-green swallow	●	●	●	●	●	●		●	●			●					●	R						11	10
IRBI	tree swallow	●	●	●	●	●	●		●	●			●					●	R						11	10
PAAT	black-capped chickadee	●	●	●	●	●			●	●			●			F	●		●	●					11	12
PAGA	mountain chickadee	F	F		F		F		F	F			F				●	●	●	●					4	11
Letter code																									Reproduction	Feeding
		Special habitats (components)							Marshes					Edges (ecotones)					Unique habitats					Number of habitats used by each species for:	

[1]Species of special interest; see appendix 4.

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≧0.8 ha (≧2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≧0.8 ha (≧2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
		● Reproduction and feeding									R Reproduction only							F Feeding only								
	BIRDS																									
PARU	chestnut-backed chickadee[1]	●	●		●		●			F			F						●	F					5	8
CEFA	brown creeper	F	F	F	F	F	F		F	F			F						●	F					1	11
TRAE	house wren	●	●	●	●	●	●	●	●	●			●				●		R	●					13	12
SIME	western bluebird[1]	F	F	F	F	F	F	F	●	●			●				●	●	R	●		F	F		7	15
SICU	mountain bluebird[1]	F	F	F	F	F	F	F	●	●			●				●	●	R	●		F	F		7	15
STVU	starling	●	●	●	●	●	●	●	●	●	F	F	●					●	R	R		●			14	14
PADO	house sparrow	●	●	●	●	●	●	●		●			●			F	●	●	R						12	12
	MAMMALS																									
MYLU	little brown myotis	F	F	F	F	F	F	F	●	●	F	F	●				●	●	R			●	F		7	16
MYYU	Yuma myotis	●	●	●	●	●	●	●	●	●	F	F	●						R						11	12
MYEV	long-eared myotis[1]	●	●	●	●	●	●	●	●	●	F	F	●						R						11	12
MYVO	long-legged myotis[1]	●	●	●	●	●	●	●	●	●	F	F	●						R						11	12
MYCA	California myotis	F	F	F	F	F	F	F	●	●	F	F	●						R			●		R	6	13
LANO	silver-haired bat[1]	F	F	F	F	F	F	F	●	●	F	F	●						R						4	12
EPFU	big brown bat	F	F	F	F	F	F	F	●	●	F	F	●						R			●	F	R	6	14
SCNI	eastern fox squirrel[1]	●	●	●	●	●	●												●						7	7
GLSA	northern flying squirrel	F	F		F		F	F										●	●	F					2	8
PRLO	raccoon	●	●	●	●	●	F	F	●	●	F	F	●						R						9	12

Special habitats (components): Rivers, Streams, Sloughs, Lakes, Reservoirs ≧0.8 ha (≧2 acres), Reservoirs <0.8 ha (<2 acres), Intermittent ponds, Large ≧0.8 ha (≧2 acres), Small <0.8 ha (<2 acres), Rush, cattail, Sedge, Deciduous vegetation, Standing or slow-running water, Fast-running water, Grass-shrub, Shrub-forest, Grass-forest, Snags, Logs, Burrows, Cliffs, rimrock, Talus, Caves

Marshes

Edges (ecotones)

Unique habitats

Number of habitats used by each species for: Reproduction, Feeding

[1]Species of special interest; see appendix 4.

Life form 14. Continued

SPECIES		Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
		Special habitats (components)						Marshes						Edges (ecotones)					Unique habitats						Number of habitats used by each species for:	
	MAMMALS																									
MAAM	marten[1]																		R	F		F	F	F	1	4
MAPE	fisher[1]	●	●		●	●	●												R	●		F	F	F	7	9
Letter code	Reproduction	25	24	21	22	20	14	6	26	23	0	0	27	0	0	0	13	14	37	11	0	8	0	4		
	Feeding	35	34	29	32	31	28	15	28	27	11	11	31	5	1	5	15	17	10	12	0	12	11	2		
	Number of species using each habitat for:																									

● Reproduction and feeding R Reproduction only F Feeding only

[1]Species of special interest; see appendix 4.

Life form 15. Reproduces in a burrow underground and feeds on the ground or under it (40 species)

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
		Special habitats (components)						Marshes							Edges (ecotones)					Unique habitats					Number of habitats used by each species for:	
	REPTILES																									
CHBO	rubber boa	●	●	●			●													●	●		●		7	7
	BIRDS																									
SPCU	burrowing owl[1]		F				F	F								●					R	F	F		2	6
	MAMMALS																									
SOPR	Malheur shrew[1]	●	●	●	●	●	●		●	●	●		●							●	●				12	12
SOVA	vagrant shrew	●	●	●	●	●	●	●	●	●		●	●			●	●	●		●	●		●		17	17
SOOB	dusky shrew	●	●	●	●	●	●													●	●				8	8
SOME	Merriam shrew[1]		●				●	●								●					R				5	4
SCOR	coast mole	●	●	●	●	●										●	●	●		F	●				9	10
SYID	pygmy rabbit[1]		F				F	F								F					R				1	4
SYNU	mountain cottontail	●	●	●	●	●	●		●	●			●			●	●			R	R		●		14	12
EUMI	least chipmunk															●					●	●	●		4	4
EUAM	yellow pine chipmunk	●	●	●	●	●	●	●		●			●			●	●		R	●	R	●	●		16	14
SPTO	Townsend ground squirrel	●	●	●	●	●										●					R				7	6
SPWA	Washington ground squirrel	●	●	●	●	●	●	●													R				8	7
SPBE	Belding ground squirrel	●	●	●	●	●	●	●													R				8	7
SPCO	Columbian ground squirrel	●	●	●	●	●	●	●								●	●				R	R	●		12	10

● Reproduction and feeding R Reproduction only F Feeding only

[1]Species of special interest; see appendix 4.

Life form 15. Continued

Letter code	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Reproduction	Feeding
	MAMMALS																									
SPLA	mantled ground squirrel	F	F	F	F	F	F	F									●	●	●			R	●	●		6	12
THTO	Townsend pocket gopher	●	●	●	●	●																●				6	6
THTA	northern pocket gopher	●	●	●	●	●	●	●		●			●									●				10	10
PEPA	Great Basin pocket mouse	F	F	F	F	F	F										●					R		●		3	8
DIOR	Ord kangaroo rat[1]																					R				1	0
REME	western harvest mouse	●	●	●	●	●	●	●														R		●		9	8
PEMA	deer mouse	●	●	●	●	●	●	●	●	●	●	●	●				●	●	●	●	●	●	●	●	●	21	21
ONLE	northern grasshopper mouse[1]	●	●	●	●	●	●										●					R		●		9	8
CLGA	Gapper red-backed vole	●	●																		●	●				4	4
PHIN	heather vole[1]		●		●																R	R				4	2
MIMO	mountain vole	●	●	●	●	●	●	●													R	R		●		10	8
MILO	long-tailed vole	●	●	●	●	●	●	●													R	R				9	7
LACU	sagebrush vole[1]																●					R		●		3	2
RANO	Norway rat	●	●	●	●	●	●	●	●	●	●		●									R				12	11
MUMU	house mouse	●	●	●	●	●	●	●	●	●	●		●									●				12	12
CALAT	coyote	●	●	●	●	●	●	F	F	F	F	F	F								F	R	●	F	R	9	15
CALU	gray wolf[1]	F	F	F	F	F	F	F		F	F	F	F									R				1	11

● Reproduction and feeding R Reproduction only F Feeding only

Special habitats (components): Rivers, Streams, Sloughs, Lakes, Reservoirs ≥0.8 ha (≥2 acres), Reservoirs <0.8 ha (<2 acres), Intermittent ponds, Large ≥0.8 ha (≥2 acres), Small <0.8 ha (<2 acres), Rush, cattail, Sedge, Deciduous vegetation, Standing or slow-running water, Fast-running water, Grass-shrub, Shrub-forest, Grass-forest, Snags, Logs, Burrows, Cliffs, rimrock, Talus, Caves

Marshes: Rush, cattail; Sedge; Deciduous vegetation

Edges (ecotones): Standing or slow-running water; Fast-running water; Grass-shrub; Shrub-forest; Grass-forest

Unique habitats: Burrows; Cliffs, rimrock; Talus; Caves

Number of habitats used by each species for: Reproduction; Feeding

[1]Species of special interest; see appendix 4.

Life form 15. Continued

SPECIES		● Reproduction and feeding R Reproduction only F Feeding only																								
	MAMMALS																									
VUVU	red fox[1]	●	●	●	●	●	●	●	●	●	●	●	●			●	●			F	R	F	F		15	17
URCI	gray fox	●	●	●		●			F	F	F	F	F							F	R			R	6	10
URAM	black bear	●	●	●	F	F	F	F	F	F	F	F	F			F	F			F	R	F	F		4	17
MUER	short-tailed weasel	●	●	●	●	F	F	F	F	F			F			F	F		R	●	●	F	F	R	8	16
MUFR	long-tailed weasel	●	●	●	●	●	●	●	●	●	●	●	●						●	●	●	●	●	R	18	17
TATA	badger[1]	●	●	●	F	●	●	F		F			F								●	F	●		7	12
SPPU	spotted skunk	●	●																R	●	R	●	F	R	7	5
MEMEP	striped skunk	●	●	●	●	●	●	●	●	●	F	F	●			●	●			●	R	F	F		14	17
Letter code	Reproduction	30	32	28	25	25	23	16	9	11	6	4	11	0	0	16	9	4	5	15	40	8	15	6	Reproduction	Feeding
	Feeding	33	37	31	30	30	30	24	13	17	11	9	17	0	0	19	11	4	2	16	14	13	22	1		
	Number of species using each habitat for:	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for:	
		Special habitats (components)						Marshes						Edges (ecotones)						Unique habitats						

[1]Species of special interest; see appendix 4.

Life form 16. Reproduces in a burrow underground and feeds in the air or in water (10 species)

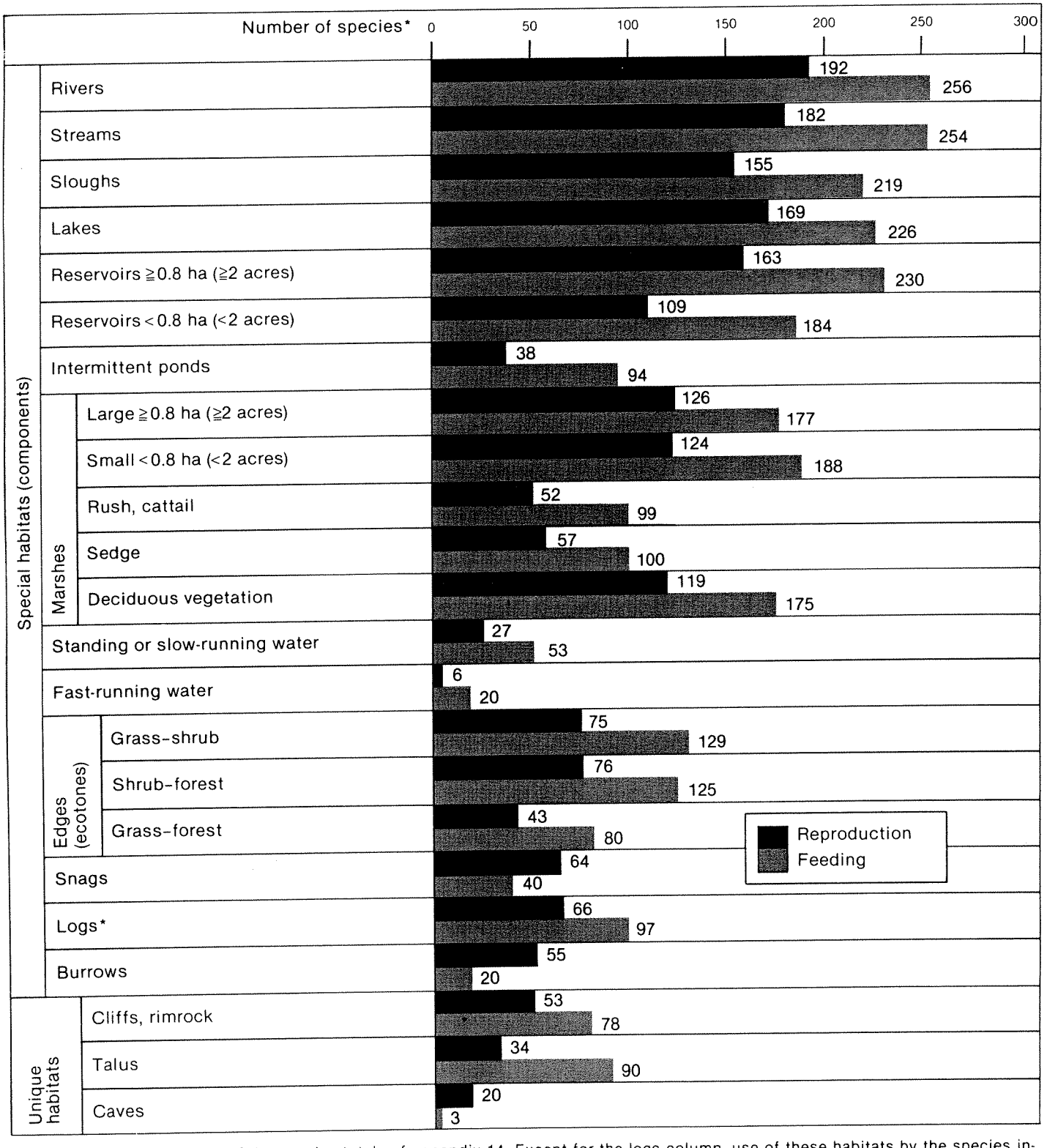
SPECIES		Rivers	Streams	Sloughs	Lakes	Reservoirs ≧0.8 ha (≧2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≧0.8 ha (≧2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for: Reproduction	Feeding
		● Reproduction and feeding												R Reproduction only						F Feeding only						
	BIRDS																									
MEAL	belted kingfisher	●	●	●	●	●								F	F						R				6	7
RIRI	bank swallow	●	●	●	●	●	F	F	F	F	F	F	F			●					R				7	13
STRU	rough-winged swallow	●	●	●	●	●	F	F	F	F	F	F	F			●					R				7	13
	MAMMALS																									
SOPA	northern water shrew	●	●		●	●								F	F					●	R				6	7
CACAN	beaver	●	●	●	●	●	●		●	●			●	●	●					F	R				12	12
MIRI	water vole	●	●		●	●	●			●			●								R				8	7
ONZI	muskrat	●	●	●	●	●	●		●	●	●	●	●	●							R				13	12
MYCO	nutria	●	●	●		●			●		●	●	●								R				9	8
MUVI	mink	●	●	●	●	●	●	F	●	●	●	●	●							●	●				13	14
LUCA	river otter[1]	●	●	●	●	●	F	F	●	F	F	F	●								●				8	13
Letter code	Reproduction	10	10	8	9	10	4	0	5	4	3	3	6	2	1	2	0	0	0	2	10	0	0	0		
	Feeding	10	10	8	9	10	7	4	7	7	6	6	8	4	3	2	0	0	0	3	2	0	0	0		

Special habitats (components): Marshes; Edges (ecotones); Unique habitats

[1]Species of special interest; see appendix 4.

Appendix 15

Number of wildlife species using each special and unique habitat (component)



*Appendix 15 is a summary of the species totals of appendix 14. Except for the logs column, use of these habitats by the species includes both primary and secondary reproduction and feeding orientations as defined in appendix 6. See appendix 24 for more information on species that use logs.

Appendix 16

Additional habitat considerations for 378 wildlife species of the Blue Mountains listed in phylogenetic sequence by common name

Letter code	Life form	Common name	Comments
		AMPHIBIANS	
AMTI	2	tiger salamander	Population peripheral to Blue Mountains. Adult home range tends to be linear, near 30.48 meters (100 ft) along riparian-emergent ecotones.
AMMA	2	long-toed salamander	Regular distribution between 336- and 2 195-meter (1,200 and 7,200-ft) elevation. Adult home range tends to be linear, near 30.48 meters (100 ft) along riparian-emergent ecotones.
ASTR	2	tailed frog	Requires fast, cold, rocky streams; has a maximum high water-temperature tolerance of 9°-11°C (48°-52° F); populations are disjunct from other populations. Individual adult home range is near 21.9 meters (72 ft) along suitable streams.
SCIN	2	Great Basin spadefoot toad	Heavy dependence on sagebrush zone; intermittent ponds make summer dormancy critical.
BUBO	2	western toad	Widely distributed in most habitats throughout the Blue Mountains.
BUWO	2	Woodhouse toad	Peripheral; Blue Mountains are near the northern limits of its distribution.
HYRE	2	Pacific treefrog	Widespread in most habitats throughout the Blue Mountains.
RAPR	2	spotted frog	Widespread along rivers and valleys throughout the Blue Mountains area.
RAPI	2	leopard frog	Populations probably peripheral in region of Snake River.
RACA	1	bullfrog	Introduced for commercial purposes into a number of selected waters; now feral.
		REPTILES	
CHPI	3	painted turtle	Blue Mountains are near the southern periphery of its distribution in the Northwest.
SCOC	5	western fence lizard	Most abundant in foothill rocky areas.
SCGR	5	sagebrush lizard	Predominantly associated with sagebrush.
UTST	4	side-blotched lizard	Most abundant in rocky areas within sagebrush habitats.
PHDO	5	short-horned lizard	Occurs in disjunct populations associated with sandy soils; species has been suggested as threatened in Oregon (see appendix 4).
EUSK	3	western skink	Predominantly associated with foothill riparian habitats.
CNTI	5	western whiptail	Peripheral; reaches the northern extent of its range in the Blue Mountains.
CHBO	15	rubber boa	Widespread, probably in disjunct populations.
DIPU	3	ringneck snake	Predominantly in foothills and canyons.

Letter code	Life form	Common name	Comments
COCO	5	yellow-bellied racer	Predominantly in foothills and canyons.
MATA	5	striped whipsnake	Predominantly in valleys and adjacent foothills.
PIME	5	gopher snake	Predominantly in valleys, canyons, and adjacent foothills.
THSI	3	common garter snake	Widely distributed in riparian habitats.
THEL	5	western terrestrial garter snake	Widely distributed in riparian habitats.
HYTO	5	night snake	Widely distributed, but apparently not abundant; mildly poisonous.
CRVI	5	western rattlesnake	Predominantly in foothills and canyons; poisonous.
		BIRDS	
GAIM	3	common loon	No longer known except during migration; occurs on larger water bodies.
GAAR	3	Arctic loon	Uncommon; occurs during migration.
POGR	3	red-necked grebe	Irregular migrant.
POAU	3	horned grebe	Irregular migrant.
PONI	3	eared grebe	Irregular migrant; one known nesting population peripheral to the Blue Mountains.
AEOC	3	western grebe	Regular migrant; found on both rivers and lakes.
POPO	3	pied-billed grebe	Nests in lower transition zone ponds and marshes.
PEER	3	white pelican	Irregular migrant; sometimes seen along major watercourses; densely colonial.
PHAU	3	double-crested cormorant	Uncommon migrant; two known nesting populations peripheral to the Blue Mountains; densely colonial.
ARHE	12	great blue heron	Nests communally in trees; strong perennial nest-site fidelity.
CAAL	7	common egret	Irregular and uncommon migrant; one known population peripheral to the Blue Mountains; colonial nester.
NYNY	7	black-crowned night heron	Several small, nesting populations known peripheral to the Blue Mountains; colonial nester.
BOLE	3	American bittern	Irregular migrant; several small nesting populations occur within the Blue Mountains area.
PLCH	12	white-faced ibis	Uncommon; irregular migrant; colonial nester.
CYOL	3	mute swan	Rare; irregular migrant.
OLCO	3	whistling swan	Irregular migrant in some locations.
BRCA	3	Canada goose	Regular nester along most major water bodies.

Letter code	Life form	Common name	Comments
BRNI	3	black brant	Uncommon; irregular migrant.
ANAL	3	white-fronted goose	Regular but uncommon migrant.
CHCA	3	snow goose	Irregular migrant.
CHRO	3	Ross' goose	Rare; irregular migrant.
ANPL	3	mallard	Regular nester along larger rivers, most lakes, and many ponds.
ANST	3	gadwall	Regular nester like the mallard but much more common during migration.
ANAC	3	pintail	Regular nester on small ponds and marshes.
ANCR	3	green-winged teal	Regular nester on small ponds and marshes.
ANDI	3	blue-winged teal	Irregular nester on small ponds; far more abundant during migration.
ANCY	3	cinnamon teal	Regular nester on small ponds and marshes.
ANPE	3	European wigeon	Rare; irregular migrant.
ANAM	3	American wigeon	Irregular nester but abundant migrant; occurs on most large bodies of still water.
ANCL	3	northern shoveler	Irregular nester on small ponds, but fairly common migrant.
AISP	14	wood duck	Uncommon, but regular occurrence in the few remaining suitable marshes. This species feeds within the aquatic features indicated rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only for purposes of relative interpretability with all other species—i.e., the species is not limited in feeding by the successional stage of the community surrounding the aquatic zone.
AYAM	3	redhead	Nesting largely peripheral to the Blue Mountains.
AYCO	3	ring-necked duck	Uncommon; irregular nester and migrant.
AYVA	3	canvasback	Irregular migrant.
AYMA	3	greater scaup	Irregular migrant.
AYAF	3	lesser scaup	Regular but not abundant migrant.
BUCL	14	common goldeneye	Regular but not abundant migrant.
BUIS	14	Barrow's goldeneye	Uncommon nester, but regular migrant. This species feeds within the aquatic features indicated rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only for purposes of relative interpretability with all other species—i.e., the species is not limited in feeding by the successional stage of the community surrounding the aquatic zone.

Letter code	Life form	Common name	Comments
BUAL	14	bufflehead	Regular migrant; nesting expected but not recorded. This species feeds within the aquatic features indicated rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only for purposes of relative interpretability with all other species—i.e., the species is not limited in feeding by the successional stage of the community surrounding the aquatic zone.
HIHI	3	harlequin duck	Rare nester; possibly extirpated from the Blue Mountains area.
MEDE	3	white-winged scoter	Rare; irregular migrant.
OXJA	3	ruddy duck	Abundant migrant but uncommon nester on small ponds and marshes.
LOCU	14	hooded merganser	Rare nester and uncommon, irregular migrant. This species feeds within the aquatic features indicated rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only for purposes of relative interpretability with all other species—i.e., the species is not limited in feeding by the successional stage of the community surrounding the aquatic zone.
MEME	14	common merganser	Regular abundant nester on most rivers and perennial streams. This species feeds within the aquatic features indicated rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only for purposes of relative interpretability with all other species—i.e., the species is not limited in feeding by the successional stage of the community surrounding the aquatic zone.
MESE	3	red-breasted merganser	Uncommon; irregular migrant along major bodies of water.
CAAU	4	turkey vulture	Population low; nesting vulnerable to disturbance; uses communal roosts in winter.
ELLE	11	white-tailed kite	Rare; irregular summer migrant.
ACGE	11	goshawk	Nesting habitat critical; population low and sparse.
ACST	11	sharp-shinned hawk	Nesting habitat critical; population apparently lower than normal due to significant habitat impacts.
ACCO	11	Cooper's hawk	Moderately common, though irregularly distributed throughout conifer zones.
BUJA	12	red-tailed hawk	Most common nesting raptor throughout all timbered areas.
BUSW	7	Swainson's hawk	Nesting status of the species within the Blue Mountains may be one of the most stable in North America; species suggested as rare in North America (see appendix 4).
BULA	5	rough-legged hawk	Common; regular migrant and winter vistor.

Letter code	Life form	Common name	Comments
BURE	4	ferruginous hawk	Blue Mountains area populations appear uniquely stable and fairly substantial; species suggested as threatened in North America (see appendix 4).
AQCH	12	golden eagle	Nests on cliffs and in trees in the Blue Mountains area.
HALE	12	bald eagle	Nests in trees in Blue Mountains; no known current nests in area, although common winter resident.
CICY	5	marsh hawk	Primarily oriented to agricultural grassland habitats.
PAHA	12	osprey	Strictly fisheaters; nests on snags and live trees; population very limited but may be expanding. This species feeds within the aquatic features indicated rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only for purposes of relative interpretability with all other species—i.e., the species is not limited in feeding by the successional stage of the community surrounding the aquatic zone.
FAME	4	prairie falcon	Population low in Blue Mountains; nests vulnerable to falconers.
FAPE	4	peregrine	Officially "endangered species" (see appendix 4); population in Blue Mountains extremely limited; requires vertical cliffs higher than 30.48 meters (100 ft) for nesting.
FACO	11	merlin	Nesting population very low; more common winter migrant and visitor.
FASP	14	American kestrel	Feeds largely in edges between timber and grass-forb, and shrub-seedling successional stages; nests in cavities.
DEOB	5	blue grouse	Oriented to forest-grass ecotone; migrates vertically; nests at lower elevations.
CACA	5	Franklin's grouse	Only population in Oregon is in and around Wallowa Mountains which are peripheral to the Blue Mountains.
BOUM	5	ruffed grouse	Regularly and variably abundant in its riparian-timber association.
LALE	4	white-tailed ptarmigan	Introduced in alpine habitats in the Wallowa Mountains; still present.
PEPH	5	sharp-tailed grouse	Near southern periphery of its distribution; currently extinct in Blue Mountains area; reintroduction has been proposed.
CEUR	5	sage grouse	Populations very low in foothills of the Blue Mountains.
COVI	5	bobwhite	Introduced in the 1940's into foothill ranges; may be extirpated within the area.
LOCA	5	California quail	Predominantly in agricultural-shrubland habitats.
ORPI	5	mountain quail	Range limited to brushy canyons; populations local; distribution spotty.
ALCH	4	chukar	Introduced into dry, essentially treeless canyons; cliffs and rimrock important for roosting; populations high.

Letter code	Life form	Common name	Comments
PEPE	5	gray partridge	Introduced; successful in more open foothill grasslands.
PHCO	5	ring-necked pheasant	Introduced; primarily oriented to agricultural lands and foothills adjacent to such areas.
MEGA	5	turkey	Introduced; success appears to be limited by human disturbance; populations may be defined as lingering.
GRCA	3	sandhill crane	The Blue Mountains are peripheral to current nesting populations; historically common; apparently reoccupying area.
RALI	3	Virginia rail	Irregular occurrence; nesting restricted to moderate to large marshes.
POCA	3	sora	Irregular and uncommon nester in small to large marshes.
FUAM	3	American coot	Common nester and winter occupant on larger bodies of still water.
CHAL	3	snowy plover	Nesting largely peripheral to Blue Mountains; most occurrences limited to seasonal migrants.
CHVO	3	killdeer	Common, abundant nester on exposed gravels adjacent to moving or still waters.
CHMO	3	mountain plover	No recent confirmed reports in the Blue Mountains; identified as a species of special interest (see appendix 4).
CAGA	3	common snipe	Nesting largely restricted to agricultural and marshland habitats.
NUAM	3	long-billed curlew	Colonial nester; strong colony-site fidelity in sage-grassland ecotones of foothill areas.
BALO	5	upland sandpiper	Once common; currently a rare nester in forest zone, tall grass, moist meadows.
ACMA	3	spotted sandpiper	Common nester on exposed riparian situations throughout the Blue Mountains.
TRSO	7	solitary sandpiper	Nesting largely peripheral to the Blue Mountains.
TRME	3	greater yellowlegs	Regular, uncommon migrant.
TRFL	3	lesser yellowlegs	Irregular, uncommon migrant.
CASE	3	willet	Irregular but common migrant.
CAME	3	pectoral sandpiper	Uncommon and irregular migrant in mixed flocks of sandpipers.
CABA	3	Baird's sandpiper	Migrant; in moist lowlands and high snow fields.
CAMI	3	least sandpiper	Common but irregular migrant in mixed flocks of sandpipers.
CAMA	3	western sandpiper	Migrant; in moist lowlands and high snowfields.
LISC	3	long-billed dowitcher	Regular, common but not abundant migrant in flocks of sandpipers and snipes.

Letter code	Life form	Common name	Comments
REAM	3	American avocet	Irregular summer migrant; limited to several small nesting colonies on and near major marshes.
STTR	3	Wilson's phalarope	Common nester on small ponds in grassland zones.
LOLO	3	northern phalarope	Common migrant with Wilson's phalarope on small ponds.
LAAR	3	herring gull	Irregular migrant in mixed gull flocks; colonial nester.
LACA	3	California gull	Several nesting colonies peripheral to the Blue Mountains; colonial nester.
LADE	3	ring-billed gull	Irregular migrant; comes into the area from adjacent peripheral nesting colonies.
LAPI	3	Franklin's gull	Irregular; uncommon migrant; comes into the area from adjacent peripheral nesting colonies; colonial nester.
LAPH	3	Bonaparte's gull	Irregular; uncommon migrant only; colonial nester.
STFO	3	Forster's tern	Irregular; uncommon migrant from adjacent peripheral nesting colonies.
HYCA	3	Caspian tern	Irregular; uncommon migrant only; colonial nester.
CHNI	3	black tern	Irregular; uncommon migrant from adjacent peripheral nesting colonies; colonial nester.
COFA	11	band-tailed pigeon	Irregular; uncommon spring migrant.
COLI	4	rock dove	Introduced; feral and widespread; cliff nester.
ZEMA	11	mourning dove	Common nester in fringes of conifer zone.
COAM	8	yellow-billed cuckoo	Rare; low-elevation nester in shrublands.
TYAL	14	barn owl	Feeds largely in edges between timber and grass-forb and shrub-seedling successional stages; cavity nester.
OTAS	14	screech owl	Feeds largely in edges between timber and grass-forb and shrub-seedling successional stages; cavity nester.
OTFL	14	flammulated owl	Feeds largely in edges between timber and grass-forb and shrub-seedling successional stages; feeds largely on insects.
BUVI	12	great horned owl	Nests in hawk nests and holes in cliffs.
NYSC	5	snowy owl	Irregular; uncommon winter migrant.
GLGN	14	pygmy owl	Feeds largely in edges between timber and grass-forb and shrub-seedling successional stages.
SPCU	15	burrowing owl	Largely extirpated over the Blue Mountains area although locally common as a nesting species.
STVA	14	barred owl	Rare; only Oregon records are from the Blue Mountains where it may be expanding its range.

Letter code	Life form	Common name	Comments
STOC	14	spotted owl	Not recorded in Blue Mountains; listed as "possible" based on occurrence of suitable habitat and lack of an intensive survey.
STNE	12	great gray owl	Rare nester in the Blue Mountains.
ASOT	11	long-eared owl	Nests primarily in old Cooper's hawk nests in conifers and in old black-billed magpie nests in other communities.
ASFL	5	short-eared owl	Primarily oriented to low-elevation agricultural lands and adjacent foothills.
AEAC	14	saw-whet owl	Nests and feeds primarily in tall, open timber stands.
PHNU	6	poorwill	Characteristic nester in open sage communities but enters grass-forb successional stage timber zones.
CHMI	6	common nighthawk	Characteristic ground nester in open ponderosa pine and rimrock communities.
CYNI	4	black swift	Nesting not reported in the Blue Mountains, but considered probable; colonial nesting and roosting.
CHVA	14	Vaux's swift	Feeds over canopy of mature timber; nests in cavities high in trees; colonial.
AESA	4	white-throated swift	Nesting not reported in the Blue Mountains, but considered probable; loosely colonial.
ARAL	7	black-chinned hummingbird	Distribution and abundance generally varies with flower bloom sequence.
SEPL	7	broad-tailed hummingbird	Probably uncommon nester in low elevations to midelevations.
SERU	11	rufous hummingbird	Common nester throughout conifer zones in cool brushy situations.
STCA	7	calliope hummingbird	Moderately common nester in conifer-willow open forest situations.
MEAL	16	belted kingfisher	Nests in burrows in riverbanks; mainly a fisheater. This species feeds within the aquatic features indicated rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only for purposes of relative interpretability with all other species—i.e., the species is not limited in feeding by the successional stage of the community surrounding the aquatic zone.
COAU	13	common flicker	Feeds extensively on ground; uses open areas; occurs in all habitat types.
DRPI	13	pileated woodpecker	Feeds largely in dead wood; requires large snags for nesting.
ASLE	13	Lewis' woodpecker	Feeds largely in air—hawking; locally abundant in deciduous timber situations; semicolonial nester.
SPVA	13	yellow-bellied sapsucker	Feeds by gleaning, sapsucking, hawking, and pecking; nesting largely restricted to open water sources.

Letter code	Life form	Common name	Comments
SPTH	13	Williamson's sapsucker	Feeds by gleaning and sapsucking; locally abundant.
DEVI	13	hairy woodpecker	Feeds in both live and dead wood; widely distributed in conifer zones.
DEPU	13	downy woodpecker	Feeds and nests largely in deciduous trees; feeds primarily on surface insects on trees and bushes.
DEAL	13	white-headed woodpecker	Primarily associated with ponderosa pine; feeds by gleaning; eats pine seeds in winter; locally distributed and abundant.
PIAR	13	black-backed three-toed woodpecker	Feeds on bark and subsurface insects in both live and dead wood.
PITR	13	northern three-toed woodpecker	Feeds on bark and subsurface insects in both live and dead wood; species suggested as rare in Oregon due to restricted habitat and local distribution (see appendix 4).
TYTY	7	eastern kingbird	Blue Mountains are near the eastern periphery of its distribution.
TYVE	11	western kingbird	Widespread in open brush country adjacent to conifer zones.
MYCI	14	ash-throated flycatcher	Nests in cavities in open grass-shrublands.
SASA	4	Say's phoebe	Ground, stump, and low rock nester.
EMTR	7	willow flycatcher	Widespread nester in conifer zone riparian shrublands.
EMHA	11	Hammond's flycatcher	Widespread nester in high coniferous zones.
EMOB	8	dusky flycatcher	Widespread nester in areas ranging from open shrubland to mixed shrubland-forest.
EMWR	7	gray flycatcher	Widespread nester in sagebrush or predominantly sagebrush areas.
EMDI	10	western flycatcher	Widespread conifer zone nester, closely associated with dense, cool, moist conditions.
COVIR	9	eastern wood pewee	Rare seasonal visitor.
COSO	11	western wood pewee	Common, widespread nester in open woodlands.
NUBO	10	olive-sided flycatcher	The characteristic nesting flycatcher of extensive dense conifer to broken conifer zones.
ERAL	5	horned lark	Common; abundant species of most open grasslands.
TATH	14	violet-green swallow	Feeds over water and openings and within open timber; cavity nester.
IRBI	14	tree swallow	Feeds over water and openings and within open timber; cavity nester.
RIRI	16	bank swallow	Nests in burrows in sandy or clayey streambanks and riverbanks; colonial.
STRU	16	rough-winged swallow	Nests in burrows in banks or crevices in rocks; loosely colonial.

Letter code	Life form	Common name	Comments
HIRU	4	barn swallow	Accepts artificial cliff simulations for nesting sites, such as barns and concrete bridges.
PEPY	4	cliff swallow	Colonial in historic locations; colonies not abundant but generally widespread.
PECA	11	gray jay	Common, characteristic year-round inhabitant of most extensive coniferous areas.
CYCR	9	blue jay	Rare visitor; species appears to be expanding its range westward.
CYST	11	Steller's jay	Common, characteristic year-round inhabitant of open timberlands to shrubland areas.
PIPI	7	black-billed magpie	Common nester in predominantly shrubland habitats; forages seasonally in all situations.
COCOR	4	common raven	Common nester on cliffs, rimrock, and trees throughout the area.
COBR	11	common crow	Common nester in primarily deciduous timber zones and associated conifer edges.
GYCY	10	pinyon jay	Common, characteristic nester in juniper and juniper-sage associations in southern Blue Mountains area.
NUCO	10	Clark's nutcracker	Nests at high elevations; bird's feeding behavior is primary mode of whitebark pine seed release.
PAAT	14	black-capped chickadee	Feeds by gleaning throughout canopy; nesting restricted to deciduous zones; cavity nester.
PAGA	14	mountain chickadee	Feeds by gleaning throughout canopy; cavity nester.
PARU	14	chestnut-backed chickadee	Feeds by gleaning throughout canopy; nests in dense coniferous zones; Blue Mountains are on eastern periphery of its distribution.
PSMI	8	bushtit	Primarily peripheral to the Blue Mountains due to sage-juniper habitat orientation.
SICA	13	white-breasted nuthatch	Primarily associated with ponderosa pine; feeds extensively on insects in trunk bark of live trees.
SICAN	13	red-breasted nuthatch	Associated with mixed conifer stands; feeds extensively on insects in bark of live trees.
SIPY	13	pygmy nuthatch	Primarily associated with ponderosa pine; forages in flocks; feeds on insects in bark and on surface of trees; locally distributed in ponderosa pine zone; loosely colonial.
CEFA	14	brown creeper	Nests under loose bark; roosts in cavities; feeds on trunks and branches; characteristic of mature ponderosa pine zones.
CIME	3	dipper	Strictly stream oriented; feeding dependent on aquatic insects.
TRAE	14	house wren	Typically an "edge" species; nests in cavities in trees in or adjacent to openings.
TRTR	3	winter wren	Primarily associated with dense coniferous riparian zones.

Letter code	Life form	Common name	Comments
TEPA	3	long-billed marsh wren	Closely associated with rush, cattail marshes.
CAMEX	4	canyon wren	Closely associated with cliffs, rimrock, and talus in canyons.
SAOB	4	rock wren	Accepts artificial habitats, such as rock fills and slash piles.
MIPO	7	mockingbird	Rare visitor; the Blue Mountains are on the western periphery of its distribution.
DUCA	7	gray catbird	The Blue Mountains are near western periphery of the species' distribution, but it is common.
ORMO	7	sage thrasher	A sagebrush obligate.
TUMI	7	American robin	Common; widespread in most habitats providing shrubs for nesting.
IXNA	11	varied thrush	Locally distributed; nests in dense, double-storied conifer situations.
CAGU	5	hermit thrush	A characteristic nester in well-formed mature and old-growth, true fir, and mixed conifer forests.
CAUS	7	Swainson's thrush	A characteristic conifer, conifer-shrubland ecotonal nester.
CAFU	5	veery	Largely restricted to well-developed deciduous habitats, principally riparian, in the Blue Mountains.
SIME	14	western bluebird	Typically an "edge" species; nests in cavities in trees in or adjacent to openings.
SICU	14	mountain bluebird	Typically an "edge" species; nests in cavities in trees in or adjacent to openings.
MYTO	6	Townsend's solitaire	Principally an open dryland or shrub-grassland nester; winters in extensive juniper stands.
RESA	10	golden-crowned kinglet	A year-round resident of mixed conifer and true fir communities with the greatest canopy form (largest live canopy volume).
RECA	10	ruby-crowned kinglet	A common migratory species; nesting closely associated with dense conifer development.
ANSP	5	water pipit	Most commonly reported as a migrant, but a fairly common alpine-zone grassland nester.
BOGA	8	Bohemian waxwing	Winter migrant only; common forager of deciduous mast producing situations; loosely colonial; flocking.
BOCE	9	cedar waxwing	Migratory but common nester in dense deciduous habitats—usually riparian zones; loosely colonial; flocking.
LAEX	7	northern shrike	Winter migrant only; forages widely in all habitats.
LALU	7	loggerhead shrike	Migratory but moderately common nester in juniper-sage, sage, and other shrubland communities.
STVU	14	starling	Introduced; typically an "edge" species; nests in cavities in trees in or adjacent to openings; loosely colonial.

Letter code	Life form	Common name	Comments
VISO	11	solitary vireo	Widespread and common nester—principally in well-formed intermediate-stage conifer communities.
VIOL	11	red-eyed vireo	Uncommon, but perhaps only rarely reported; largely restricted to dense deciduous riparian habitats.
VIGI	11	warbling vireo	Moderately common; nesting is principally restricted to tree-form deciduous communities.
VECE	6	orange-crowned warbler	Common nester in dense willow habitats throughout the Blue Mountains area.
VERU	6	Nashville warbler	Moderately common nester—principally in habitats with a deciduous shrub understory and conifer overstory.
PAAM	10	northern parula	Rare winter visitor; the Blue Mountains are on western periphery of its distribution.
DEPE	8	yellow warbler	Common deciduous habitat nester throughout the Blue Mountains.
DECO	10	yellow-rumped warbler	Widespread and abundant nester in nearly all tree-form habitats throughout the Blue Mountains.
DENI	10	black-throated gray warbler	Moderately common nester of 0.3- to 1.2-meter (1- to 4-ft) high shrub-form habitats interspersed throughout the conifer zone.
DETO	10	Townsend's warbler	A characteristic nesting species of multiple canopy, mature, and old-growth true fir and mixed conifer stands where it nests low and forages high.
SENO	3	northern waterthrush	Uncommon nester in northern portion of the Blue Mountains—the southwest periphery of its distribution.
OPTO	7	MacGillivray's warbler	Common nester in moist, shrubby situations within the conifer zone.
GETR	3	common yellowthroat	Common nester in tall rush, cattail marsh habitats.
ICVI	8	yellow-breasted chat	The Blue Mountains are on the western periphery of its distribution, but the species is a common nester in dense shrubs.
WIPU	5	Wilson's warbler	Widespread but uncommon nester in low shrubby areas throughout the conifer zone.
SERUT	9	American redstart	Uncommon nesting species; Blue Mountains are near western periphery of its distribution; habitat restricted to deciduous riparian communities.
PADO	14	house sparrow	Introduced; feeds in openings adjacent to mature stands; dependent cavity nester, occupancy closely associated with humans.
DOOR	5	bobolink	Colonial nester; migratory; occurs in only a few areas; the Blue Mountains are on western periphery of its distribution. Habitat is moist grass-shrubland areas.
STNEG	5	western meadowlark	Common in open, dry grasslands.

Letter code	Life form	Common name	Comments
XAXA	7	yellow-headed blackbird	Colonial; closely associated with alkaline sedge marsh habitats.
AGPH	7	red-winged blackbird	Common; widespread nester in moist grassland and grass-shrubland habitats.
ICSP	9	orchard oriole	Rare full-winter visitor; Blue Mountains are on western periphery of its distribution.
ICGA	9	northern oriole	Common nester in tall shrub-form and tree-form deciduous communities.
EUCY	7	Brewer's blackbird	Common; widespread nester in shrub and shrub-tree communities.
QUQU	7	common grackle	Rare seasonal visitor; the Blue Mountains are on the western periphery of its distribution.
MOAT	7	brown-headed cowbird	Parasitic; eggs laid in nests of other species—often blackbirds.
PILU	10	western tanager	Common widespread tree-form habitat nester, principally in broken and open conifer situations.
PHME	11	black-headed grosbeak	Common; widespread nester principally in mature, old-growth ponderosa pine zones.
PAAMO	7	lazuli bunting	Common; widespread nester in shrub-form and shrub-grassland habitats along rivers and valleys.
HEVE	11	evening grosbeak	Common; nomadic; nests principally in young and old-growth stages of conifer communities throughout the Blue Mountains.
CAPU	11	purple finch	Nesting in Blue Mountains generally restricted to elevations above 1829 meters (6,000 ft) in open conifer habitats.
CACAS	11	Cassin's finch	Common; nests in midelevation coniferous zones.
CAMEXI	9	house finch	Common; nests in dense conifers at low elevations.
PIEN	11	pine grosbeak	Locally distributed nester throughout mature ponderosa pine zones.
LETE	4	gray-crowned rosy finch	Common winter visitor, but the nesting subspecies (Wallowa finch) is listed as "threatened" (see appendix 4) because it only nests in alpine zones of the Eagle Cap Wilderness in the Wallowa Mountains adjacent to the Blue Mountains.
LEAT	4	black rosy finch	Regular occurrence and/or nesting unreported in the area, but is anticipated.
SPPI	11	pine siskin	Often referred to as the coniferous-zone goldfinch; nesting is widespread in conifer communities.
SPTR	8	American goldfinch	Nests principally in deciduous tree-form habitats at low elevations.
SPPS	7	lesser goldfinch	Locally common; nests in dry grass-shrubland ecotone.
LOCUR	10	red crossbill	Flocking; nomadic; nests in most coniferous zones.

Letter code	Life form	Common name	Comments
LOLE	10	white-winged crossbill	Uncommon; flocking; nomadic migrant only.
CHCH	7	green-tailed towhee	Common; low to moderate shrub-form nester in extensive shrublands of ceanothus and sagebrush.
PIER	7	rufous-sided towhee	Common nester in dense shrubby habitats, usually riparian in orientation.
PASA	5	savannah sparrow	Common; nests in open, dry grassland.
AMSA	5	grasshopper sparrow	Suggested as a threatened species nationally (see appendix 4); uncommon in the Blue Mountains area.
POGRA	5	vesper sparrow	Common; nests in open, dry grassland.
CHGR	5	lark sparrow	Nesting principally oriented to shrub-grass ecotone.
AMBE	7	sage sparrow	Sagebrush obligate.
JUHY	5	dark-eyed junco	Common ground nester in open conifer stands.
SPAR	7	tree sparrow	Uncommon winter visitor.
SPPA	7	chipping sparrow	Probably the most common nesting passerine in the Blue Mountains; principally nests in shrubs in conifer zones.
SPBR	7	Brewer's sparrow	Sagebrush obligate; as widespread as its sagebrush habitat.
ZOLE	7	white-crowned sparrow	Common nesting species of open alpine and subalpine conifer situations.
ZOAT	5	golden-crowned sparrow	Uncommon winter visitor.
ZOAL	5	white-throated sparrow	Uncommon winter visitor.
PAIL	7	fox sparrow	Moderately common migrant; less common nester of open timber and open shrubland.
MELI	6	Lincoln's sparrow	Nests in shrubby bogs throughout conifer zone but principally in alpine and subalpine situations.
MEMEL	7	song sparrow	Perhaps the most conspicuous, common, shrubland and tree-shrubland nester in the Blue Mountains area.
CALA	5	Lapland longspur	Rare winter visitor.
PLNI	5	snow bunting	Uncommon, irregular winter visitor.
		MAMMALS	
DIMA	5	opossum	Introduced in Umatilla County between 1910 and 1921; probably extirpated by now.
SOPR	15	Malheur shrew	Considered rare.
SOVA	15	vagrant shrew	Widely distributed.
SOOB	15	dusky shrew	Widely distributed.

Letter code	Life form	Common name	Comments
SOPA	16	northern water shrew	Predominantly associated with swift, rocky, mountain streams.
SOME	15	Merriam shrew	Rare; uses xeric sagebrush and other grass-dominant habitats.
SCOR	15	coast mole	Generally uncommon but may be locally abundant.
MYLU	14	little brown myotis	Feeds in openings in and adjacent to mature stands and within open stands; colonial.
MYYU	14	Yuma myotis	Feeds primarily over water surfaces; apparently not common; colonial.
MYEV	14	long-eared myotis	Feeds in openings in and adjacent to mature stands and within open stands; occurrence predominantly in open stands; colonial.
MYVO	14	long-legged myotis	Feeds within and adjacent to mature timber; predominantly in dense stands; colonial.
MYCA	14	California myotis	Feeds in openings in and adjacent to mature stands and within open stands; apparently not common; colonial.
MYLE	4	small-footed myotis	Uncommon; feeds along cliffs and in canyons; loosely colonial.
LANO	14	silver-haired bat	Feeds in openings in and adjacent to mature stands and within open stands; migrant.
PIHE	4	western pipistrelle	Forms small nursery colonies and hibernacula in volcanic substrate; feeds along cliffs, in canyons, and over talus; loosely colonial.
EPFU	14	big brown bat	Feeds over canopy, in openings in and adjacent to mature stands, and within open stands; colonial.
LACI	11	hoary bat	Migrant; predominantly males in Oregon—most females spend summer east of Rocky Mountains; feeds over forest canopy, along roads, forest edges, and over meadows; roosts singly in foliage.
EUMA	4	spotted bat	Officially a "threatened species" (see appendix 4), may enter Blue Mountains in southeast portions; flies very late at night.
PLTO	4	western big-eared bat	Forms nursery colonies and hibernacula in caves (occasionally in buildings); intolerant of human disturbance; feeds late at night.
ANPA	4	pallid bat	Forms nursery colonies and hibernacula in cliffs, hollow trees, and buildings; feeds in open areas close to ground.
OCPR	4	pika	Highly stable populations; associated primarily with talus above foothills; colonial.
SYID	15	pygmy rabbit	Uncommon; in sagebrush and other shrublands with sandy soil.
SYNU	15	mountain cottontail	Predominantly in agricultural lands and adjacent foothills.
LEAM	5	snowshoe hare	"Cyclic," in that population highs and lows seem to occur at more or less regular intervals; regular distribution in conifer habitats.
LETO	5	whitetail jackrabbit	Locally distributed; common.

Letter code	Life form	Common name	Comments
LECA	5	blacktail jackrabbit	Generally distributed in sagebrush and other dry shrubland zones.
EUMI	15	least chipmunk	Peripheral to the Blue Mountains in sagebrush zones.
EUAM	15	yellow pine chipmunk	Widely distributed throughout most habitats.
MAFL	4	yellow-bellied marmot	Widely distributed in rocky habitats; colonial.
SPTO	15	Townsend ground squirrel	Peripheral; locally abundant; colonial.
SPWA	15	Washington ground squirrel	Peripheral; possibly extirpated; colonial.
SPBE	15	Belding ground squirrel	Widely distributed; colonial.
SPCO	15	Columbian ground squirrel	Widely distributed; colonial.
SPLA	15	mantled ground squirrel	Widely distributed; colonial.
SCGRI	10	western gray squirrel	Peripheral; unconfirmed reports from western edge of the Blue Mountains.
SCNI	14	eastern fox squirrel	Introduced into some towns; extensively uses deciduous trees.
TAHU	10	red squirrel	Widely distributed.
TADO	10	chickaree	Populations limited to western portions of Blue Mountains.
GLSA	14	northern flying squirrel	Widely distributed in conifer zone; greatest populations in areas with abundance of downed logs.
THTO	15	Townsend pocket gopher	Peripheral; may occur in southeastern corner of the Blue Mountains.
THTA	15	northern pocket gopher	Widely distributed; greatest numbers in deep soil sites.
PEPA	15	Great Basin pocket mouse	Predominantly associated with sagebrush.
DIOR	15	Ord kangaroo rat	Predominantly associated with sagebrush.
CACAN	16	beaver	Widely distributed along significant watercourses.
REME	15	western harvest mouse	Predominantly associated with sagebrush.
PECR	4	canyon mouse	Northern periphery of its range is in the Blue Mountains.
PEMA	15	deer mouse	Widely distributed.
PETR	4	pinyon mouse	Northern and eastern periphery of its range is in the Blue Mountains.
ONLE	15	northern grasshopper mouse	Predominantly associated with sagebrush.
NECI	4	bushy-tailed woodrat	Widely distributed.
CLGA	15	Gapper red-backed vole	Widely distributed in coniferous forests.
PHIN	15	heather vole	Occupies marginal habitat; frequently associated with wet mountain meadows.

Letter code	Life form	Common name	Comments
MIMO	15	mountain vole	Populations fluctuate locally.
MILO	15	long-tailed vole	Populations fluctuate locally.
MIRI	16	water vole	Associated mainly with cold mountain streams and lakes.
LACU	15	sagebrush vole	Populations fluctuate locally.
ONZI	16	muskrat	Predominantly in slow, quiet water.
RANO	15	Norway rat	Introduced; occurs around human habitation.
MUMU	15	house mouse	Introduced; occurs around human habitation.
ZAPR	3	western jumping mouse	Primarily associated with riparian habitats.
ERDO	6	porcupine	Widely distributed.
MYCO	16	nutria	Introduced; peripheral to Blue Mountains.
CALAT	15	coyote	Widely distributed.
CALU	15	gray wolf	Extremely rare, but probably present.
VUVU	15	red fox	Native subspecies uncommon; valley populations are introduced eastern subspecies; restricted to open forests and mountain meadows.
URCI	15	gray fox	Rare; Blue Mountains are on eastern periphery of its range.
URAM	15	black bear	Widely distributed.
PRLO	14	raccoon	Associated with riparian habitat.
MAAM	14	marten	Blue Mountains and Wallowa Mountains populations probably the most stable in Oregon; intolerant of human disturbance.
MAPE	14	fisher	Reintroduced; rare, probably restricted to the Wallowa Mountains; peripheral to Blue Mountains.
MUER	15	short-tailed weasel	Widely distributed in coniferous habitats.
MUFR	15	long-tailed weasel	Widely distributed.
MUVI	16	mink	Widely distributed in riparian habitats.
GUGU	5	wolverine	Rare; occurs predominantly at high elevations.
TATA	15	badger	Predominantly associated with sagebrush.
SPPU	15	spotted skunk	Primarily in valleys and foothills.
MEMEP	15	striped skunk	Primarily in valleys around agricultural lands.
LUCA	16	river otter	Widely distributed along rivers and larger streams.
FECO	4	puma	Widely distributed.

Letter code	Life form	Common name	Comments
FECA	5	feral house cat	Primarily in valleys and adjacent foothills; gradually spreading.
LYCA	5	lynx	Rare, but probably present.
LYRU	4	bobcat	Populations currently low; given status as a fur-bearing mammal in 1977.
EQCA	5	feral horse	Locally distributed; variably abundant as managed.
CEEL	5	elk	Primary game species; see chapter 8.
ODHE	5	mule deer	Primary game species; see chapter 8.
ODVI	5	white-tailed deer	Locally common along major watercourses.
ANAME	5	pronghorn	Distribution scattered and local in foothills.
ORAM	4	mountain goat	Introduced into Wallowa Mountains; local; one band of about 30 present, more introductions proposed.
OVCA	4	big-horned sheep	Reintroduced into Wallowa Mountains; local; reintroductions continuing.

Appendix 17

Wildlife species that use tree cavities—primary occurrence by major habitat (plant community)

Species				1	2	3	4	5	6	7	8
BIRDS											
AISP	14	wood duck	S		•	•	•	•			
BUCL	14	common goldeneye	S			•					
BUIS	14	Barrow's goldeneye	S	•	•	•	•	•			
BUAL	14	bufflehead	S	•	•	•	•	•	•	•	•
LOCU	14	hooded merganser	S	•	•	•	•	•			
MEME	14	common merganser	S	•	•	•	•				
FASP	14	American kestrel	S	•	•	•	•	•			
TYAL	14	barn owl	S			•	•	•	•		
OTAS	14	screech owl	S	•	•	•					
OTFL	14	flammulated owl	S				•	•			
GLGN	14	pygmy owl	S	•	•	•	•	•			
STVA	14	barred owl	S			•	•	•	•		
AEAC	14	saw-whet owl	S		•	•	•	•	•	•	
CHVA	14	Vaux's swift	S			•		•	•	•	•
COAU	13	common flicker	P	•	•	•	•	•	•		
DRPI	13	pileated woodpecker	P				•	•	•		
ASLE	13	Lewis' woodpecker	P			•	•	•			
SPVA	13	yellow-bellied sapsucker	P		•	•					
SPTH	13	Williamson's sapsucker	P				•	•	•		•
DEVI	13	hairy woodpecker	P				•	•	•	•	•
DEPU	13	downy woodpecker	P		•	•					
DEAL	13	white-headed woodpecker	P				•	•			
PIAR	13	black-backed three-toed woodpecker	P					•	•	•	•
PITR	13	northern three-toed woodpecker	P							•	•
MYCI	14	ash-throated flycatcher	S	•	•	•	•				
TATH	14	violet-green swallow	S		•	•	•				

Letter code — Life form

P Primary cavity excavator
S Secondary cavity user
• Symbol denotes primary occurrence

1 Western juniper
2 Quaking aspen
3 Riparian (cottonwood)
4 Ponderosa pine
5 Mixed conifer
6 White fir (grand fir)
7 Lodgepole pine
8 Subalpine fir

Occurrence by major habitat (plant community)

Letter code	Life form	Species		1 Western juniper	2 Quaking aspen	3 Riparian (cottonwood)	4 Ponderosa pine	5 Mixed conifer	6 White fir (grand fir)	7 Lodgepole pine	8 Subalpine fir
		BIRDS									
IRBI	14	tree swallow	S		•	•	•	•			
PAAT	14	black-capped chickadee	P		•	•					
PAGA	14	mountain chickadee	P	•			•	•	•	•	•
PARU	14	chestnut-backed chickadee	P					•	•	•	
SICA	13	white-breasted nuthatch	P				•	•			
SICAN	13	red-breasted nuthatch	P					•	•	•	
SIPY	13	pygmy nuthatch	P		•		•	•			
CEFA	14	brown creeper	S			•	•	•			
TRAE	14	house wren	S		•	•	•	•			
SIME	14	western bluebird	S	•	•		•	•			
SICU	14	mountain bluebird	S	•	•		•	•			
STVU	14	starling	S			•					
PADO	14	house sparrow	S			•					
		MAMMALS									
DIMA	5	opossum	S			•					
MYLU	14	little brown myotis	S	•	•	•	•	•	•	•	•
MYYU	14	Yuma myotis	S			•					
MYEV	14	long-eared myotis	S	•	•	•	•	•	•	•	•
MYVO	14	long-legged myotis	S	•	•	•	•	•	•	•	•
MYCA	14	California myotis	S	•	•	•	•	•	•	•	•
LANO	14	silver-haired bat	S	•	•	•	•	•	•	•	•
EPFU	14	big brown bat	S	•	•	•	•	•	•	•	•
ANPA	4	pallid bat	S				•				
EUAM	15	yellow pine chipmunk	S	•	•	•	•	•	•	•	•
SCGRI	10	western gray squirrel	S			•	•	•			
SCNI	14	eastern fox squirrel	S			•					

Letter code — Life form

P Primary cavity excavator
S Secondary cavity user
• Symbol denotes primary occurrence

Occurrence by major habitat (plant community)

Species				1	2	3	4	5	6	7	8
MAMMALS											
TAHU	10	red squirrel	S			•	•	•	•	•	•
TADO	10	chickaree	S			•	•	•	•	•	•
GLSA	14	northern flying squirrel	S			•	•	•	•	•	•
PEMA	15	deer mouse	S	•	•	•	•	•	•	•	•
NECI	4	bushy-tailed woodrat	S	•	•	•	•	•	•	•	•
PRLO	14	raccoon	S			•					
MAAM	14	marten	S					•	•	•	•
MAPE	14	fisher	S			•		•	•	•	•
MUER	15	short-tailed weasel	S			•		•	•	•	•
MUFR	15	long-tailed weasel	S	•	•	•	•	•	•	•	•
SPPU	15	spotted skunk	S		•		•	•			
		Totals: 39 bird species 23 mammal species 62 species		22	31	45	43	46	29	25	23
Letter code	Life form	P Primary cavity excavator S Secondary cavity user • Symbol denotes primary occurrence		1 Western juniper	2 Quaking aspen	3 Riparian (cottonwood)	4 Ponderosa pine	5 Mixed conifer	6 White fir (grand fir)	7 Lodgepole pine	8 Subalpine fir
				Occurrence by major habitat (plant community)							

Appendix 18

Tree species preferred for nesting by woodpeckers in the Pacific Northwest, with particular reference to the Blue Mountains

Letter code	Life form	Species	Alder	Aspen	Cottonwood	Fir (grand, subalpine)	Douglas-fir	Hemlock	Juniper	Larch	Lodgepole pine	Ponderosa pine	Poplar (not aspen)	Spruce	Willow	Comments
COAU	13	common flicker		[1]20	2	15	4		•	16		12	•		2	Prefers soft wood
DRPI	13	pileated woodpecker		1	2	1				10		42				
ASLE	13	Lewis' woodpecker			35	1			5	•		6			2	Prefers open stands near water
SPVA	13	yellow-bellied sapsucker	•	26	•	2				20	1	•		2	•	
SPTH	13	Williamson's sapsucker		4		8	1	5		12	6	14				Often associated with ponderosa pine
DEVI	13	hairy woodpecker		22	4	8	2			11	1	7		1		Prefers relatively open situations
DEPU	13	downy woodpecker	•	23											4	Prefers soft decayed wood
DEAL	13	white-headed woodpecker		1		2	1					9		1		
PIAR	13	black-backed three-toed woodpecker		3		2	1			5	•	2		9		Prefers snag clumps
PITR	13	northern three-toed woodpecker		1		3				•	5	4		4		Prefers snag clumps
		Number of woodpecker species using each tree species	2	9	5	9	5	1	2	8	5	9	1	5	4	

[1]Numbers of nests are from unpublished data of the principal authors of chapter 5 and from Bull (1975), Jackman (1974b), McClelland (1977), and Miller and Miller (1974-1975).

• Symbol represents nesting observations mentioned by the above authors or other observed nesting with no record of numbers of nests.

Appendix 19

Wildlife species that use cavities—minimum d.b.h. for nesting and minimum nesting heights

Letter code	Life form	Species	Minimum nesting height, in meters (feet): ≥1.8 (≥6)	≥4.6 (≥15)	≥9.1 (≥30)	≥9.5 (≥31)	Minimum d.b.h. required for nesting, in centimeters (inches)
PAAT	14	black-capped chickadee	•				10.2 (4)
PAGA	14	mountain chickadee	•				
PARU	14	chestnut-backed chickadee	•				
DEPU	13	downy woodpecker		•			15.2 (6)
SPVA	13	yellow-bellied sapsucker		•			25.4 (10)
DEVI	13	hairy woodpecker		•			
DEAL	13	white-headed woodpecker	•				
MYCI	14	ash-throated flycatcher		•			
TATH	14	violet-green swallow		•			
IRBI	14	tree swallow		•			
CEFA	14	brown creeper		•			
TRAE	14	house wren	•				
SIME	14	western bluebird	•				
SICU	14	mountain bluebird	•				
STVU	14	starling	•				
PADO	14	house sparrow		•			
EUAM	15	yellow pine chipmunk	•				
PEMA	15	deer mouse	•				25.4 (10)
MUER	15	short-tailed weasel	•				
FASP	14	American kestrel		•			30.5 (12)
OTAS	14	screech owl		•			
OTFL	14	flammulated owl	•				
GLGN	14	pygmy owl			•		
AEAC	14	saw-whet owl		•			
COAU	13	common flicker	•				
ASLE	13	Lewis' woodpecker			•		
SPTH	13	Williamson's sapsucker		•			
PIAR	13	black-backed three-toed woodpecker	•				
PITR	13	northern three-toed woodpecker		•			
SICA	13	white-breasted nuthatch		•			
SICAN	13	red-breasted nuthatch		•			
SIPY	13	pygmy nuthatch			•		
MYLU	14	little brown myotis	•				
MYYU	14	Yuma myotis	•				
MYEV	14	long-eared myotis	•				
MYVO	14	long-legged myotis	•				

• Symbol denotes occurrence only.

Letter code	Life form	Species	Minimum nesting height, in meters (feet) ≥1.8 (≥6)	≥4.6 (≥15)	≥9.1 (≥30)	≥9.5 (≥31)	Minimum d.b.h. required for nesting, in centimeters (inches)
MYCA	14	California myotis	•				30.5 (12)
LANO	14	silver-haired bat		•			
EPFU	14	big brown bat		•			
ANPA	4	pallid bat		•			
TAHU	10	red squirrel		•			
TADO	10	chickaree		•			
GLSA	14	northern flying squirrel		•			
MUFR	15	long-tailed weasel	•				
BUAL	14	bufflehead	•				38.1 (15)
LOCU	14	hooded merganser	•				
SCGRI	10	western gray squirrel		•			
SCNI	14	eastern fox squirrel		•			
NECI	4	bushy-tailed woodrat	•				
MAAM	14	marten		•			

Letter code	Life form	Species	Minimum nesting height, in meters (feet) ≥1.8 (≥6)	≥4.6 (≥15)	≥9.1 (≥30)	≥9.5 (≥31)	Minimum d.b.h. required for nesting, in centimeters (inches)
AISP	14	wood duck	•				50.8 (20)
BUCL	14	common goldeneye	•				
BUIS	14	Barrow's goldeneye	•				
MEME	14	common merganser	•				
TYAL	14	barn owl		•			
STVA	14	barred owl			•		
CHVA	14	Vaux's swift				•	
DRPI	13	pileated woodpecker				•	
DIMA	5	opossum	•				
PRLO	14	raccoon	•				
MAPE	14	fisher			•		
SPPU	15	spotted skunk	•				
		Totals: 39 birds 23 mammals 62 species	30	25	5	2	

• Symbol denotes occurrence only

Appendix 20

Types of cavities and specific wildlife uses

Letter code	Life form	Species	Minimum d.b.h., in centimeters (inches), suitable for nesting	1 Excavates cavity, usually in sound wood	2 Excavates cavity, usually in soft or decayed wood	3 Occupies cavity made by another species	4 Occupies "natural" cavities created by decay, etc.	5 Occupies space under loose bark	6 Construction part of courtship ritual	7 Nests and/or raises young	8 Roosting	9 Overwintering	10 Hibernating
PAAT	14	black-capped chickadee[1]	10.2 (4)		•	•	•			•	•	•	
PAGA	14	mountain chickadee[1]			•	•	•			•	•	•	
PARU	14	chestnut-backed chickadee[1]			•	•	•			•	•	•	
DEPU	13	downy woodpecker[2]	15.2 (6)	•	•				•	•	•	•	
SPVA	13	yellow-bellied sapsucker[2]	25.4 (10)	•					•	•	•		
DEVI	13	hairy woodpecker[2]		•					•	•	•	•	
DEAL	13	white-headed woodpecker[2]		•					•	•	•	•	
MYCI	14	ash-throated flycatcher				•	•			•			
TATH	14	violet-green swallow				•				•			
IRBI	14	tree swallow				•				•			
CEFA	14	brown creeper					•	•		•	•	•	
TRAE	14	house wren				•	•			•			
SIME	14	western bluebird				•	•			•	•		
SICU	14	mountain bluebird				•	•			•	•		
STVU	14	starling				•	•			•	•	•	
PADO	14	house sparrow				•	•			•	•		
EUAM	15	yellow pine chipmunk				•	•			•			
PEMA	15	deer mouse				•	•	•		•		•	
MUER	15	short-tailed weasel				•	•			•			
FASP	14	American kestrel	30.5 (12)			•	•			•			
OTAS	14	screech owl				•	•			•	•	•	
OTFL	14	flammulated owl				•	•			•	•		
GLGN	14	pygmy owl				•	•			•	•	•	
AEAC	14	saw-whet owl				•	•			•	•	•	
COAU	13	common flicker[2]		•		•	•		•	•	•	•	

[1]Primary excavators in soft wood.
[2]Primary excavators in sound wood.
• Symbol denotes occurrence only.

Types of cavities utilized: 1–5. Uses of cavities: 6–10.

Letter code	Life form	Species	Minimum d.b.h., in centimeters (inches), suitable for nesting	Types of cavities utilized: 1 Excavates cavity, usually in sound wood	2 Excavates cavity, usually in soft or decayed wood	3 Occupies cavity made by another species	4 Occupies "natural" cavities created by decay, etc.	5 Occupies space under loose bark	Uses of cavities: 6 Construction part of courtship ritual	7 Nests and/or raises young	8 Roosting	9 Overwintering	10 Hibernating
ASLE	13	Lewis' woodpecker[1]	30.5 (12)		•	•				•	•		
SPTH	13	Williamson's sapsucker[2]		•					•	•	•		
PIAR	13	black-backed three-toed woodpecker[2]		•					•	•	•	•	
PITR	13	northern three-toed woodpecker[2]		•					•	•	•	•	
SICA	13	white-breasted nuthatch[1]			•	•				•	•	•	
SICAN	13	red-breasted nuthatch[1]			•	•				•	•	•	
SIPY	13	pygmy nuthatch[1]		•	•				•	•	•	•	
MYLU	14	little brown myotis				•	•	•		•	•	•	
MYYU	14	Yuma myotis				•	•	•			•		
MYEV	14	long-eared myotis				•	•	•		•	•		
MYVO	14	long-legged myotis				•	•	•		•	•		•
MYCA	14	California myotis				•	•	•		•	•		•
LANO	14	silver-haired bat				•	•	•		•	•		•
EPFU	14	big brown bat				•	•	•		•	•		•
ANPA	4	pallid bat				•	•	•		•	•		•
TAHU	10	red squirrel				•	•			•		•	
TADO	10	chickaree				•	•			•		•	
GLSA	14	northern flying squirrel				•	•			•		•	
MUFR	15	long-tailed weasel					•			•		•	
BUAL	14	bufflehead	38.1 (15)			•	•			•			
LOCU	14	hooded merganser				•	•			•			
SCGRI	10	western gray squirrel				•	•			•		•	
SCNI	14	eastern fox squirrel				•	•			•		•	
NECI	4	bushy-tailed woodrat				•	•			•		•	
MAAM	14	marten				•	•			•			

[1]Primary excavators in soft wood.
[2]Primary excavators in sound wood.
• Symbol denotes occurrence only.

Letter code	Life form	Species	Minimum d.b.h., in centimeters (inches), suitable for nesting	1 Excavates cavity, usually in sound wood	2 Excavates cavity, usually in soft or decayed wood	3 Occupies cavity made by another species	4 Occupies "natural" cavities created by decay, etc.	5 Occupies space under loose bark	6 Construction part of courtship ritual	7 Nests and/or raises young	8 Roosting	9 Overwintering	10 Hibernating
AISP	14	wood duck	50.8 (20)			•	•			•			
BUCL	14	common goldeneye				•	•			•			
BUIS	14	Barrow's goldeneye				•	•			•			
MEME	14	common merganser					•			•			
TYAL	14	barn owl				•	•			•			
STVA	14	barred owl					•			•			
CHVA	14	Vaux's swift				•	•			•	•		
DRPI	13	pileated woodpecker[2]		•					•	•	•	•	
DIMA	5	opossum					•			•		•	
PRLO	14	raccoon					•			•		•	
MAPE	14	fisher					•			•			
SPPU	15	spotted skunk					•			•		•	
		Total number of species:		10	8	45	48	10	10	61	34	30	5
		Types of cavities utilized		1	2	3	4	5	Uses of cavities 6	7	8	9	10

[1]Primary excavators in soft wood.
[2]Primary excavators in sound wood.
• Symbol denotes occurrence only.

Appendix 21

Woodpecker territory sizes, maximum densities, cavities excavated per year, and nest tree sizes

Letter code	Life form	Species	1 Reported territory sizes in hectares (acres)	2 Territory sizes used in this book in hectares (acres)	3 Maximum pairs/100 hectares (pairs/100 acres)	4 Number of cavities excavated per pair per year	5 Minimum d.b.h. size of nest tree in centimeters (inches)	Comments
COAU	13	common flicker	11-130 (27-320)	16.2 (40)	6.2 (2.5)	1	30.5 (12)	
DRPI	13	pileated woodpecker	40-243 (100-600)	121 (300)	0.7 (0.3)	3	50.8 (20)	
ASLE	13	Lewis' woodpecker	1-6 (2.5-15)	6.1 (15)	16.6 (6.7)	1	[1]38.1 (15)	
SPVA	13	yellow-bellied sapsucker	2.1-4.9 (5.1-12)	4 (10)	24.7 (10)	1	25.4 (10)	
SPTH	13	Williamson's sapsucker	see comments	4 (10)	24.7 (10)	1	30.5 (12)	
DEVI	13	hairy woodpecker	2.4-3.6 (6-9)	10.1 (25)	9.9 (4)	3	25.4 (10)	Territory based on data of Evelyn Bull (unpublished, see "References Cited")
DEPU	13	downy woodpecker	2-3.6 (5-9)	4 (10)	24.7 (10)	2	15.2 (6)	Territory based on data of Evelyn Bull (unpublished, see "References Cited")
DEAL	13	white-headed woodpecker	6.1 (15)	8.1 (20)	12.4 (5)	3	25.4 (10)	Territory based on data of Evelyn Bull (unpublished, see "References Cited")
PIAR	13	black-backed three-toed woodpecker	see comments	30.4 (75)	[2]3.22 (1.3)	3	30.5 (12)	No literature; assumed to be the same as for the northern three-toed woodpecker for purposes of developing appendices 22 and 23
PITR	13	northern three-toed woodpecker	14.2-42.9 (35-106)	30.4 (75)	[2]3.22 (1.3)	3	30.5 (12)	

[1]Assumed 30.5-centimeter (12-in) minimum d.b.h. size of nest tree for purposes of developing appendices 22 and 23.

[2]Degree of accuracy in hundredths to right of decimal in 3.22 is probably not biologically significant; it is used as a mechanical construct for purposes of developing appendices 22 and 23.

Appendix 22

Specific hard snag requirements for woodpeckers by plant community

Letter code	Life form	Species	Minimum snag d.b.h. in centimeters (inches)	Snags required per 100 hectares (100 acres) to support various percentages of maximum woodpecker populations									
				100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Western juniper community													
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
Quaking aspen community													
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
SPVA	13	yellow-bellied sapsucker	≧25.4 (≧10)	371 (150)	333 (135)	296 (120)	259 (105)	222 (90)	185 (75)	148 (60)	111 (45)	74 (30)	37 (15)
DEPU	13	downy woodpecker	≧15.2 (≧6)	741 (300)	667 (270)	593 (240)	519 (210)	445 (180)	371 (150)	296 (120)	222 (90)	148 (60)	74 (30)
Riparian (cottonwood-alder) community													
ASLE	13	Lewis' woodpecker	≧30.5 (≧12)	249 (101)	224 (90)	199 (80)	174 (70)	149 (60)	125 (50)	100 (40)	75 (30)	50 (20)	25 (10)
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
SPVA	13	yellow-bellied sapsucker	≧25.4 (≧10)	371 (150)	333 (135)	296 (120)	259 (105)	222 (90)	185 (75)	148 (60)	111 (45)	74 (30)	37 (15)
DEPU	13	downy woodpecker	≧15.2 (≧6)	741 (300)	667 (270)	593 (240)	519 (210)	445 (180)	371 (150)	296 (120)	222 (90)	148 (60)	74 (30)
Ponderosa pine community													
DRPI	13	pileated woodpecker	≧50.8 (≧20)	32 (14)	28 (12)	25 (11)	22 (9)	19 (8)	16 (7)	13 (5)	9 (4)	6 (3)	3 (1)
SPTH	13	Williamson's sapsucker	≧30.5 (≧12)	371 (150)	333 (135)	296 (120)	259 (105)	222 (90)	185 (75)	148 (60)	111 (45)	74 (30)	37 (15)
ASLE	13	Lewis' woodpecker	≧30.5 (≧12)	249 (101)	224 (90)	199 (80)	174 (70)	149 (60)	125 (50)	100 (40)	75 (30)	50 (20)	25 (10)
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
DEAL	13	white-headed woodpecker	≧25.4 (≧10)	558 (225)	502 (203)	446 (180)	391 (158)	335 (135)	279 (113)	223 (90)	167 (68)	112 (45)	56 (23)
DEVI	13	hairy woodpecker	≧25.4 (≧10)	446 (180)	401 (162)	356 (144)	312 (126)	267 (108)	223 (90)	178 (72)	134 (54)	89 (36)	45 (18)
Mixed conifer community													
DRPI	13	pileated woodpecker	≧50.8 (≧20)	32 (14)	28 (12)	25 (11)	22 (9)	19 (8)	16 (7)	13 (5)	9 (4)	6 (3)	3 (1)
SPTH	13	Williamson's sapsucker	≧30.5 (≧12)	371 (150)	333 (135)	296 (120)	259 (105)	222 (90)	185 (75)	148 (60)	111 (45)	74 (30)	37 (15)

Letter code	Life form	Species	Minimum snag d.b.h. in centimeters (inches)	Snags required per 100 hectares (100 acres) to support various percentages of maximum woodpecker populations									
				100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Mixed conifer community (continued)													
PIAR	13	black-backed three-toed woodpecker	≧30.5 (≧12)	145 (59)	131 (53)	116 (47)	101 (41)	87 (35)	73 (29)	58 (23)	44 (18)	29 (12)	15 (6)
ASLE	13	Lewis' woodpecker	≧30.5 (≧12)	249 (101)	224 (90)	199 (80)	174 (70)	149 (60)	125 (50)	100 (40)	75 (30)	50 (20)	25 (10)
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
DEAL	13	white-headed woodpecker	≧25.4 (≧10)	558 (225)	502 (203)	446 (180)	391 (158)	335 (135)	279 (113)	223 (90)	167 (68)	112 (45)	56 (23)
DEVI	13	hairy woodpecker	≧25.4 (≧10)	446 (180)	401 (162)	356 (144)	312 (126)	267 (108)	223 (90)	178 (72)	134 (54)	89 (36)	45 (18)
White fir (grand fir) community													
DRPI	13	pileated woodpecker	≧50.8 (≧20)	32 (14)	28 (12)	25 (11)	22 (9)	19 (8)	16 (7)	13 (5)	9 (4)	6 (3)	3 (1)
SPTH	13	Williamson's sapsucker	≧30.5 (≧12)	371 (150)	333 (135)	296 (120)	259 (105)	222 (90)	185 (75)	148 (60)	111 (45)	74 (30)	37 (15)
PIAR	13	black-backed three-toed woodpecker	≧30.5 (≧12)	145 (59)	131 (53)	116 (47)	101 (41)	87 (35)	73 (29)	58 (23)	44 (18)	29 (12)	15 (6)
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
DEVI	13	hairy woodpecker	≧25.4 (≧10)	446 (180)	401 (162)	356 (144)	312 (126)	267 (108)	223 (90)	178 (72)	134 (54)	89 (36)	45 (18)
Lodgepole pine and subalpine fir communities													
PIAR	13	black-backed three-toed woodpecker	≧30.5 (≧12)	145 (59)	131 (53)	116 (47)	101 (41)	87 (35)	73 (29)	58 (23)	44 (18)	29 (12)	15 (6)
PITR	13	northern three-toed woodpecker	≧30.5 (≧12)	145 (59)	131 (53)	116 (47)	101 (41)	87 (35)	73 (29)	58 (23)	44 (18)	29 (12)	15 (6)
COAU	13	common flicker	≧30.5 (≧12)	93 (38)	84 (34)	74 (30)	65 (26)	56 (23)	47 (19)	37 (15)	28 (11)	19 (8)	9 (4)
DEVI	13	hairy woodpecker	≧25.4 (≧10)	446 (180)	401 (162)	356 (144)	312 (126)	267 (108)	223 (90)	178 (72)	134 (54)	89 (36)	45 (18)

Appendix 23

Generalized snag management requirements for woodpeckers by plant community

Snag d.b.h. size class in centimeters (inches)[2]	Percent of maximum potential populations									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the western juniper community[1]										
≧30.5(≧12)	93(38)	84(34)	74(30)	65(26)	56(23)	47(19)	37(15)	28(11)	19(8)	9(4)
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the quaking aspen community[1]										
≧30.5(≧12)	93(38)	84(34)	74(30)	65(26)	56(23)	47(19)	37(15)	28(11)	19(8)	9(4)
≧25.4(≧10)	278(112)	249(101)	222(90)	194(79)	166(67)	138(56)	111(45)	83(34)	55(22)	28(11)
≧15.2(≧6)	370(150)	334(135)	297(120)	260(105)	223(90)	186(75)	148(60)	111(45)	74(30)	37(15)
Total	741(300)	667(270)	593(240)	519(210)	445(180)	371(150)	296(120)	222(90)	148(60)	74(30)
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the riparian (cottonwood-alder) community[1]										
≧30.5(≧12)	249(101)	224(90)	199(80)	174(70)	149(60)	125(50)	100(40)	75(30)	50(20)	25(10)
≧25.4(≧10)	122(49)	109(45)	97(40)	85(35)	23(30)	60(25)	48(20)	36(15)	24(10)	12(5)
≧15.2(≧6)	370(150)	334(135)	297(120)	260(105)	223(90)	186(75)	148(60)	111(45)	74(30)	37(15)
Total	741(300)	667(270)	593(240)	519(210)	445(180)	371(150)	296(120)	222(90)	148(60)	74(30)
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the ponderosa pine community[1]										
≧50.8(≧20)	32(14)	28(12)	25(11)	22(9)	19(8)	16(7)	13(5)	9(4)	6(3)	3(1)
≧30.5(≧12)	339(136)	305(123)	271(109)	237(96)	203(82)	169(68)	135(55)	102(41)	68(27)	34(14)
≧25.4(≧10)	187(75)	169(68)	150(60)	132(53)	113(45)	94(38)	75(30)	56(23)	38(15)	19(8)
Total	558(225)	502(203)	446(180)	391(158)	335(135)	279(113)	223(90)	167(68)	112(45)	56(23)
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the mixed conifer community[1]										
≧50.8(≧20)	32(14)	28(12)	25(11)	22(9)	19(8)	16(7)	13(5)	9(4)	6(3)	3(1)
≧30.5(≧12)	339(136)	305(123)	271(109)	237(96)	203(82)	169(68)	135(55)	102(41)	68(27)	34(14)
≧25.4(≧10)	187(75)	169(68)	150(60)	132(53)	113(45)	94(38)	75(30)	56(23)	38(15)	19(8)
Total	558(225)	502(203)	446(180)	391(158)	335(135)	279(113)	223(90)	167(68)	112(45)	56(23)

See footnotes at end of appendix.

Snag d.b.h. size class in centimeters (inches)[2]	Percent of maximum potential populations									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the white fir (grand fir) community[1]										
≧50.8(≧20)	32(14)	28(12)	25(11)	22(9)	19(8)	16(7)	13(5)	9(4)	6(3)	3(1)
≧30.5(≧12)	339(136)	305(123)	271(109)	237(96)	203(82)	169(68)	135(55)	102(41)	68(27)	34(14)
≧25.4(≧10)	75(30)	68(27)	60(24)	53(21)	45(18)	38(15)	30(12)	23(9)	15(6)	8(3)
Total	446(180)	401(162)	356(144)	312(126)	267(108)	223(90)	178(72)	134(54)	89(36)	45(18)
Snags required per 100 hectares (100 acres) by d.b.h. class to meet the needs of primary excavators at 10-percent increment levels of their populations in the lodgepole pine and subalpine fir communities[1]										
≧30.5(≧12)	145(59)	131(53)	116(47)	101(41)	87(35)	73(29)	58(23)	44(18)	29(12)	15(6)
≧25.4(≧10)	301(121)	270(109)	240(97)	211(85)	180(73)	150(61)	120(49)	90(36)	60(24)	30(12)
Total	446(180)	401(162)	356(144)	312(126)	267(108)	223(90)	178(72)	134(54)	89(36)	45(18)

[1]This assumes that similar population levels will be chosen for all species. If different levels are selected among species, the resulting overall requirement must be individually computed for that unique combination of habitat levels and species.

[2]Division by d.b.h. does not preclude total or partial substitutability of larger snags for smaller ones. For example, the entire snag requirement could be met by sufficient numbers of the largest d.b.h. class required (e.g., downy woodpeckers fit in 50.8-centimeter (20-in) d.b.h. snags; pileated woodpeckers do not fit in 15.2-centimeter (6-in) d.b.h. snags).

Appendix 24

Wildlife uses of downed logs

Letter code	Life form	Species (• Symbol indicates extensive use[1])	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		AMPHIBIANS																				
AMTI	2	tiger salamander	•	•	•			•	•	•												
AMMA	2	long-toed salamander			•	•	•			•	•	•										
ASTR	2	tailed frog	•	•	•																	
BUBO	2	western toad			•	•	•			•	•	•										
HYRE	2	Pacific treefrog			•	•	•		•	•	•	•						•	•	•		
		REPTILES																				
CHPI	3	painted turtle																•	•			
SCOC	5	western fence lizard	•	•	•			•	•	•	•	•				•	•	•	•	•		
EUSK	3	western skink			•	•	•		•	•	•	•				•	•					
CHBO	15	rubber boa			•	•	•			•	•	•			•	•	•					
DIPU	3	ringneck snake				•	•				•	•				•	•					
PIME	5	gopher snake		•	•	•	•			•	•	•				•	•					
THSI	3	common garter snake	•	•																		
THEL	5	western terrestrial garter snake	•	•																		
CRVI	5	western rattlesnake		•	•				•	•	•	•		•	•							
		BIRDS																				
PEER	3	white pelican																•	•			
PHAU	3	double-crested cormorant																•	•			
ARHE	12	great blue heron																•	•			
NYNY	7	black-crowned night heron																•	•			
PLCH	12	white-faced ibis																•	•			
CYOL	3	mute swan																•	•			
OLCO	3	whistling swan																•	•			
BRCA	3	Canada goose											•	•	•			•	•			
ANAL	3	white-fronted goose																•	•			
CHCA	3	snow goose																•	•			
CHRO	3	Ross' goose																•	•			
ANPL	3	mallard											•	•	•			•	•			

See footnotes at end of appendix.

Letter code	Life form	Species (• Symbol indicates extensive use[1])	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ANST	3	gadwall																•	•			
ANAC	3	pintail																•	•			
ANCR	3	green-winged teal																•	•			
ANDI	3	blue-winged teal																•	•			
ANCY	3	cinnamon teal																•	•			
ANPE	3	European wigeon																•	•			
ANAM	3	American wigeon																•	•			
ANCL	3	northern shoveler																•	•			
AISP	14	wood duck											•	•				•	•			
AYCO	3	ring-necked duck																•	•			
AYMA	3	greater scaup																•	•			
AYAF	3	lesser scaup																•	•			
BUCL	14	common goldeneye											•	•				•	•			
BUIS	14	Barrow's goldeneye											•	•				•	•			
HIHI	3	harlequin duck											•	•				•	•			
LOCU	14	hooded merganser											•	•				•	•			
MEME	14	common merganser											•	•				•	•			
CAAU	4	turkey vulture											•	•								
ACGE	11	goshawk						•	•									•	•			
ACST	11	sharp-shinned hawk						•	•									•	•			
ACCO	11	Cooper's hawk						•	•									•	•			
BULA	5	rough-legged hawk																•	•			
CICY	5	marsh hawk																•	•			
DEOB	5	blue grouse	•	•	•			•	•	•			•	•							•	•
CACA	5	Franklin's grouse	•	•	•			•	•	•			•	•							•	•
BOUM	5	ruffed grouse	•	•	•			•	•	•			•	•							•	•
COVI	5	bobwhite	•	•	•						•	•	•	•				•	•		•	•
LOCA	5	California quail	•	•	•						•	•	•	•				•	•		•	•
ORPI	5	mountain quail									•	•	•	•							•	•

See footnotes at end of appendix.

Letter code	Life form	Species (• Symbol indicates extensive use[1])	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ALCH	4	chukar											•	•								
PHCO	5	ring-necked pheasant											•	•								
MEGA	5	turkey	•	•	•				•	•	•	•	•	•							•	•
STTR	3	Wilson's phalarope																•	•			
LOLO	3	northern phalarope																•	•			
LAAR	3	herring gull																•	•			
LACA	3	California gull																•	•			
LADE	3	ring-billed gull																•	•			
LAPI	3	Franklin's gull																•	•			
LAPH	3	Bonaparte's gull																•	•			
COAM	8	yellow-billed cuckoo						•	•	•	•	•										
NYSC	5	snowy owl																•	•			
SPCU	15	burrowing owl																•	•			
STVA	14	barred owl						•	•	•												
CHMI	6	common nighthawk														•	•	•	•			
COAU	13	common flicker						•	•													
DRPI	13	pileated woodpecker						•	•	•	•	•						•	•			
ASLE	13	Lewis' woodpecker						•														
DEVI	13	hairy woodpecker						•	•	•												
DEPU	13	downy woodpecker						•														
PIAR	13	black-backed three-toed woodpecker						•	•	•												
PITR	13	northern three-toed woodpecker						•	•													
TYTY	7	eastern kingbird																•				
TYVE	11	western kingbird						•										•				
MYCI	14	ash-throated flycatcher						•										•				
SASA	4	Say's phoebe						•	•	•			•	•				•	•			
EMTR	7	willow flycatcher						•														
EMHA	11	Hammond's flycatcher						•														

See footnotes at end of appendix.

Letter code	Life form	• Symbol indicates extensive use[1] Species	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
EMOB	8	dusky flycatcher						•														
EMDI	10	western flycatcher						•														
COVIR	9	eastern wood pewee						•														
COSO	11	western wood pewee						•														
NUBO	10	olive-sided flycatcher						•														
CYCR	9	blue jay						•	•	•								•	•			
CYST	11	Steller's jay						•	•	•								•	•			
GYCY	10	pinyon jay						•										•				
NUCO	10	Clark's nutcracker						•	•													
PAAT	14	black-capped chickadee						•	•				•									
PAGA	14	mountain chickadee						•	•				•									
PARU	14	chestnut-backed chickadee						•	•													
PSMI	8	bushtit						•	•													
SICA	13	white-breasted nuthatch						•														
SICAN	13	red-breasted nuthatch						•	•													
CEFA	14	brown creeper						•														
CIME	3	dipper											•	•				•	•			
TRAE	14	house wren	•	•	•			•	•	•			•	•				•	•			
TRTR	3	winter wren	•	•	•			•	•	•			•	•				•	•			
CAMEX	4	canyon wren	•	•																		
SAOB	4	rock wren	•	•																		
CAGU	5	hermit thrush	•	•				•	•	•			•	•								
CAUS	7	Swainson's thrush	•	•				•	•	•			•	•								
CAFU	5	veery	•	•				•	•	•			•	•								
SIME	14	western bluebird						•	•				•	•								
SICU	14	mountain bluebird						•	•				•	•								
MYTO	6	Townsend's solitaire						•	•				•	•								
LAEX	7	northern shrike						•														
LALU	7	loggerhead shrike						•														

See footnotes at end of appendix.

Letter code	Life form	Species (• Symbol indicates extensive use[1])	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
STVU	14	starling											•	•								
VERU	6	Nashville warbler	•	•				•	•													
SENO	3	northern waterthrush	•	•				•	•													
ICVI	8	yellow-breasted chat	•	•				•	•													
WIPU	5	Wilson's warbler	•	•				•	•				•	•								
AGPH	7	red-winged blackbird																•	•			
SPTR	8	American goldfinch																•	•			
SPPS	7	lesser goldfinch																•	•			
CHCH	7	green-tailed towhee	•	•	•			•	•	•			•	•				•	•	•		
PIER	7	rufous-sided towhee	•	•	•			•	•	•	•	•	•	•				•	•	•		
JUHY	5	dark-eyed junco	•	•				•	•				•	•				•	•			
SPPA	7	chipping sparrow	•	•				•	•				•	•				•	•			
ZOLE	7	white-crowned sparrow	•	•				•	•									•				
ZOAT	5	golden-crowned sparrow	•	•				•	•									•				
ZOAL	5	white-throated sparrow	•	•				•	•									•				
PAIL	7	fox sparrow	•	•				•	•									•	•			
MELI	6	Lincoln's sparrow	•	•				•	•									•				
MEMEL	7	song sparrow	•	•				•	•	•			•	•				•	•			
		MAMMALS																				
DIMA	5	opossum	•	•	•								•	•	•			•	•	•		
SOPR	15	Malheur shrew		•	•	•	•		•	•	•	•			•	•	•	•	•	•		
SOVA	15	vagrant shrew		•	•	•	•		•	•	•	•			•	•	•	•	•	•		
SOOB	15	dusky shrew		•	•	•	•		•	•	•	•			•	•	•	•	•	•		
SOPA	16	northern water shrew		•	•	•	•		•	•					•	•	•					
SCOR	15	coast mole		•	•	•	•		•	•	•	•										
SYNU	15	mountain cottontail	•	•	•									•	•							
LEAM	5	snowshoe hare	•	•	•								•	•								
EUAM	15	yellow pine chipmunk		•	•			•	•	•	•	•			•	•	•	•	•	•	•	•
MAFL	4	yellow-bellied marmot	•	•	•													•	•	•		

See footnotes at end of appendix.

Letter code	Life form	Species (● Symbol indicates extensive use[1])	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SPBE	15	Belding ground squirrel	●	●	●	●	●											●	●	●	●	
SPCO	15	Columbian ground squirrel	●	●	●	●	●											●	●	●	●	
SPLA	15	mantled ground squirrel	●	●	●	●	●											●	●	●	●	
SCGRI	10	western gray squirrel						●	●	●								●	●	●		
TAHU	10	red squirrel	●	●	●			●	●	●	●	●						●	●	●		
TADO	10	chickaree	●	●	●			●	●	●	●	●						●	●	●		
GLSA	14	northern flying squirrel						●	●	●	●	●						●	●	●		
CACAN	16	beaver						●										●				
PEMA	15	deer mouse			●	●	●		●	●	●	●			●	●	●					
PETR	4	pinyon mouse	●	●	●								●	●	●							
NECI	4	bushy-tailed woodrat	●	●	●			●	●	●			●	●	●			●	●	●		
CLGA	15	Gapper red-backed vole		●	●	●	●		●	●	●	●			●	●	●					
PHIN	15	heather vole	●	●	●	●	●								●	●	●					
MIMO	15	mountain vole			●	●	●								●	●	●					
MILO	15	long-tailed vole		●	●	●	●								●	●	●					
ONZI	16	muskrat																●	●			
ZAPR	3	western jumping mouse		●	●	●								●	●	●	●	●	●	●		
ERDO	6	porcupine	●	●	●								●	●	●		●	●	●	●		
CALAT	15	coyote						●	●	●	●	●										
VUVU	15	red fox	●	●	●			●	●	●	●	●										
URCI	15	gray fox	●	●	●			●	●	●	●	●										
URAM	15	black bear								●	●	●										
PRLO	14	raccoon	●	●	●																	
MAAM	14	marten	●	●	●			●	●	●	●	●						●	●	●		
MAPE	14	fisher	●	●	●			●	●	●	●	●	●	●				●	●	●		
MUER	15	short-tailed weasel	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
MUFR	15	long-tailed weasel	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
MUVI	16	mink	●	●	●			●	●	●	●	●	●	●	●			●	●			
GUGU	5	wolverine	●	●																		

ee footnotes at end of appendix.

Letter code	Life form	Species (• Symbol indicates extensive use[1])	Cover					Feeding					Reproduction					Other[2]				
			Log classes[3]					Log classes					Log classes					Log classes				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SPPU	15	spotted skunk	•	•	•			•	•	•	•	•	•	•	•							
MEMEP	15	striped skunk	•	•	•			•	•	•	•	•	•	•	•							
LUCA	16	river otter																•	•	•		
FECO	4	puma	•	•	•													•	•	•		
FECA	5	feral house cat	•	•	•			•	•	•								•	•	•		
LYCA	5	lynx	•	•	•			•	•	•								•	•	•		
LYRU	4	bobcat	•	•	•			•	•	•								•	•	•		
CEEL	5	elk																•	•	•	•	•
ODHE	5	mule deer																•	•	•	•	•
ODVI	5	white-tailed deer																•	•	•	•	•
		TOTALS:	60	71	58	23	22	82	76	56	37	37	48	49	25	19	20	104	95	32	14	11
		Species: 179 Amphibians: 5 Reptiles: 9 Birds: 116 Mammals: 49																				

[1]The degree to which welfare of each species is influenced by presence, absence, or relative abundance of log classes is not implied.

[2]Other uses include sites for resting, preening, bedding, dusting, lookout, drumming, sunning, and bridges.

[3]See the following table for log class definitions (adapted from report no. 135 of the Coniferous Forest Biome by Robert Fogel, M. Ogawa, and J. M. Trappe 1973, entitled "Terrestrial Decomposition: A Synopsis," used with permission; see also Minore 1966):

A 5-class scheme of Douglas-fir log decomposition based on easily recognized physical characteristics

Log characteristics	Log decomposition class				
	1	2	3	4	5
Bark	intact	intact	trace	absent	absent
Twigs <3 cm (1.18 in)	present	absent	absent	absent	absent
Texture	intact	intact to partly soft	hard, large pieces	small, soft, blocky pieces	soft and powdery
Shape	round	round	round	round to oval	oval
Color of wood	original color	original color	original color to faded	light brown to faded brown or yellowish	faded to light yellow or gray
Portion of log on ground	log elevated on support points	log elevated on support points but sagging slightly	log is sagging near ground	all of log on ground	all of log on ground

Appendix 25

Descriptions of land-types on National Forests in the Blue Mountains

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
1	1		G4	5	0-35	All	20	7.6-16.8 (25-55)	K51	GB-49-11	•	Bunchgrass on shallow soil, gentle slopes
									K51	GB-49-12	•	Bunchgrass on deep soil, gentle slopes
									K51	GB-91-11	•	Bluegrass scabland
									K11	CP-G1-11	•	Ponderosa pine/wheatgrass
									K11	CP-G1-12	•	Ponderosa pine/fescue
2	1a 13	1a		5	0-70	All	15	17.7-25.0 (58-82)	K52	GS-39-11	•	Alpine sedge
									K52	FS-59-11	•	Alpine fleeceflower
									K52	CA-G1-11	•	Subalpine fir/whitebark pine-sedge
									K15	CE-S4-11		Subalpine fir/grouse huckleberry
									K52	SS-49-11		Alpine sagebrush
3	2 14		S5	5	30-80	All	25	6.1-19.5 (20-64)	K51	GB-49-13	•	Bunchgrass on shallow soil, steep slopes
									K51	GB-49-14	•	Bunchgrass on deep soil, steep slopes
									K12	CD-S7-11	•	Ponderosa pine-Douglas-fir/ ninebark
									K11	CP-G1-11	•	Ponderosa pine/wheatgrass
									K11	CP-G1-12	•	Ponderosa pine/fescue
									*	SM-19		Ninebark shrubland
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
									K14	CW-G1-11		Mixed conifer/pinegrass, residual soil

See footnotes at end of appendix.

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
4	3		S4	2	30-80	All	60	6.1-19.5 (20-64)	K12	CD-S7-11	•	Ponderosa pine-Douglas-fir/ ninebark
									K14	CW-S2-11	•	White fir/big huckleberry
									K51	GB-49-13	•	Bunchgrass on shallow soil, steep slopes
									K51	GB-49-14	•	Bunchgrass on deep soil, steep slopes
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
									K14	CW-G1-11		Mixed conifer/pinegrass, residual soil
5	3c				30-80	North, south	35	6.1-18.3 (20-60)	K51	GB-49-13	•	Bunchgrass on shallow soil, steep slopes
									K51	GB-49-14	•	Bunchgrass on deep soil, steep slopes
									K12	CD-S7-11	•	Ponderosa pine-Douglas-fir/ ninebark
									K14	CW-S2-11	•	White fir/big huckleberry
									*	SM-19		Ninebark shrubland
									K12	CD-G1-11		Ponderosa pine-Douglas-fir/ elk sedge
6	4 16 16a 17 20 20a		S7	1	30-80	All, mostly north	90	7.3-24.4 (24-80)	K14	CW-S2-11	•	White fir/big huckleberry
									K15	CE-S3-11	•	Subalpine fir/big huckleberry
									K14	CW-G1-12	•	Mixed conifer/pinegrass, ash soil
									K12	CD-S7-11		Ponderosa pine-Douglas-fir/ ninebark
									K14	CW-S8-11		White fir/grouse huckleberry
7	2a		S1	5	30-100	All	40	18.2-30.5 (60-100)	K52	GS-39-11	•	Alpine sedge
									K52	FS-59-11	•	Alpine fleeceflower
									K52	GS-12-11	•	Alpine fescue
									K52	SS-49-11		Alpine sagebrush
									K52	CA-G1-11		Subalpine fir-whitebark pine/sedge

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
8		2a 2b	S2		30-80	All	85	13.7-24.4 (45-80)	K15	CE-S3-11	•	Subalpine fir/big huckleberry
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									K15	CE-S4-11		Subalpine fir/grouse huckleberry
									*	CL-S4-11		Lodgepole pine/grouse huckleberry
									K52	CA-G1-11		Subalpine fir-whitebark pine/sedge
9	3a			3	30-80	South	85	12.2-15.2 (40-50)	K11	CP-G1-11	•	Ponderosa pine/wheatgrass
									K11	CP-G1-12	•	Ponderosa pine/fescue
									K12	CD-S7-11	•	Ponderosa pine-Douglas-fir/ ninebark
									K12	CD-S6-11		Ponderosa pine-Douglas-fir/ snowberry-oceanspray
									K12	CD-G1-11		Ponderosa pine-Douglas-fir/ elk sedge
10	4a				30-80	North	50	12.2-19.5 (40-64)	K14	CW-S2-11	•	White fir/big huckleberry
									*	SM-29	•	Thinleaf alder snowslides
									K14	CW-S8-11		White fir/grouse huckleberry
11	5a 12a		G3		0-30	All	50	9.1-19.8 (30-65)	K51	GB-49-11	•	Bunchgrass on shallow soil, gentle slopes
									K14	CW-G1-12	•	Mixed conifer/pinegrass, ash soil
									K51	GB-49-12	•	Bunchgrass on deep soil, gentle slopes
									K14	CW-S2-11	•	White fir/big huckleberry
									*	CL-G2-11	•	Lodgepole pine/pinegrass-grouse huckleberry
									K14	CW-F3-11		White fir/twinflower-forb
12	5a 17a			1	0-30	All	75	13.7-23.2 (45-76)	K15	CE-S4-11	•	Subalpine fir/grouse huckleberry
									K15	CE-S3-11		Subalpine fir/big huckleberry

See footnotes at end of appendix.

Land-type number	Land-type codes used by each National Forest[1]: Umatilla	Malheur	Wallowa-Whitman	Ochoco	% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
13	5b 5c 5d	5a 5b 5c 5d	G2	2	0-100	All	80	9.1-19.8 (30-65)	K12	CD-S7-11	•	Ponderosa pine–Douglas-fir/ninebark
									K14	CW-S2-11	•	White fir/big huckleberry
									K11	CP-G1-12	•	Ponderosa pine/fescue
									K11	CP-G1-11	•	Ponderosa pine/wheatgrass
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
14	6 11b 18	3a 3b		1	0-70	All	100	10.7-21.3 (35-70)	K14	CW-G1-12	•	Mixed conifer/pinegrass, ash soil
									K14	CW-S2-11	•	White fir/big huckleberry
									K14	CW-F3-11	•	White fir/twinflower–forb
									K14	CW-S8-11		White fir/grouse huckleberry
15	6a 15a 18a		G5	1	0-30	All	90	15.2-24.4 (50-80)	K15	CE-S4-11	•	Subalpine fir/grouse huckleberry
									*	CL-S4-11	•	Lodgepole pine/grouse huckleberry
									K14	CW-S8-11	•	White fir/grouse huckleberry
									K15	CE-S3-11		Subalpine fir/big huckleberry
									*	CL-S5-11		Lodgepole pine/big huckleberry
									*	CL-G2-11		Lodgepole pine/pinegrass–grouse huckleberry
16	6b 12 19 19a			1	0-80	All, mostly south	90	7.3-24.4 (24-80)	K14	CW-G1-11	•	Mixed conifer/pinegrass, residual soil
									K15	CE-S4-11	•	Subalpine fir/grouse huckleberry
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									K14	CW-S2-11		White fir/big huckleberry
									K15	CE-S3-11		Subalpine fir/big huckleberry

See footnotes at end of appendix.

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
17	7 7a				0-40	All	95	10.7-19.8 (35-65)	K14	CW-S2-11	•	White fir/big huckleberry
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									*	CL-G2-11		Lodgepole pine/pinegrass-grouse huckleberry
									*	CL-S4-11		Lodgepole pine/grouse huckleberry
									K14	CW-F3-11		White fir/twinflower-forb
18		7a 7b 7c 7d	S8	5	0-70	All	0	9.1-18.9 (30-62)	K51	GB-49-11	•	Bunchgrass on shallow soil, gentle slopes
									K51	GB-49-12	•	Bunchgrass on deep soil, gentle slopes
									K51	GB-49-13	•	Bunchgrass on shallow soil, steep slopes
									K51	GB-49-14	•	Bunchgrass on deep soil, steep slopes
									K51	GB-91-11	•	Bluegrass scabland
									K55	SD-91-11	•	Stiff sage scabland
									K11	CP-G1-12	•	Ponderosa pine/fescue
									K11	CP-G1-11		Ponderosa pine/wheatgrass
									K51	GB-B9		Biscuit-scabland
19	7b 7c				0-40	All	95	13.7-18.3 (45-60)	K15	CE-S3-11	•	Subalpine fir/big huckleberry
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									K15	CE-S4-11		Subalpine fir/grouse huckleberry
									*	CL-G2-11		Lodgepole pine/pinegrass-grouse huckleberry
									*	CL-S4-11		Lodgepole pine/grouse huckleberry
									*	SM-29		Thinleaf alder snowslides

See footnotes at end of appendix.

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
20	8		S3	4	30-80	North	90	10.7-19.8 (35-65)	K14	CW-S2-11	•	White fir/big huckleberry
									K14	CW-G1-12	•	Mixed conifer/pinegrass, ash soil
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									K14	CW-S8-11		White fir/grouse huckleberry
									*	CL-S4-11		Lodgepole pine/grouse huckleberry
21	9				0-50	All	75	6.1-18.3 (20-60)	K12	CD-S6-11	•	Ponderosa pine-Douglas-fir/ snowberry-oceanspray
									K12	CD-G1-11	•	Ponderosa pine-Douglas fir/ elk sedge
									*	CL-G2-11	•	Lodgepole pine/pinegrass-grouse huckleberry
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
									*	CL-S5-11		Lodgepole pine/big huckleberry
22	10			2	0-20	All	75	7.3-12.2 (24-40)	K14	CW-G1-12	•	Mixed conifer/pinegrass, ash soil
									K14	CW-G1-11	•	Mixed conifer/pinegrass, residual soil
									K14	CW-F3-11	•	White fir/twinflower-forb
									*	MM	•	Moist meadow
									*	HQ-M1	•	Quaking aspen meadow
									K12	CD-S6-11		Ponderosa pine-Douglas-fir/ snowberry-oceanspray
									K11	CP-M1-11		Ponderosa pine/blue wildrye
									K14	CW-S2-11		White fir/big huckleberry
									*	CL-G2-11		Lodgepole pine/pinegrass-grouse huckleberry

See footnotes at end of appendix.

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
23		8a 8b		5	0-70	South	15	9.1-18.3 (30-60)	K55	SD-19-11	•	Low sagebrush/bunchgrass
									K55	SD-29-11	•	Big sagebrush/bunchgrass
									K24	CJ-S2-11	•	Juniper/big sagebrush
									K24	CJ-S1-11		Juniper/low sagebrush
									K11	CP-G1-12		Ponderosa pine/fescue
									K11	CP-G1-11		Ponderosa pine/wheatgrass
24		9a 9b 9c 9d		5	0-70	All	0	10.7-18.9 (35-62)	K51	GB-91-11	•	Bluegrass scabland
									K55	SD-91-11	•	Stiff sage scabland
									K24	CJ-S8-11		Juniper/stiff sage scabland
									K55	SD-B9		Biscuit-shrub scabland
									K51	GB-B9		Biscuit-grass scabland
25	11 11c		G6		0-35	All	95	9.8-19.5 (32-64)	K14	CW-S2-11	•	White fir/big huckleberry
									*	CL-G2-11	•	Lodgepole pine/pinegrass-grouse huckleberry
									K15	CE-S3-11	•	Subalpine fir/big huckleberry
									*	CL-S5-11		Lodgepole pine/big huckleberry
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
									K14	CW-F3-11		White fir/twinflower-forb
26	11a 11ac		S6		30-80	All, mostly north	95	10.4-20.7 (34-68)	K14	CW-S2-11	•	White fir/big huckleberry
									K15	CE-S3-11	•	Subalpine fir/big huckleberry
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									K12	CD-S7-11		Ponderosa pine-Douglas-fir/ninebark

See footnotes at end of appendix.

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
27	22	10a	G8	6	0-15	All	5	9.1-21.3 (30-70)	*	MM	•	Moist meadow
									*	HQ-M1	•	Quaking aspen meadow
									K11	CP-M1-11		Ponderosa pine/blue wildrye
									*	MD		Dry meadow
									*	MW		Wet meadow
28	15	4a 4b			0-70	All	95	12.2-22.9 (40-75)	K14	CW-S2-11	•	White fir/big huckleberry
									*	CL-S5-11	•	Lodgepole pine/big huckleberry
									K14	CW-S8-11		White fir/grouse huckleberry
									*	CL-S4-11		Lodgepole pine/grouse huckleberry
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
									*	CL-G2-11		Lodgepole pine/pinegrass-grouse huckleberry
29	21 21a 21b		G1		0-60	All	80	12.2-23.2 (40-76)	K15	CE-S3-11	•	Subalpine fir/big huckleberry
									*	CL-G2-11	•	Lodgepole pine/pinegrass-grouse huckleberry
									*	MM	•	Moist meadow
									K14	CW-F3-11	•	White fir/twinflower-forb
									K14	CW-G1-12		Mixed conifer/pinegrass, ash soil
									K11	CP-M1-11		Ponderosa pine/blue wildrye
30			G7	5	0-35	All	0	3.0-9.1 (10-30)	K51	GB-49-11	•	Bunchgrass on shallow soil, gentle slopes
									K51	GB-49-12	•	Bunchgrass on deep soil, gentle slopes
									K51	GB-11-21	•	Sand dropseed/bluegrass
									K51	GB-11-22	•	Threeawn/bluegrass
									K51	GB-41-21		Needlegrass/bluegrass
									K51	GB-41-22		Needlegrass/buckwheat-bluegrass

Land-type number	Land-type codes used by each National Forest[1]				% slope	Aspect	% in forest sites[2]	Elevations in 100 meters (feet)	Potential natural vegetation classifications[3]	Ecoclass codes[4]	Primary land-type components[5]	Plant community types[4]
	Umatilla	Malheur	Wallowa-Whitman	Ochoco								
31		6c 6d 6e		3	0-70	All, mostly south	45	9.1-18.9 (30-62)	K55	SD-39	•	Bitterbrush/bunchgrass
									K55	SD-19-11	•	Low sagebrush/bunchgrass
									K11	CP-G1-12	•	Ponderosa pine/fescue
									K11	CP-G1-11	•	Ponderosa pine/wheatgrass
									K12	CD-G1-11	•	Ponderosa pine-Douglas-fir/ elk sedge
									K10	CP-S2-21		Ponderosa pine/bitterbrush-Ross sedge
									K37	SD-49		Curlleaf mountainmahogany/ grass
32		6a 6b 6f		3	0-70	South	80	9.1-18.9 (30-62)	K10	CP-S2-21	•	Ponderosa pine/bitterbrush-Ross sedge
									K12	CD-G1-11	•	Ponderosa pine/Douglas-fir/ elk sedge
									K55	SD-39	•	Bitterbrush/bunchgrass
									K11	CP-G1-12		Ponderosa pine/fescue
									K11	CP-G1-11		Ponderosa pine/wheatgrass
									K37	SD-49		Curlleaf mountainmahogany/ grass
									K55	SD-19-11		Low sagebrush/bunchgrass

[1]As of 1975, each National Forest has a unique numbering system for land-types. All codes in line with a land-type number identify the same land-type.

[2]The percent in forest sites was considered the maximum amount of the area that could produce cover.

[3]See table 40 on page 165 in introduction to this appendix for explanation of potential natural vegetation classifications used (numbers preceded by letter "K").

[4]The ecoclass codes and plant community type descriptions are from Hall (1973, 1978).

[5]The primary land-type components indicated by the symbol • are the major plant communities in each land-type.

*Küchler (1964) does not recognize lodgepole pine or quaking aspen as climax or potential natural vegetation. He also does not assign a classification to mountain meadows, thinleaf alder snowslides, and ninebark shrublands, presumably because they are too small to map at a scale of 1:3,168,000 which is the scale of his revised 1975 map.

Appendix 26

Elk use related to cover-forage area ratios by land-type

Land-type number	Land-type identification codes used by each National Forest[1]: Umatilla	Malheur	Wallowa-Whitman	Ochoco	Percent of land-type in forest sites (potential cover)	1 % of land-type in cover to achieve the optimum cover-forage area ratio[2]	2 % increase in potential use attainable by reducing cover to 40% of the land-type[2]	3 % of land-type in cover to produce potential use equal to that when all forest sites are in cover[2]	4 % of land-type in cover to produce potential use 33% less than that when all forest sites are in cover[2]	5 % of land-type in cover to produce potential use 66% less than that when all forest sites are in cover[2]	6 Remarks
1	1		G4	5	20	20	NA	20	16	12	Hiding cover of primary importance
2	1a,13	1a		5	15	15	NA	15	12	9	Hiding cover of primary importance
3	2,14		S5	5	25	25	NA	25	20	15	Hiding cover of primary importance
4	3		S4	2	60	40	25	30	24	18	
5	3c				35	35	NA	35	28	21	Hiding cover of primary importance
6	4,16,16a, 17,20,20a		S7	1	90	40	25	27	18	9	Thermal cover of primary importance
7	2a		S1	5	40	40	NA	40	32	24	Thermal cover of primary importance
8		2a,2b	S2		85	40	300	17	13	9	Thermal cover of primary importance
9	3a			3	85	40	25	26	17	9	
10	4a				50	40	0	40	30	20	
11	5a,12a		G3		50	40	0	40	30	20	
12	5a,17a			1	75	40	0	40	30	15	
13	5b,5c,5d	5a,5b, 5c,5d	G2	2	80	40	25	32	24	16	
14	6,11b,18	3a,3b		1	100	40	500	20	15	10	
15	6a,15a, 18a		G5	1	90	40	300	18	14	9	
16	6b,12, 19,19a			1	90	40	50	18	9	5	

See footnotes at end of appendix.

Land-type number	Land-type identification codes used by each National Forest[1]: Umatilla	Malheur	Wallowa-Whitman	Ochoco	Percent of land-type in forest sites (potential cover)	% of land-type in cover to achieve the optimum cover-forage area ratio[2]	% increase in potential use attainable by reducing cover to 40% of the land-type[2]	% of land-type in cover to produce potential use equal to that when all forest sites are in cover[2]	% of land-type in cover to produce potential use 33% less than that when all forest sites are in cover[2]	% of land-type in cover to produce potential use 66% less than that when all forest sites are in cover[2]	Remarks
	1				2	3	4	5	6	7	8
17	7,7a				95	40	25	33	19	10	Thermal cover of primary importance
18		7a,7b, 7c,7d	S8	5	0	NA	NA	NA	NA	NA	Thermal cover of primary importance
19	7b,7c				95	40	300	20	15	10	
20	8		S3	4	90	40	25	27	18	9	
21	9				75	75	0	75	68	60	Critical elk cover; riparian habitat; used by elk in conjunction with adjacent types; required summer and winter for thermal cover
22	10			2	75	75	0	75	68	60	
23		8a,8b		5	15	15	NA	15	14	12	Hiding cover of primary importance
24		9a,9b, 9c,9d		5	0	NA	NA	NA	NA	NA	Thermal cover of primary importance
25	11,11c		G6		95	40	25	29	19	10	Often important elk cover; thermal cover of primary importance
26	11a,11ac		S6		95	40	25	29	19	10	
27	22	10a	G8	6	5	5	NA	5	4	3	Thermal cover of primary importance
28	15	4a,4b			95	40	300	19	14	10	
29	21,21a, 21b		G1		80	80	0	80	72	64	Thermal cover of primary importance
30			G7	5	0	NA	NA	NA	NA	NA	Thermal cover of primary importance

See footnotes at end of appendix.

Land-type number	Land-type identification codes used by each National Forest[1]				Percent of land-type in forest sites (potential cover)	% of land-type in cover to achieve the optimum cover-forage area ratio[2]	1 % increase in potential use attainable by reducing cover to 40% of the land-type[2]	2 % of land-type in cover to produce potential use equal to that when all forest sites are in cover[2]	3 % of land-type in cover to produce potential use 33% less than that when all forest sites are in cover[2]	4 % of land-type in cover to produce potential use 66% less than that when all forest sites are in cover[2]	5 Remarks
	Umatilla	Malheur	Wallowa-Whitman	Ochoco							
31		6c,6d, 6e		3	45	45	0	45	41	36	
32		6a,6b, 6f		3	80	40	50	32	24	16	

[1]As of 1975, each National Forest has a unique numbering system for land-types. All codes in line with a land-type number identify the same land-type as far as deer and elk are concerned.

[2]NA means not applicable.

Appendix 27

Deer use related to cover-forage area ratios by land-type

Land-type number	Land-type identification codes used by each National Forest[1]: Umatilla	Malheur	Wallowa-Whitman	Ochoco	Percent of land-type in forest sites (potential cover)	% of land-type in cover to achieve the optimum cover-forage area ratio[2]	% increase in potential use attainable by reducing cover to 40% of the land-type[2]	% of land-type in cover to produce potential use equal to that when all forest sites are in cover[2]	% of land-type in cover to produce potential use 33% less than that when all forest sites are in cover[2]	% of land-type in cover to produce potential use 66% less than that when all forest sites are in cover[2]	Remarks
					1	2	3	4	5	6	7 / 8
1	1		G4	5	20	20	NA	20	14	8	Hiding cover of primary importance.
2	1a,13	1a		5	15	15	NA	15	11	6	Hiding cover of primary importance.
3	2,14		S5	5	25	25	NA	25	18	10	Hiding cover of primary importance.
4	3		S4	2	60	40	0	24	12	6	
5	3c				35	35	NA	35	18	11	Hiding cover of primary importance
6	4,16,16a, 17,20,20a		S7	1	90	40	200	18	14	9	
7	2a		S1	5	40	40	NA	40	20	15	Hiding cover of primary importance
8		2a,2b	S2		85	40	50	22	17	13	
9	3a			3	85	40	50	22	17	13	
10	4a				50	40	10	20	10	5	
11	5a,12a		G3		50	40	10	20	10	5	
12	5a,17a			1	75	40	10	30	15	8	
13	5b,5c,5d	5a,5b, 5c,5d	G2	2	80	40	200	16	12	8	
14	6,11b,18	3a,3b		1	100	40	300	15	10	5	
15	6a,15a, 18a		G5	1	90	40	200	18	14	9	
16	6b,12, 19,19a			1	90	40	200	18	14	9	

See footnotes at end of appendix.

Land-type number	Land-type identification codes used by each National Forest[1]: Umatilla	Malheur	Wallowa-Whitman	Ochoco	Percent of land-type in forest sites (potential cover)	% of land-type in cover to achieve the optimum cover-forage area ratio[2]	% increase in potential use attainable by reducing cover to 40% of the land-type[2]	% of land-type in cover to produce potential use equal to that when all forest sites are in cover[2]	% of land-type in cover to produce potential use 33% less than that when all forest sites are in cover[2]	% of land-type in cover to produce potential use 66% less than that when all forest sites are in cover[2]	Remarks
	1	2	3	4	5	6	7	8			
17	7,7a				95	40	300	14	10	5	
18		7a,7b, 7c,7d	S8	5	0	NA	NA	NA	NA	NA	Thermal cover of primary importance
19	7b,7c				95	40	50	24	19	14	
20	8		S3	4	90	40	200	18	14	9	
21	9				75	75	0	75	57	38	Critical deer cover; riparian habitat; used by deer in conjunction with adjacent types; required summer and winter for thermal cover and fawning
22	10			2	75	75	0	75	57	38	
23		8a,8b		5	15	15	NA	15	14	12	Thermal cover of primary importance
24		9a,9b, 9c,9d		5	0	NA	NA	NA	NA	NA	
25	11,11c		G6		95	40	300	14	10	5	
26	11a,11ac		S6		95	40	300	15	10	5	
27	22	10a	G8	6	5	5	NA	5	4	3	Thermal cover of primary importance; edges around meadows important for fawning
28	15	4a,4b			95	40	300	14	10	5	
29	21,21a, 21b		G1		80	80	0	80	60	40	Thermal cover of primary importance
30			G7	5	0	NA	NA	NA	NA	NA	Thermal cover of primary importance

See footnotes at end of appendix.

Land-type number	Land-type identification codes used by each National Forest[1]				Percent of land-type in forest sites (potential cover)	1 % of land-type in cover to achieve the optimum cover-forage area ratio[2]	2 % increase in potential use attainable by reducing cover to 40% of the land-type[2]	3 % of land-type in cover to produce potential use equal to that when all forest sites are in cover[2]	4 % of land-type in cover to produce potential use 33% less than that when all forest sites are in cover[2]	5 % of land-type in cover to produce potential use 66% less than that when all forest sites are in cover[2]	6 Remarks
	Umatilla	Malheur	Wallowa-Whitman	Ochoco							
31		6c,6d, 6e		3	45	45	0	23	14	9	7
32		6a,6b, 6f		3	80	40	50	24	16	8	8

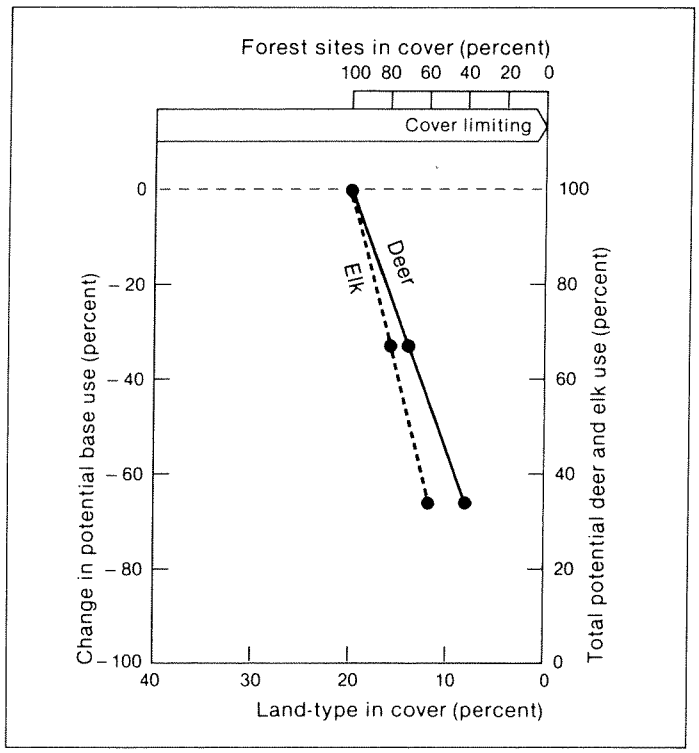
As of 1975, each National Forest has a unique numbering system for land-types. All codes in line with a land-type number identify the ame land-type as far as deer and elk are concerned.

NA means not applicable.

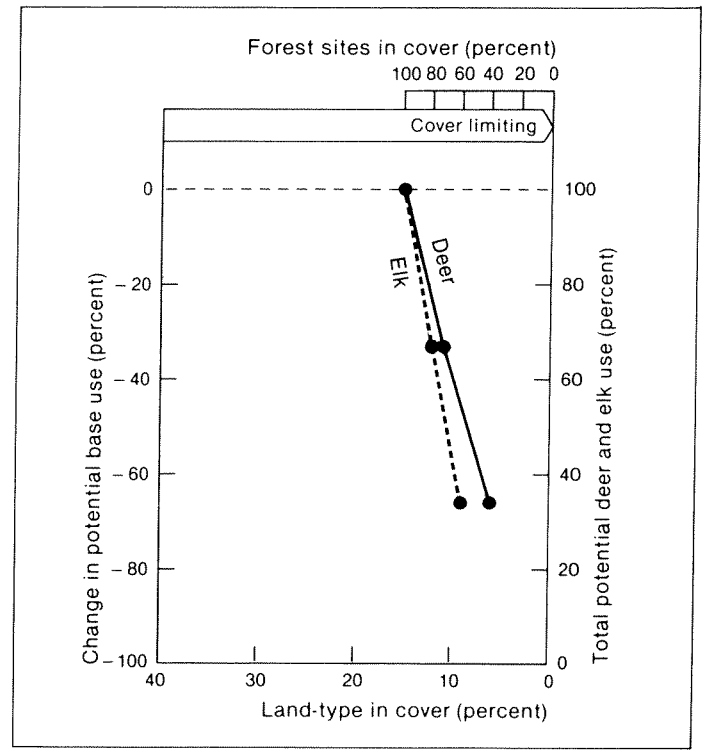
Appendix 28

Deer and elk use responses to alterations in cover-forage area ratios by land-type

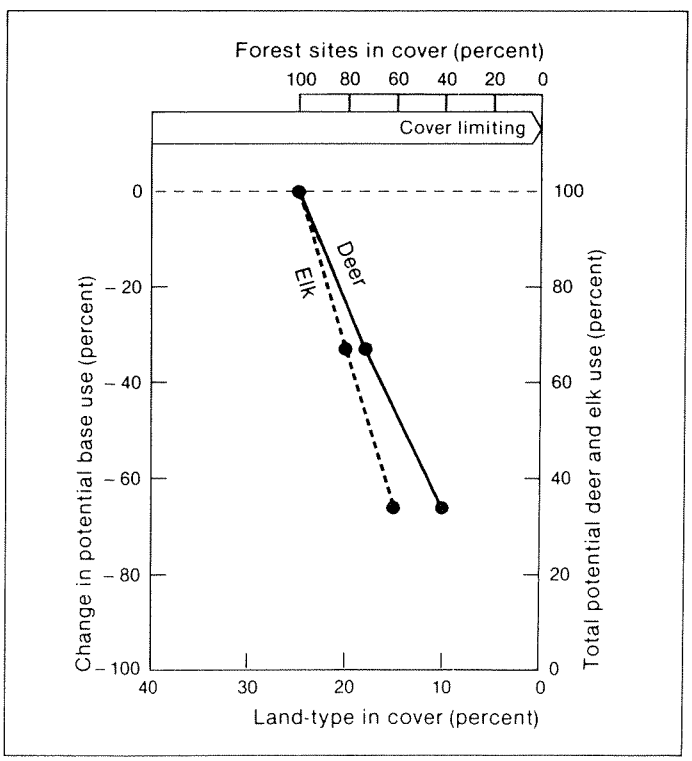
Land-type 1. Deer and elk use response to alteration in cover-forage area ratios



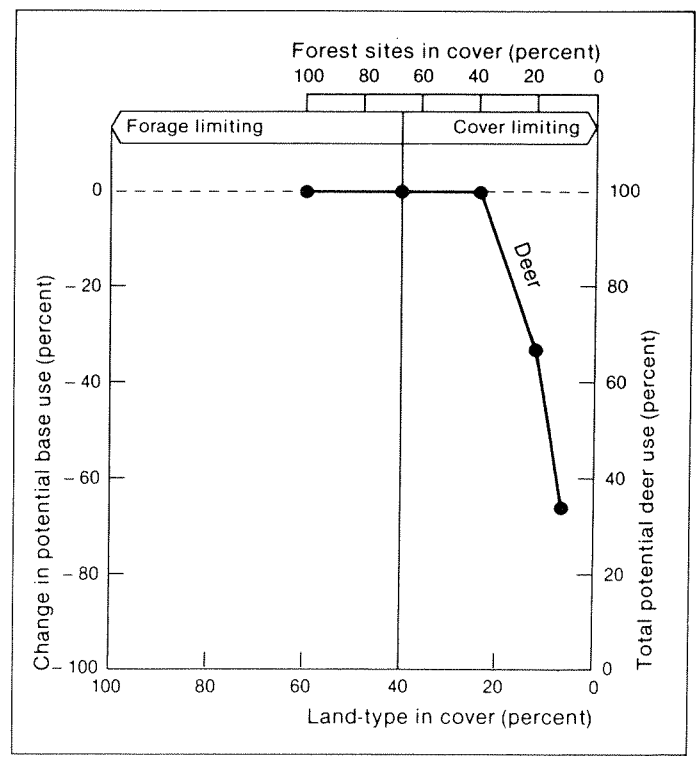
Land-type 2. Deer and elk use response to alteration in cover-forage area ratios



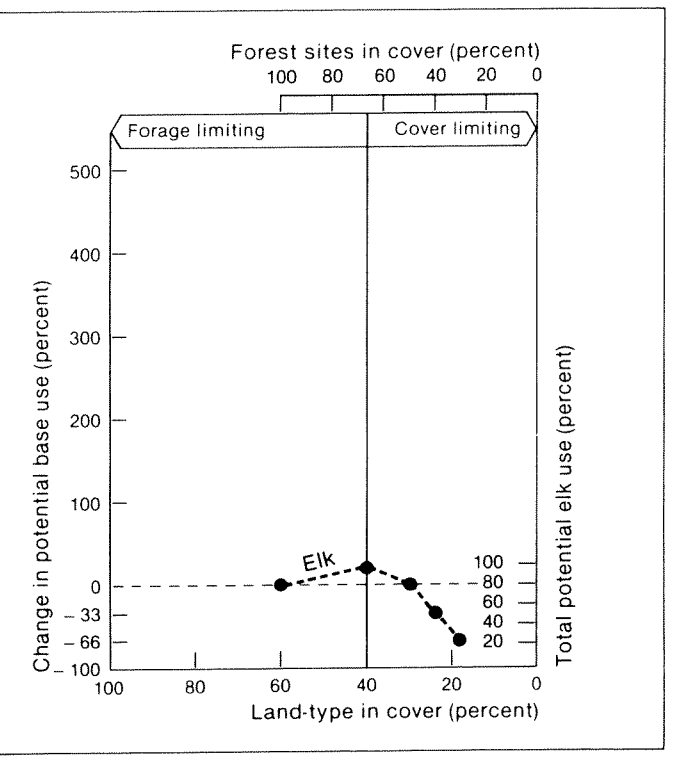
Land-type 3. Deer and elk use response to alteration in cover-forage area ratios



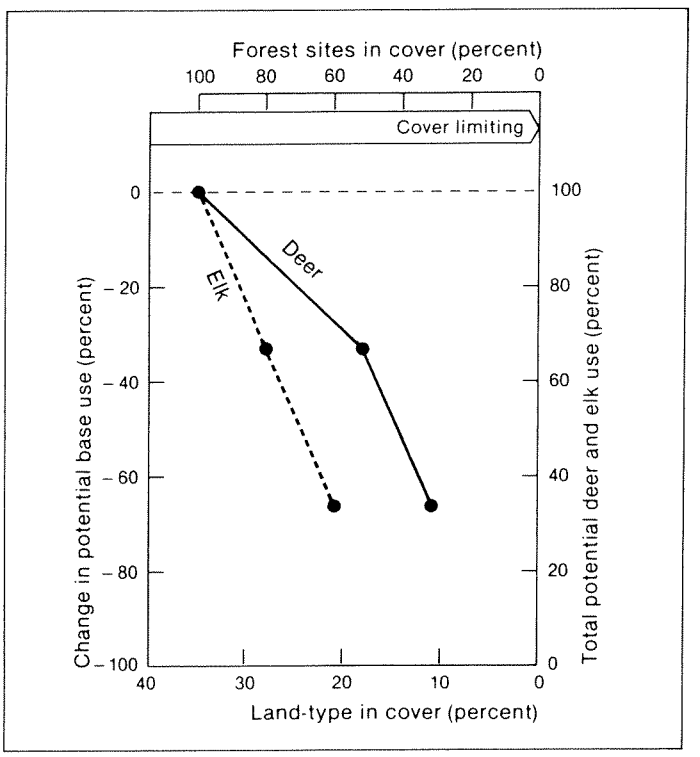
Land-type 4. Deer use response to alteration in cover-forage area ratios



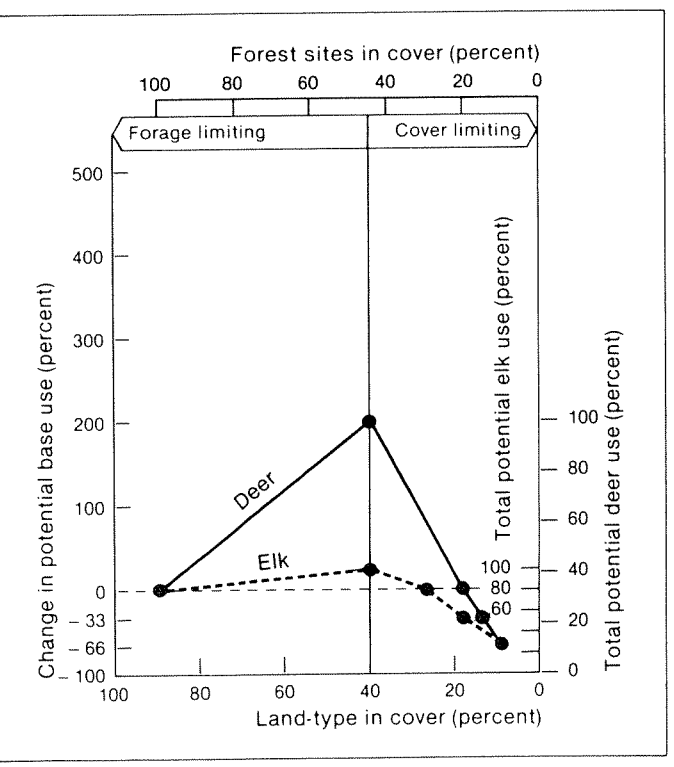
and-type 4. Elk use response to alteration in cover-orage area ratios



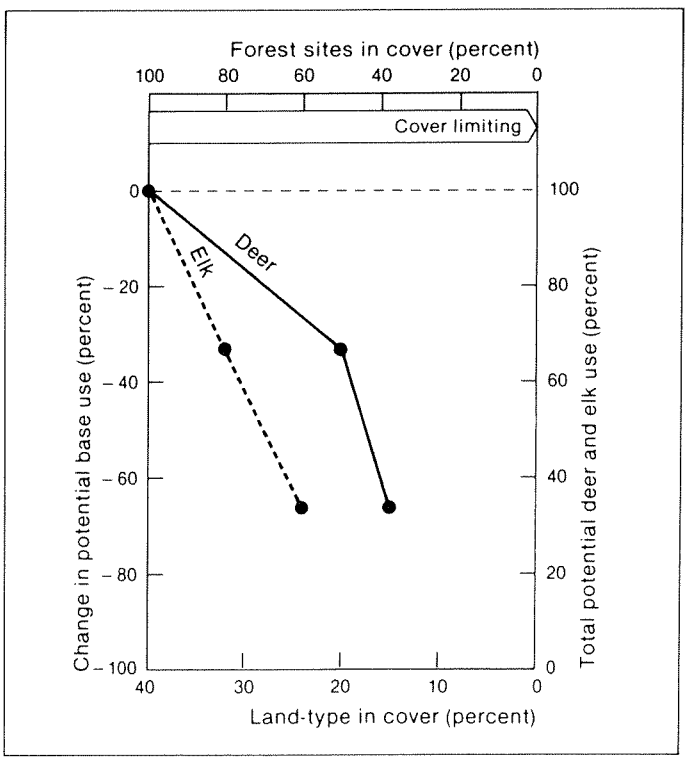
Land-type 5. Deer and elk use response to alteration in cover-forage area ratios



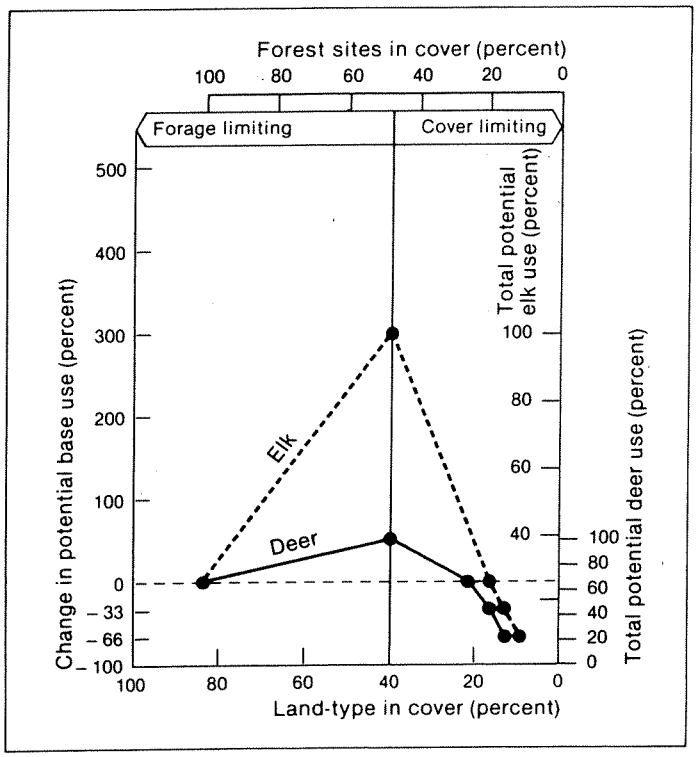
and-type 6. Deer and elk use response to alteration in over-forage area ratios



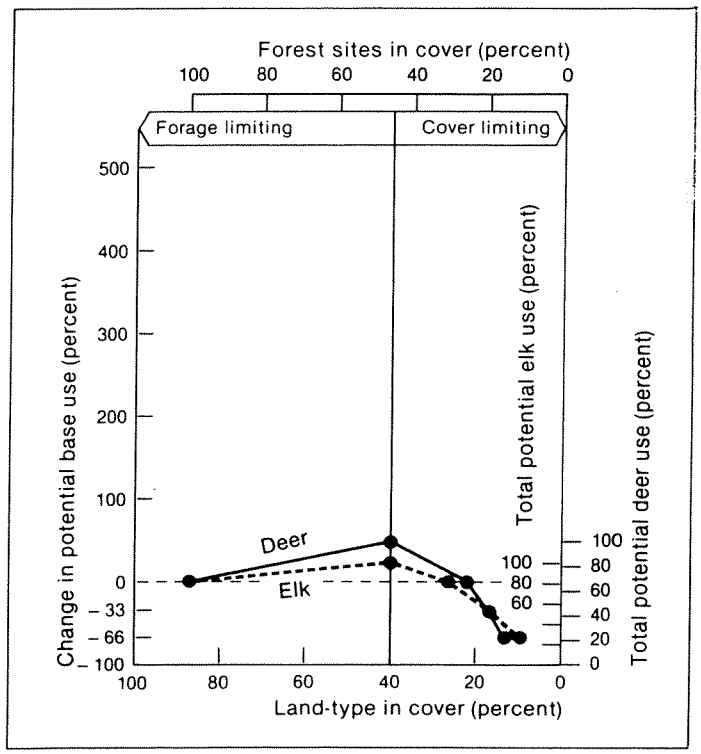
Land-type 7. Deer and elk use response to alteration in cover-forage area ratios



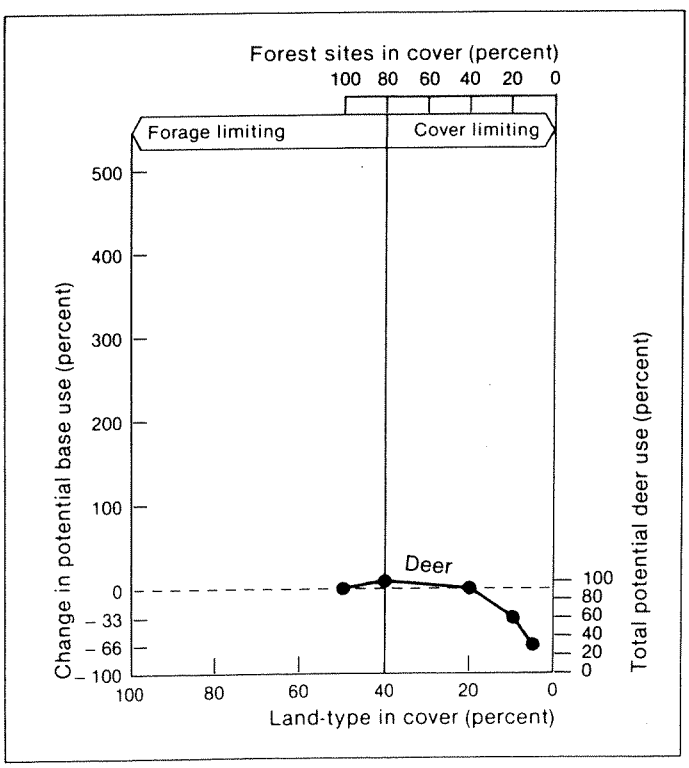
Land-type 8. Deer and elk use response to alteration in cover-forage area ratios



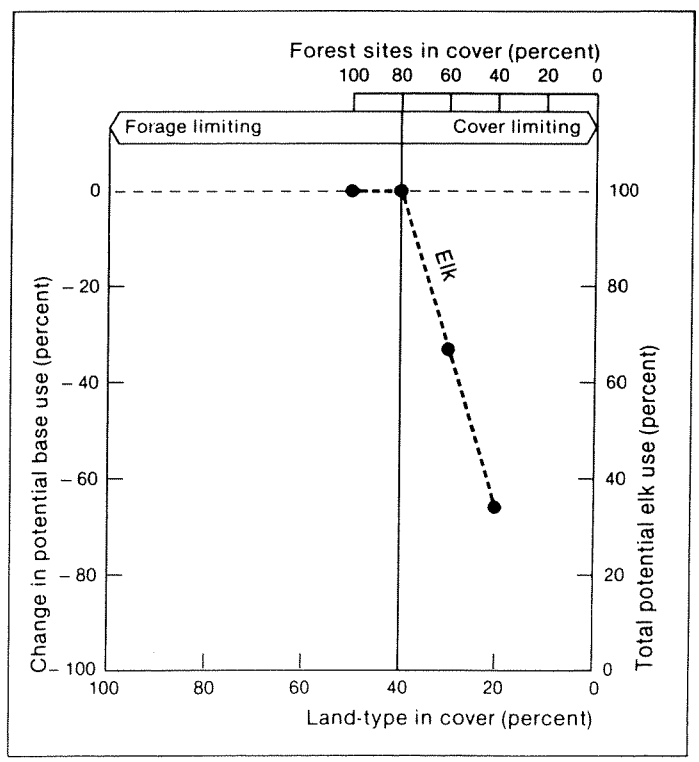
Land-type 9. Deer and elk use response to alteration in cover-forage area ratios



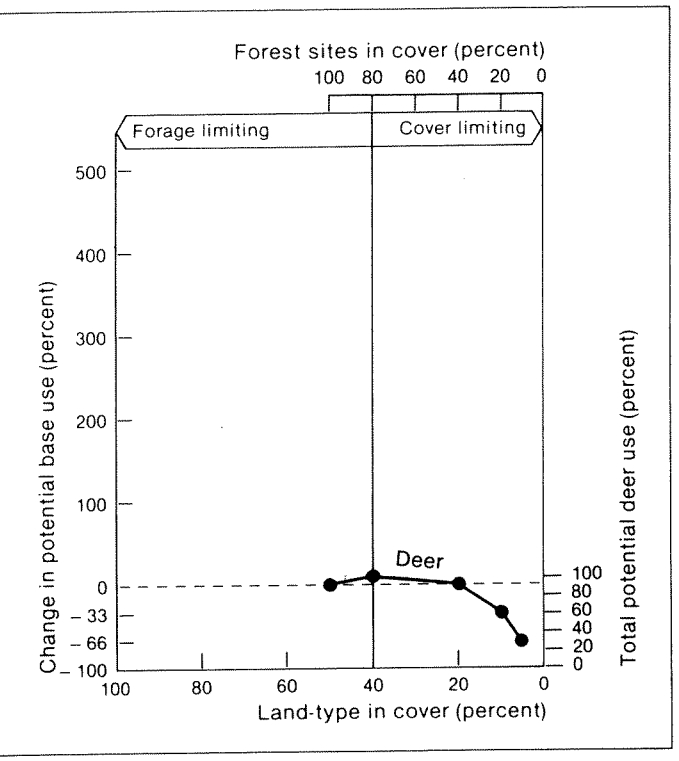
Land-type 10. Deer use response to alteration in cover-forage area ratios



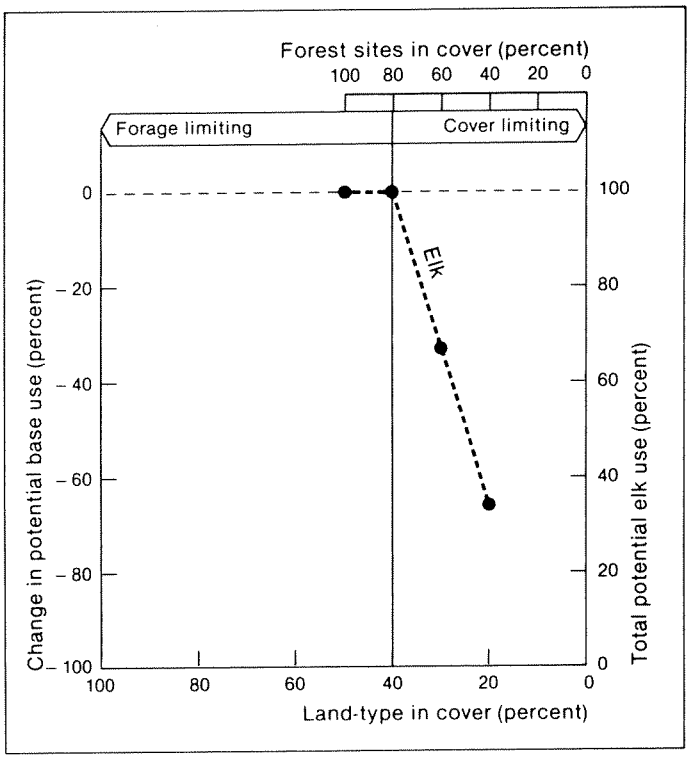
Land-type 10. Elk use response to alteration in cover-forage area ratios



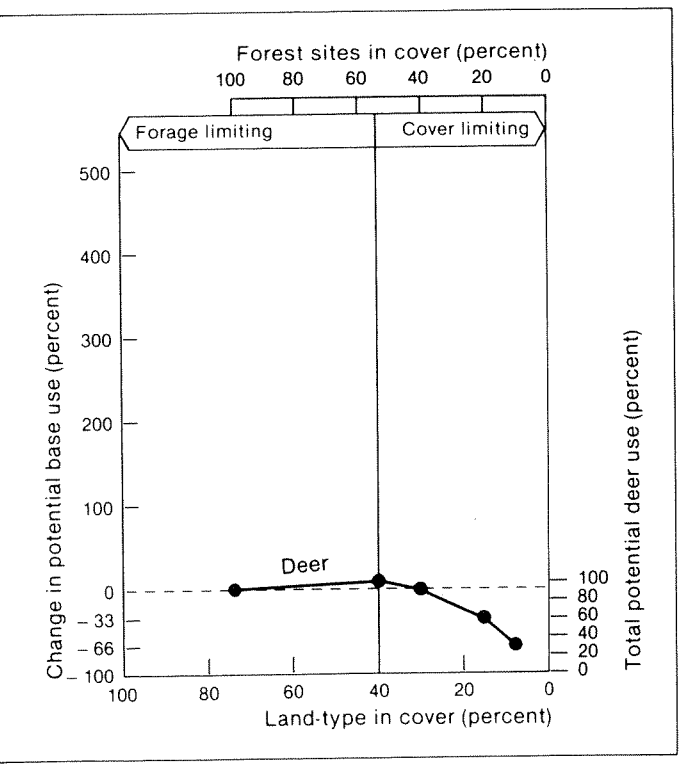
Land-type 11. Deer use response to alteration in cover-forage area ratios



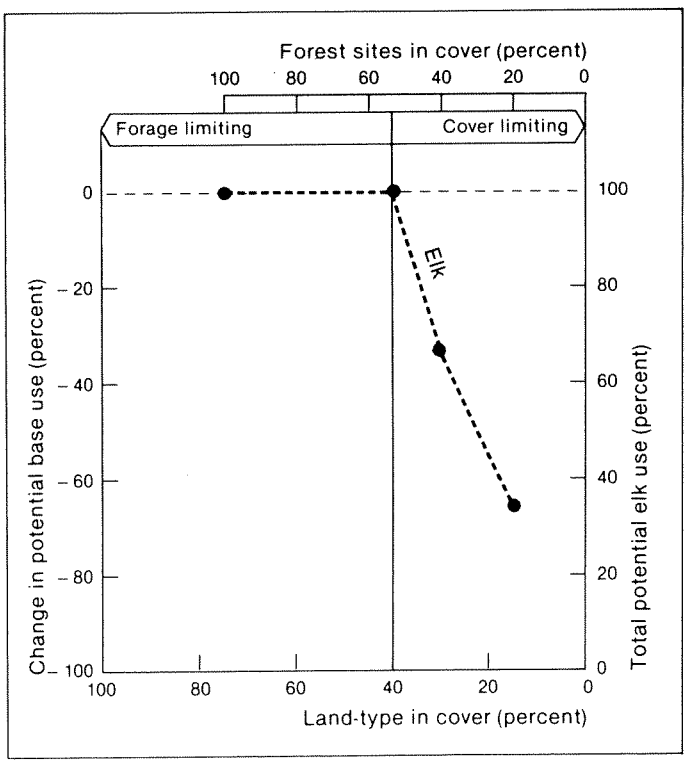
Land-type 11. Elk use response to alteration in cover-forage area ratios



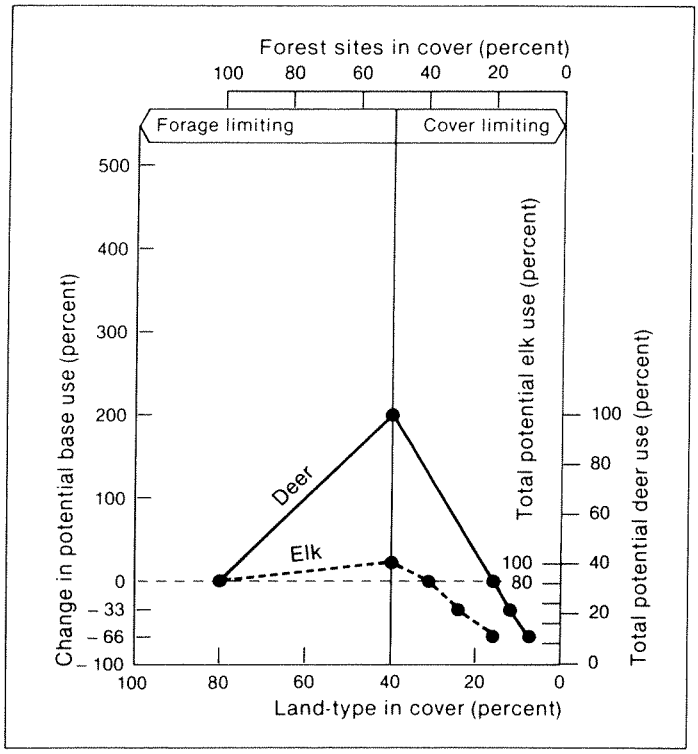
Land-type 12. Deer use response to alteration in cover-forage area ratios



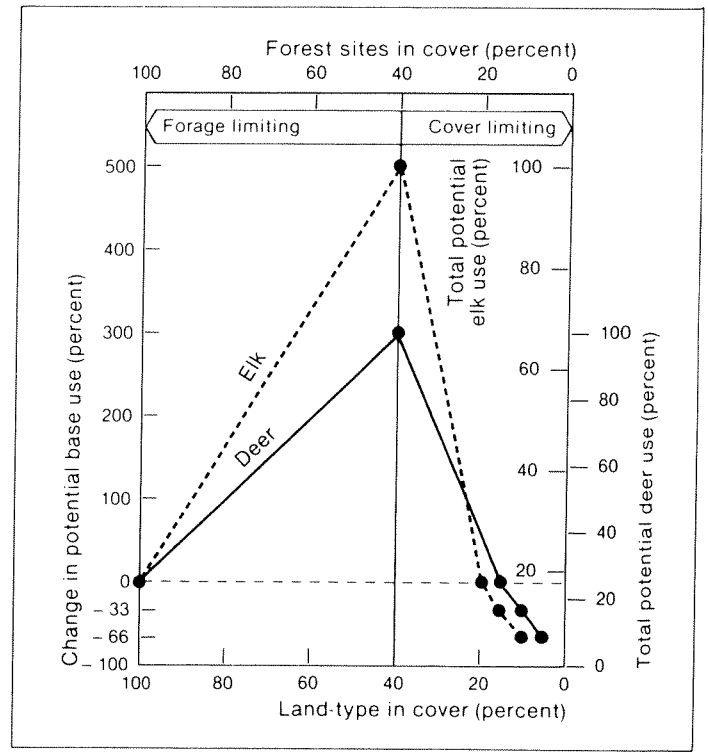
Land-type 12. Elk use response to alteration in cover-forage area ratios



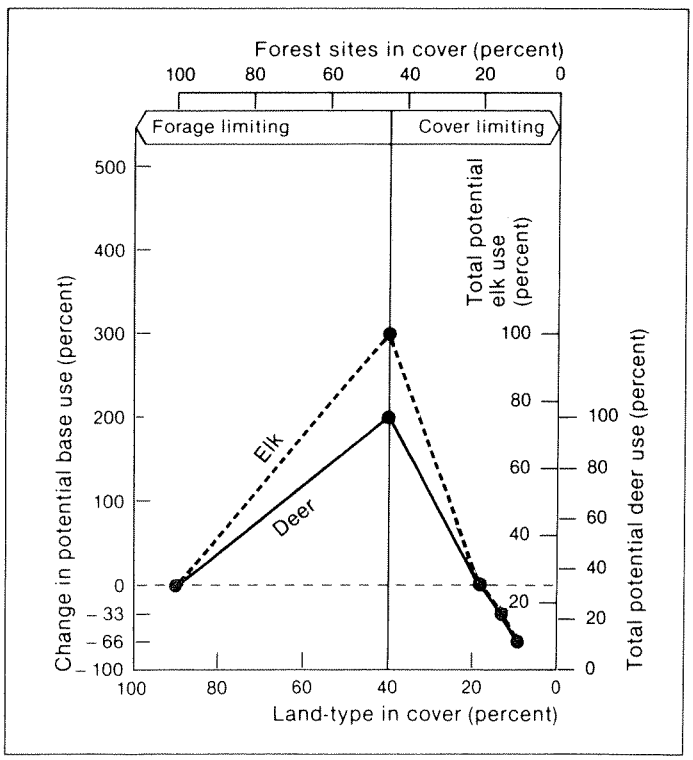
Land-type 13. Deer and elk use response to alteration in cover-forage area ratios



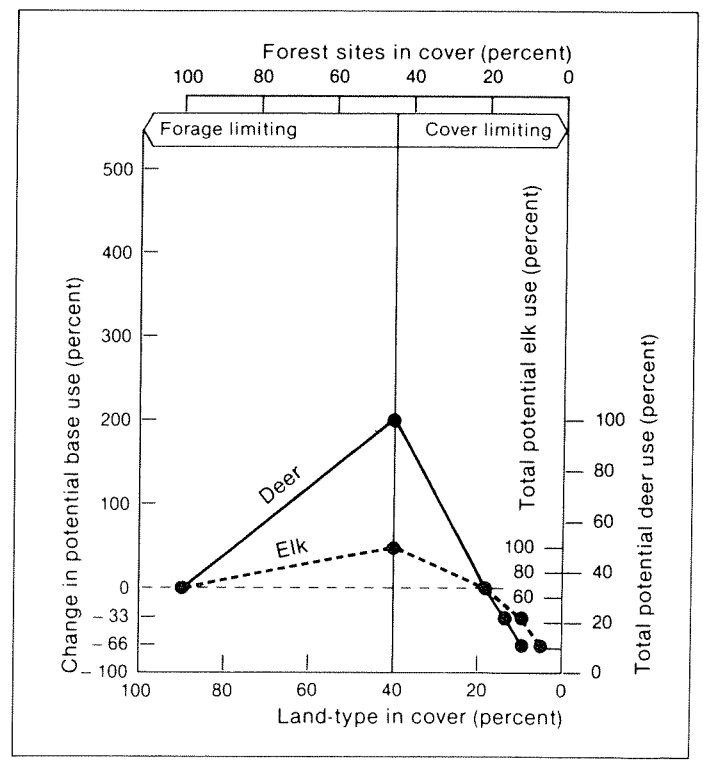
Land-type 14. Deer and elk use response to alteration in cover-forage area ratios



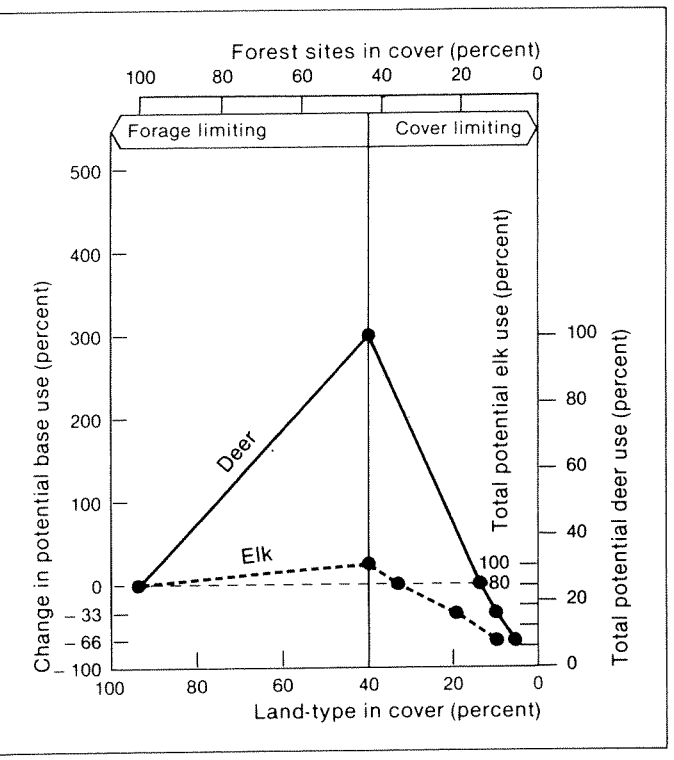
Land-type 15. Deer and elk use response to alteration in cover-forage area ratios



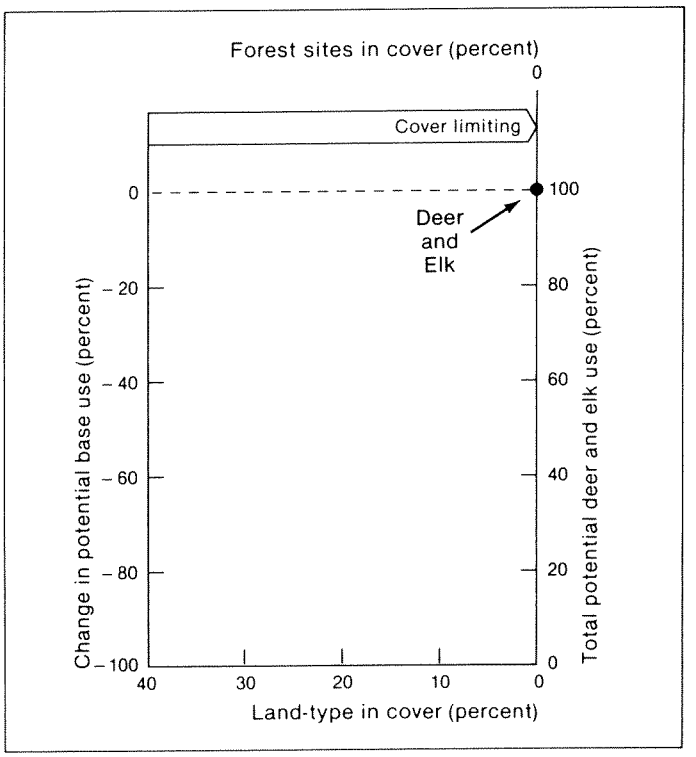
Land-type 16. Deer and elk use response to alteration in cover-forage area ratios



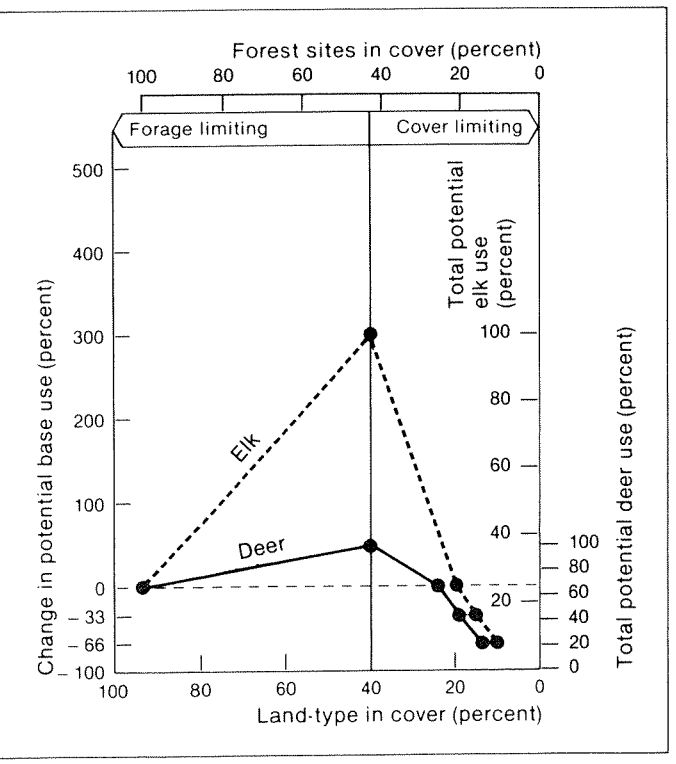
and-type 17. Deer and elk use response to alteration in over-forage area ratios



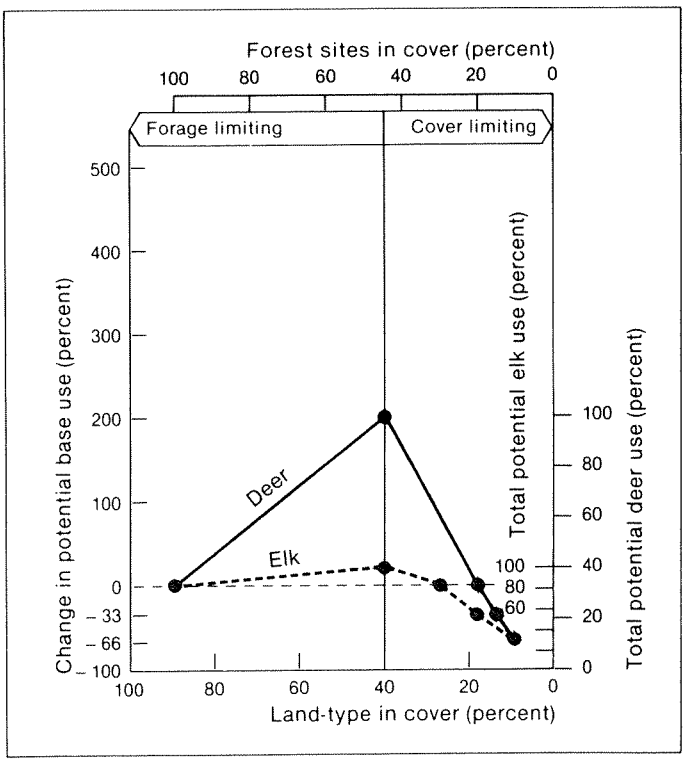
Land-type 18. Deer and elk use response to alteration in cover-forage area ratios



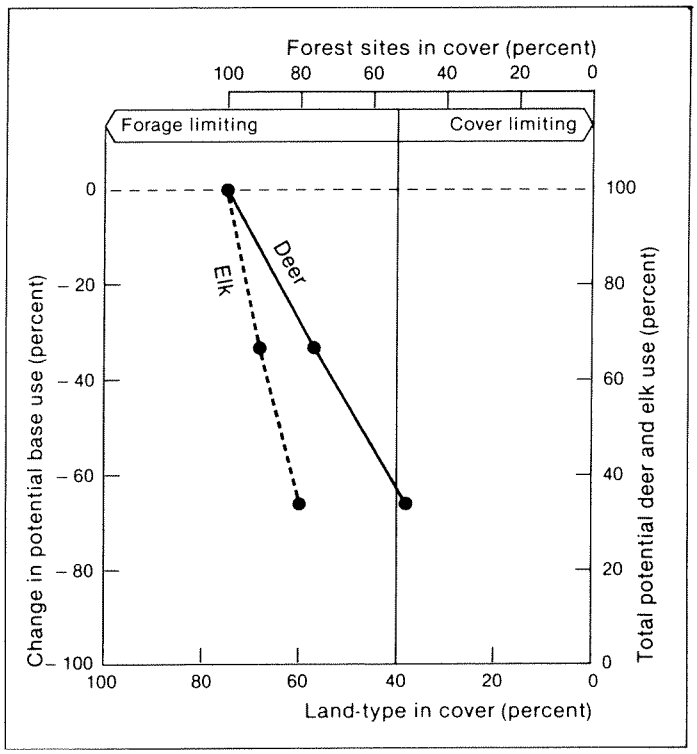
and-type 19. Deer and elk use response to alteration in over-forage area ratios



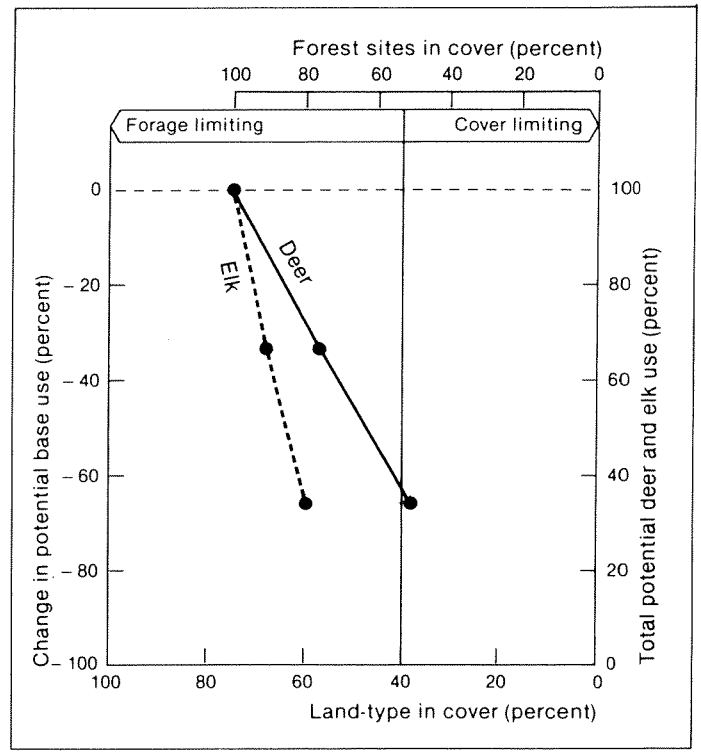
Land-type 20. Deer and elk use response to alteration in cover-forage area ratios



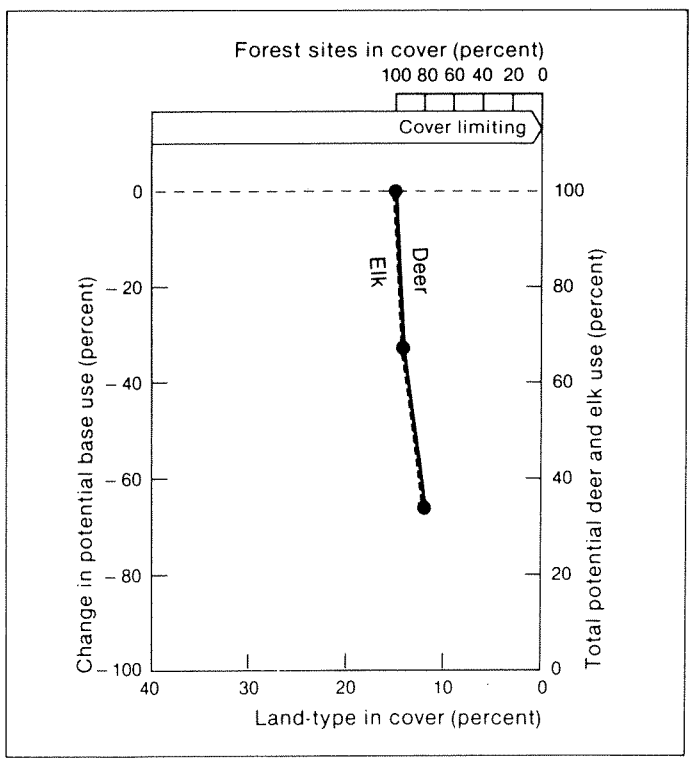
Land-type 21. Deer and elk use response to alteration in cover-forage area ratios



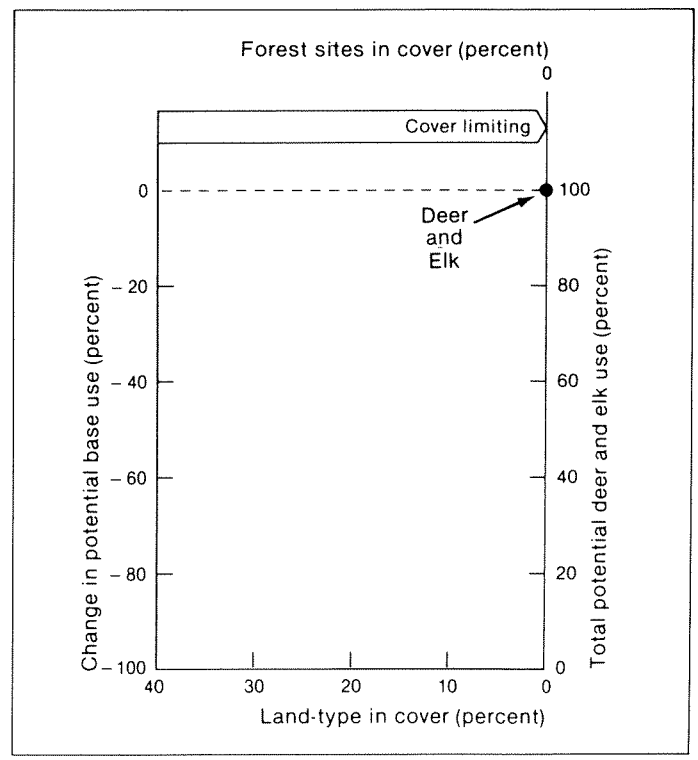
Land-type 22. Deer and elk use response to alteration in cover-forage area ratios



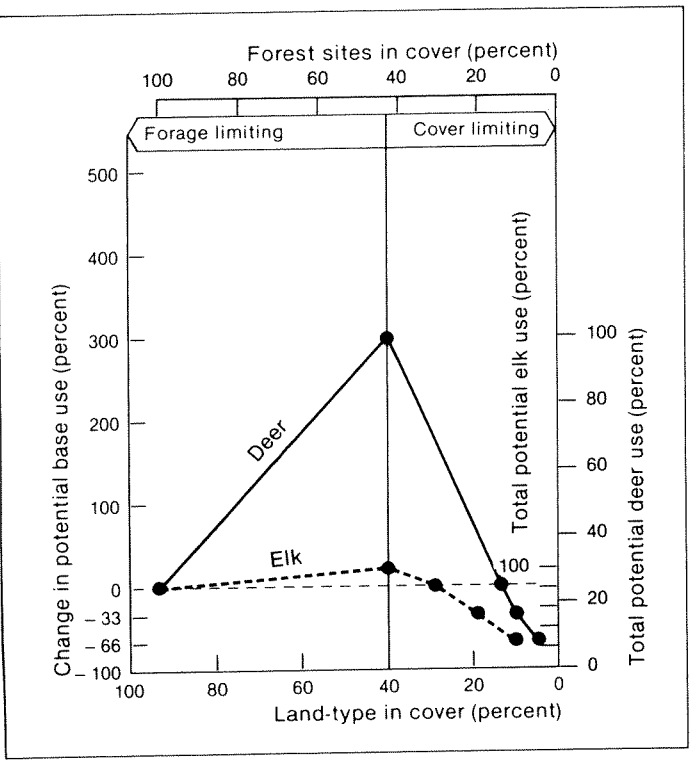
Land-type 23. Deer and elk use response to alteration in cover-forage area ratios



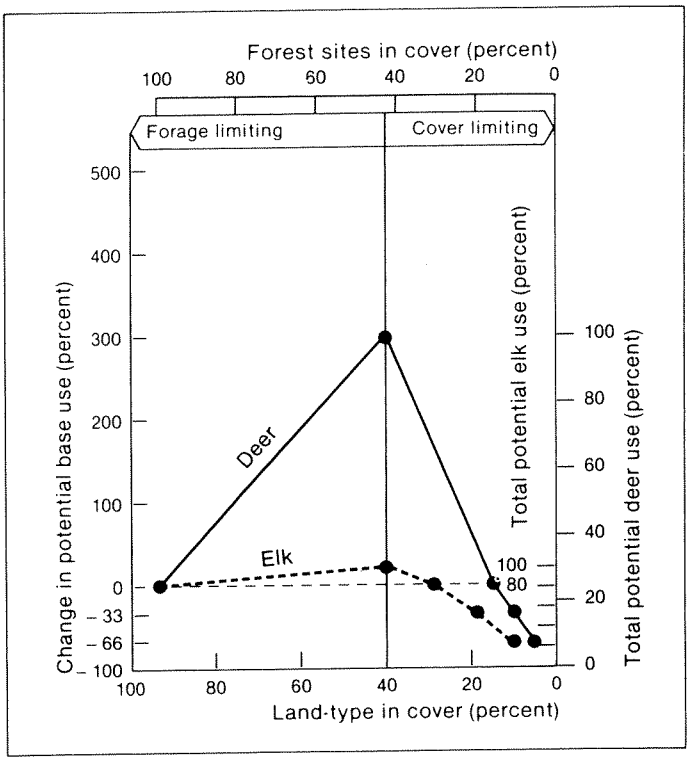
Land-type 24. Deer and elk use response to alteration in cover-forage area ratios



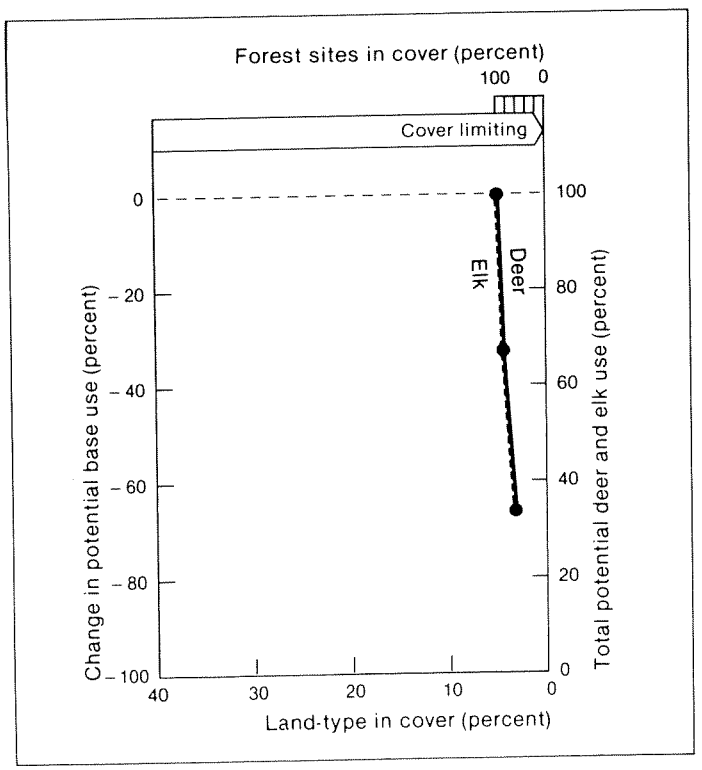
Land-type 25. Deer and elk use response to alteration in cover-forage area ratios



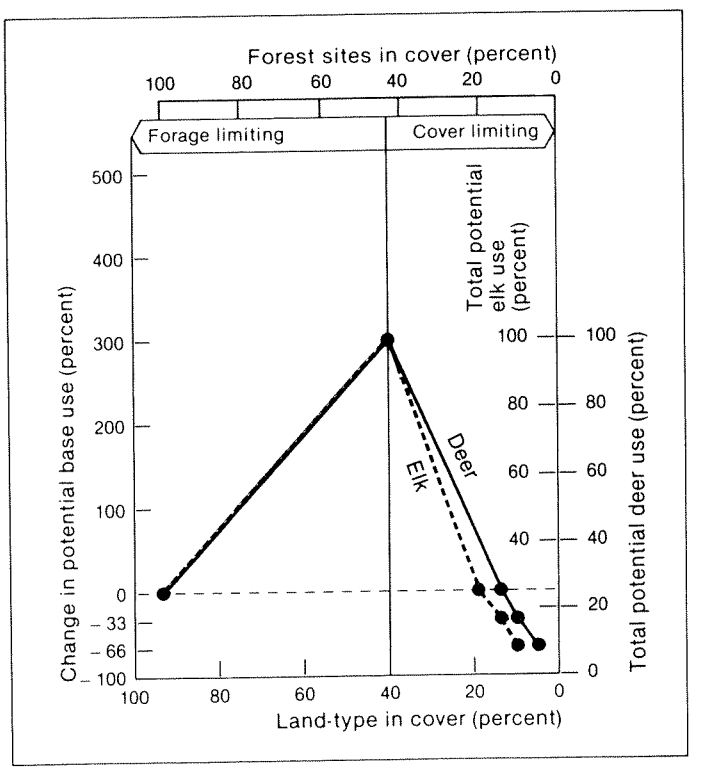
Land-type 26. Deer and elk use response to alteration in cover-forage area ratios



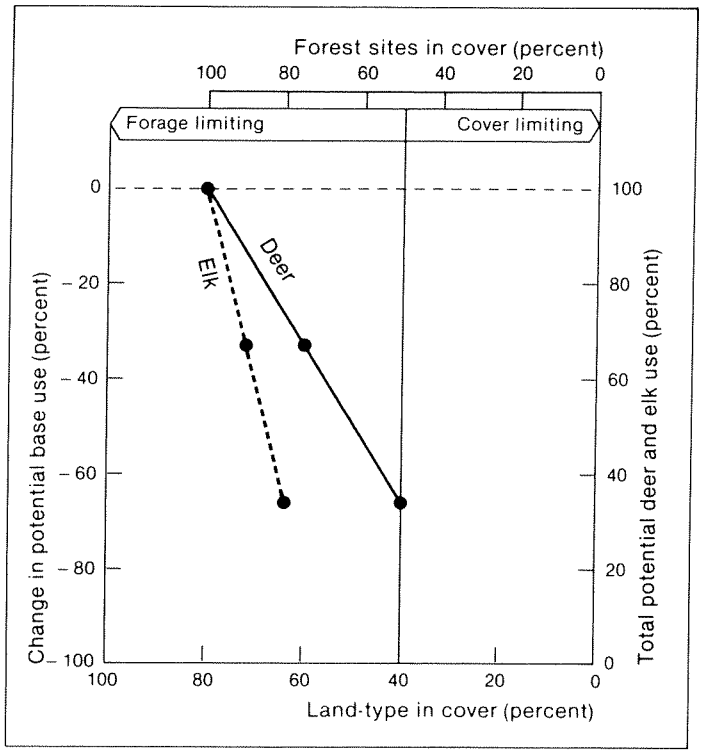
Land-type 27. Deer and elk use response to alteration in cover-forage area ratios



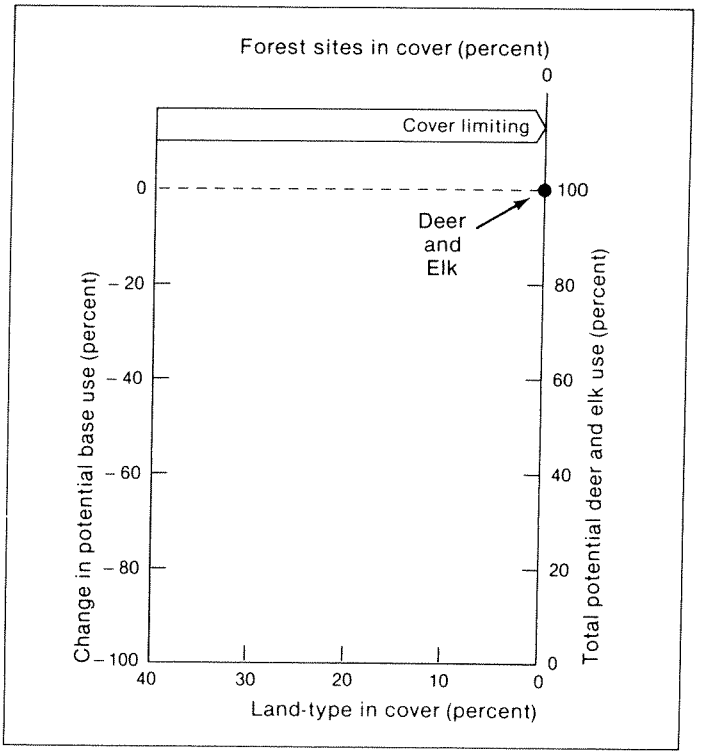
Land-type 28. Deer and elk use response to alteration in cover-forage area ratios



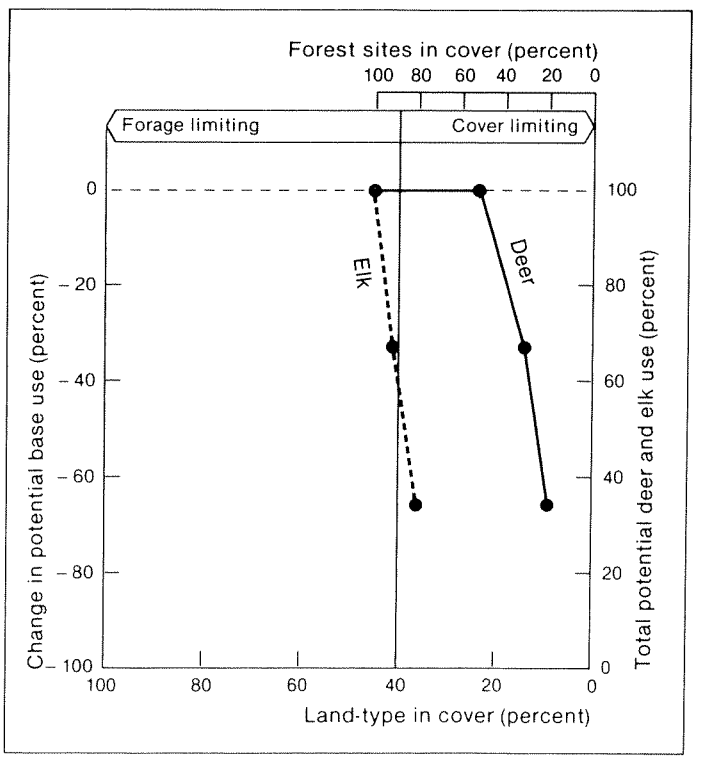
Land-type 29. Deer and elk use response to alteration in cover-forage area ratios



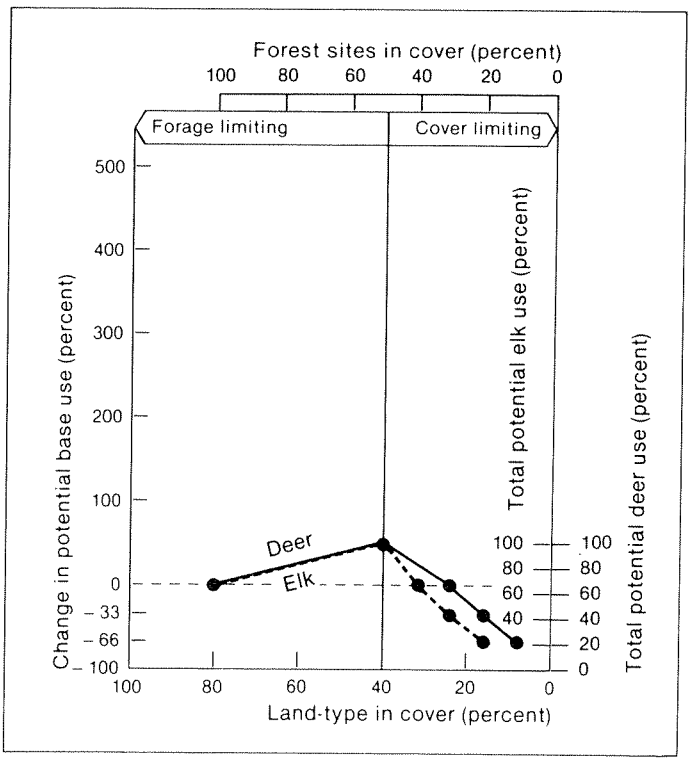
Land-type 30. Deer and elk use response to alteration in cover-forage area ratios



Land-type 31. Deer and elk use response to alteration in cover-forage area ratios



Land-type 32. Deer and elk use response to alteration in cover-forage area ratios



Appendix 29

Selected representative references for 378 wildlife species occurring in the Blue Mountains

Letter code	Life form	Species	Selected references
		AMPHIBIANS	
AMTI	2	tiger salamander	Delson 1974, Ferguson 1952, Heath 1975
AMMA	2	long-toed salamander	Anderson 1967, 1968; Stebbins 1954
ASTR	2	tailed frog	Brown 1975a, Metter 1964, Storm 1966
SCIN	2	Great Basin spadefoot toad	Bragg 1945, Stebbins 1951, Wright and Wright 1949
BUBO	2	western toad	Campbell 1970, Clarke 1974a, Lillywhite et al. 1973
BUWO	2	Woodhouse toad	Clarke 1974a, 1974b; Thornton 1960
HYRE	2	Pacific treefrog	Brown 1975b, Jameson 1956, Jameson et al. 1970
RAPR	2	spotted frog	Hollenbeck 1974, Licht 1975, Turner 1960
RAPI	2	leopard frog	Hine et al. 1975, Pace 1974, Ruibal 1962
RACA	1	bullfrog	Darham and Bennett 1963, Sebetich 1969, Wiewandt 1969
		REPTILES	
CHPI	3	painted turtle	Black 1970b, Cagle 1954, Legler 1954
SCOC	5	western fence lizard	Arnett 1974, Davis and Verbeek 1972, Marcellini and Mackey 1970
SCGR	5	sagebrush lizard	Derickson 1976, Tinkle 1973, Woodbury and Woodbury 1945
UTST	4	side-blotched lizard	Parker 1974a, Parker and Pianka 1975, Tinkle 1967
PHDO	5	short-horned lizard	Goldberg 1971, Pianka and Parker 1975, Reeve 1952
EUSK	3	western skink	Black and Storm 1970; Stebbins 1944, 1954, 1966
CNTI	5	western whiptail	Apslund 1974, Burkholder and Walker 1973, Parker 1972
CHBO	15	rubber boa	Ditmars 1936, Peabody et al. 1975, Stebbins 1954
DIPU	3	ringneck snake	Blanchard 1942, Fitch 1975, Parker and Brown 1974a
COCO	5	yellow-bellied racer	Fitch 1963, Herzog and Burghardt 1974, Van de Velde et al. 1962
MATA	5	striped whipsnake	Ditmars 1936, Goldberg and Parker 1975, Parker 1974b
PIME	5	gopher snake	Greenwald 1974, Martin and Huey 1971, Stull 1940
THSI	3	common garter snake	Carpenter 1952, Fitch 1965, Gregory 1973
THEL	5	western terrestrial garter snake	Carr and Gregory 1976; Fox 1948, 1951
HYTO	5	night snake	Clark and Lieb 1973, Schmidt and Davis 1941, Wright and Wright 1957
CRVI	5	western rattlesnake	Klauber 1972, Parker and Brown 1974b, Rahn 1942

Letter code	Life form	Species	Selected references
		BIRDS	
GAIM	3	common loon	Gabrielson and Jewett 1970, McIntyre 1974, Olson and Marshall 1952
GAAR	3	Arctic loon	Bent 1963a, Dunker 1974, Gabrielson and Jewett 1970
POGR	3	red-necked grebe	Bent 1963a, Gabrielson and Jewett 1970, Kebbe 1958, McAllister 1964
POAU	3	horned grebe	Faaborg 1976, Gabrielson and Jewett 1970, McAllister 1964
PONI	3	eared grebe	Faaborg 1976; McAllister 1955, 1964
AEOC	3	western grebe	Bent 1963a, Gabrielson and Jewett 1970, Lawrence 1950
POPO	3	pied-billed grebe	Bleich 1975, Glover 1953, Kirby 1976
PEER	3	white pelican	Bent 1964a, Boeker 1972, Lies and Behle 1966, Thompson 1932
PHAU	3	double-crested cormorant	Gabrielson and Jewett 1970, Lack 1945, Van Tets 1959
ARHE	12	great blue heron	Jackman and Scott 1975, Krebs 1974, Urhahn 1968
CAAL	7	common egret	Bent 1926, Gabrielson and Jewett 1970, Pratt 1970, Sooter 1941a, Walker 1935
NYNY	7	black-crowned night heron	Allen and Mangels 1938-39, Henny 1972, Nickell 1966
BOLE	3	American bittern	Bent 1926, Gabrielson and Jewett 1970, Scott et al. 1972
PLCH	12	white-faced ibis	American Ornithologists' Union 1957, Bent 1926, Gabrielson and Jewett 1970, Ryder 1967b
CYOL	3	mute swan	Reese 1975, Scott et al. 1972, Willey 1968
OLCO	3	whistling swan	Bent 1962a, Gabrielson and Jewett 1970, Sherwood 1960
BRCA	3	Canada goose	Hanson 1965, Hanson and Eberhardt 1971, Martin 1963
BRNI	3	black brant	Barry 1956, Einarsen 1965, Hout 1967
ANAL	3	white-fronted goose	Bent 1962a, Gabrielson and Jewett 1970, Mickelson 1975
CHCA	3	snow goose	Cooch 1958, Dzubin et al. 1975, Kerbes 1975
CHRO	3	Ross' goose	Barry 1964; Jewett 1946; Ryder 1967a, 1972
ANPL	3	mallard	Anderson and Henny 1972, Anderson et al. 1974, Pospahala et al. 1974
ANST	3	gadwall	Gates 1958, 1962; Jensen 1949
ANAC	3	pintail	Fuller 1953, Rundquist 1974, Smith 1968a
ANCR	3	green-winged teal	Gabrielson and Jewett 1970, Moisan 1966, Turner and Threlfall 1975
ANDI	3	blue-winged teal	Glover 1956, Swanson et al. 1974, Wheeler 1965
ANCY	3	cinnamon teal	Bent 1962a, Gabrielson and Jewett 1970, Spencer 1953

Letter code	Life form	Species	Selected references
		BIRDS	
ANPE	3	European wigeon	Gabrielson and Jewett 1970, Hasbrouck 1944, Owen 1973
ANAM	3	American wigeon	Bent 1962a; Gabrielson and Jewett 1970; Gates 1958, 1962
ANCL	3	northern shoveler	Girard 1939, March 1967, Poston 1974
AISP	14	wood duck	Beebe 1974, Bellrose et al. 1964, Brown 1973a, Grice and Rogers 1965, Hoyt 1957, Jackman 1974a
AYAM	3	redhead	Lokemoen 1962, Low 1945, Olson 1964
AYCO	3	ring-necked duck	Bent 1962a, Marshall and Duebbert 1965, Mendall 1958
AYVA	3	canvasback	Erickson 1948, Hochbaum 1944, Olson 1964
AYMA	3	greater scaup	Bent 1962a, Gabrielson and Jewett 1970, Gehrman 1951
AYAF	3	lesser scaup	Bent 1962a, Dirschl 1969, Gehrman 1951, Rogers 1962
BUCL	14	common goldeneye	Bent 1962b, Gibbs 1961, Jackman 1974a, McLaren 1962, Munro 1939, Wetmore 1964
BUIS	14	Barrow's goldeneye	Bent 1962b, Griffee 1958, Jackman 1974a, Munro 1939, Myres 1957
BUAL	14	bufflehead	Bent 1962b; Erskine 1960, 1961; Griffee 1961; Munro 1942
HIHI	3	harlequin duck	Bent 1962b, Gabrielson and Jewett 1970, Gashwiler 1961
MEDE	3	white-winged scoter	Gabrielson and Jewett 1970, Grosz 1966, Rawls 1949
OXJA	3	ruddy duck	Bent 1962b, Gabrielson and Jewett 1970, Misterek 1974
LOCU	14	hooded merganser	Beebe 1974, Bent 1962a, Griffee 1954, Kitchen 1968, Morse et al. 1969
MEME	14	common merganser	Bent 1962a, Erskine 1972, Miller and Barclay 1974
MESE	3	red-breasted merganser	Bent 1962a, Gabrielson and Jewett 1970
CAAU	4	turkey vulture	Bent 1961, Coles 1938, Kempton 1927
ELLE	11	white-tailed kite	Eisenmann 1971, Hawbecker 1942, Waian and Stendall 1970
ACGE	11	goshawk	Jackman and Scott 1975, McGowan 1975, Reynolds 1975
ACST	11	sharp-shinned hawk	Brown 1973b, Jackman and Scott 1975, Reynolds 1975
ACCO	11	Cooper's hawk	Henny 1972, Meng 1952, Reynolds 1975
BUJA	12	red-tailed hawk	Fitch et al. 1946, Gates 1972, Luttich et al. 1970
BUSW	7	Swainson's hawk	Browning 1974, Craighead and Craighead 1969, Olendorff 1972
BULA	5	rough-legged hawk	Brown and Amadon 1968, Schnell 1968, Springer 1975
BURE	4	ferruginous hawk	Snow 1974a, Wakeley 1974, Weston 1969

Letter code	Life form	Species	Selected references
		BIRDS	
AQCH	12	golden eagle	Baglien 1975, Olendorff 1976, Snow 1973a
HALE	12	bald eagle	Hannum et al. 1974, Snow 1973b, Swenson 1975
CICY	5	marsh hawk	Clark and Ward 1974, Craighead and Craighead 1969, Urner 1925
PAHA	12	osprey	Lind 1976, Roberts and Lind 1972, Zarn 1974a
FAME	4	prairie falcon	Denton 1976, Marti and Braun 1975, Snow 1974b
FAPE	4	peregrine	Hickey 1969, Porter and White 1973, Snow 1972
FACO	11	merlin	Fox 1971, Johnson and Coble 1967, Trimble 1975a
FASP	14	American kestrel	Balda 1975, Enderson 1960, Henny 1977, McClelland and Frissell 1975, McLaren 1962, Roest 1957, Smith et al. 1972
DEOB	5	blue grouse	Bendell and Elliott 1967, Blackford 1958, Donaldson and Bergerud 1974
CACA	5	Franklin's grouse	Haas 1974, Jackman and Scott 1975, Pendergast and Boag 1971
BOUM	5	ruffed grouse	Bump et al. 1947, Doerr et al. 1970, Moulton and Vanderschaegen 1974
LALE	4	white-tailed ptarmigan	Braun and Rogers 1971, Choate 1963, Weeden 1960
PEPH	5	sharp-tailed grouse	Buss and Dziedzic 1955, Evans 1968, Schiller 1973
CEUR	5	sage grouse	Gray 1967, Griner 1939, Wallestad 1975
COVI	5	bobwhite	Klimstra and Roseberry 1975; Stoddard 1931, 1961
LOCA	5	California quail	Anthony 1970, Storer et al. 1942, Sumner 1935
ORPI	5	mountain quail	Gutierrez 1975, Lahnum 1944, Ormiston 1966
ALCH	4	chukar	Christensen 1952, Galbreath and Moreland 1953, Mackie 1960
PEPE	5	gray partridge	McKinney 1966, Westerskov 1949, Yocom 1943
PHCO	5	ring-necked pheasant	Allen 1956, Crouse 1941, Eklund 1942
MEGA	5	turkey	Hewitt 1967, Jackman and Scott 1975, Sanderson and Schultz 1973
GRCA	3	sandhill crane	Drewien and Bizeau 1974, Reeves 1975, Walkinshaw 1949
RALI	3	Virginia rail	Gabrielson and Jewett 1970, Horak 1964, Reeves 1975
POCA	3	sora	Billard 1947, Gabrielson and Jewett 1970, Reeves 1975
FUAM	3	American coot	Jahn 1965, Jones 1940, Reeves 1975, Sooter 1945
CHAL	3	snowy plover	Gabrielson and Jewett 1970, Purdue 1974
CHVO	3	killdeer	Bunni 1959, Gerstenberg and Jurek 1972, Lenington and Mace 1975

Letter code	Life form	Species	Selected references
		BIRDS	
CHMO	3	mountain plover	Gerstenberg and Jurek 1972, Graul 1975, Laun 1957
CAGA	3	common snipe	Mason and Macdonald 1976, Reeves 1975, Tuck 1972
NUAM	3	long-billed curlew	Bent 1962c, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
BALO	5	upland sandpiper	Buss 1939, Gerstenberg and Jurek 1972, Higgins and Kirsh 1975
ACMA	3	spotted sandpiper	Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972, Nelson 1939
TRSO	7	solitary sandpiper	Bent 1962c, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
TRME	3	greater yellowlegs	Bent 1962d, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
TRFL	3	lesser yellowlegs	Bent 1962d, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
CASE	3	willet	Bent 1962c, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
CAME	3	pectoral sandpiper	Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972, Pitelka 1959
CABA	3	Baird's sandpiper	Bent 1962d, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
CAMI	3	least sandpiper	Bent 1962d, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
CAMA	3	western sandpiper	Bent 1962d, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
LISC	3	long-billed dowitcher	Bent 1962d, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
REAM	3	American avocet	Bent 1962d, Gabrielson and Jewett 1970, Gerstenberg and Jurek 1972
STTR	3	Wilson's phalarope	Burger and Howe 1975, Höhn 1967, Johns 1969
LOLO	3	northern phalarope	Cole 1943, Höhn 1971, Tinbergen 1935
LAAR	3	herring gull	Bent 1963b, Gabrielson and Jewett 1970, Keith 1966
LACA	3	California gull	Greenhalgh 1952, Odin 1957, Vermeer 1967
LADE	3	ring-billed gull	Broadbooks 1961, Miller and Emlen 1975, Southern 1968
LAPI	3	Franklin's gull	Bent 1963b, Gabrielson and Jewett 1970, Jewett 1949
LAPH	3	Bonaparte's gull	Bent 1963b, Gabrielson and Jewett 1970
STFO	3	Forster's tern	Gabrielson and Jewett 1970, McNicholl 1971, Salt and Willard 1971

Letter code	Life form	Species	Selected references
		BIRDS	
HYCA	3	Caspian tern	Bent 1963b, Gabrielson and Jewett 1970
CHNI	3	black tern	Bent 1963b, Einarsen 1941, Gabrielson and Jewett 1970
COFA	11	band-tailed pigeon	Houston 1963, Reeves 1975, Smith 1968b, Wight et al. 1967
COLI	4	rock dove	Kindschy 1964; Murton et al. 1972, 1974
ZEMA	11	mourning dove	Aldrich and Duvall 1958, Cowan 1952, U.S. Department of the Interior, Fish and Wildlife Service 1962
COAM	8	yellow-billed cuckoo	Gabrielson and Jewett 1970, Quaintance 1944, Trimble 1975b
TYAL	14	barn owl	Bent 1961; Henny 1969, 1972; Jackman 1974a; Smith et al. 1974; Stewart 1952
OTAS	14	screech owl	Bent 1961, Jackman 1974a, Nowicki 1974, VanCamp and Henny 1975
OTFL	14	flammulated owl	Balda 1975, Balda et al. 1975, Bull and Anderson 1978, Jackman 1974a, Marshall 1939, Winter 1974
BUVI	12	great horned owl	Baumgartner 1939a, Henny 1972, Rusch et al. 1972
NYSC	5	snowy owl	Bent 1961, Gabrielson and Jewett 1970, Snyder 1949
GLGN	14	pygmy owl	Balda 1975, Bent 1961, Burton 1973, Gabrielson and Jewett 1970, Jackman 1974a
SPCU	15	burrowing owl	Coulombe 1971, Maser et al. 1971, Zarn 1974b
STVA	14	barred owl	Bent 1961, Dunstan and Sample 1972, Nicholls and Warner 1972, Reichard 1974
STOC	14	spotted owl	Forsman 1975, Gould 1974, Zarn 1974c
STNE	12	great gray owl	Hoglund and Lansgren 1968, Jackman and Scott 1975, Oeming 1955
ASOT	11	long-eared owl	Armstrong 1958, Maser et al. 1970, Reynolds 1970
ASFL	5	short-eared owl	Banfield 1947, Clark 1975, Marti 1974
AEAC	14	saw-whet owl	Balda 1975, Bent 1961, Forbes and Warner 1974, Jackman 1974a, Kebbe 1959, Woods 1972
PHNU	6	poorwill	Gabrielson and Jewett 1970, Horn and Marshall 1975, Trimble 1975b
CHMI	6	common nighthawk	Armstrong 1965, Selander 1954, Trimble 1975b
CYNI	4	black swift	Bent 1964b, Gabrielson and Jewett 1970, Trimble 1975b
CHVA	14	Vaux's swift	Baldwin and Hunter 1963, Baldwin and Zaczkowski 1963, Bent 1964b, Gabrielson and Jewett 1970, Peterson 1961, Trimble 1975b
AESA	4	white-throated swift	Bent 1964b, Trimble 1975b, Weber 1975
ARAL	7	black-chinned hummingbird	Bent 1964b, Gabrielson and Jewett 1970, Trimble 1975b

Letter code	Life form	Species	Selected references
		BIRDS	
SEPL	7	broad-tailed hummingbird	Calder 1973, Calder and Booser 1973, Trimble 1975b
SERU	11	rufous hummingbird	Gass 1974, Gass et al. 1976, Horvath 1964
STCA	7	calliope hummingbird	Calder 1971, 1973; Trimble 1975b
MEAL	16	belted kingfisher	Hamas 1974, Kilham 1974, Trimble 1975b
COAU	13	common flicker	Anderson 1972, Burns 1900, Conner 1973, Jackman 1974b, Jackman and Scott 1975, Kelleher 1963, Lawrence 1967, Neff 1926
DRPI	13	pileated woodpecker	Anderson 1972, Bull 1975, Conner 1973, Hoyt 1957, Jackman 1974b, Jackman and Scott 1975, Meslow and Wight 1975, Tanner 1942
ASLE	13	Lewis' woodpecker	Bent 1964c, Bock 1970, Bock et al. 1971, Jackman 1974b, Jackman and Scott 1975
SPVA	13	yellow-bellied sapsucker	Bent 1964c, Erskine and McLaren 1972, Jackman 1974b, Kilham 1971b, Rushmore 1973
SPTH	13	Williamson's sapsucker	Bent 1964c, Jackman 1974b, Michael 1935
DEVI	13	hairy woodpecker	Anderson 1972, Conner 1973, Jackman 1974b, Kilham 1968a, Lawrence 1967, Staebler 1949
DEPU	13	downy woodpecker	Anderson 1972, Conner 1973, Jackman 1974b, Jackson 1970, Lawrence 1967, Staebler 1949
DEAL	13	white-headed woodpecker	Bent 1964c; Gabrielson and Jewett 1940, 1970; Jackman 1974b; Jackman and Scott 1975; Ligon 1973
PIAR	13	black-backed three-toed woodpecker	Bock and Bock 1974, Jackman 1974b, Short 1974
PITR	13	northern three-toed woodpecker	Jackman 1974b, Jackman and Scott 1975, Short 1974
TYTY	7	eastern kingbird	Dick and Rising 1965, Hespenheide 1964, Trimble 1975b
TYVE	11	western kingbird	Dick and Rising 1965, Ohlendorf 1974, Trimble 1975b
MYCI	14	ash-throated flycatcher	Bent 1963c, Gabrielson and Jewett 1970, Jackman 1974a, Trimble 1975b
SASA	4	Say's phoebe	Ohlendorf 1976, Trimble 1975b, Whitaker 1974
EMTR	7	willow flycatcher	Ashmole 1968, King 1955, Robbins 1974
EMHA	11	Hammond's flycatcher	Beaver and Baldwin 1975, Davis 1954, Manuwal 1970
EMOB	8	dusky flycatcher	Johnson 1963, 1966; Trimble 1975b
EMWR	7	gray flycatcher	Johnson 1963, Lavers 1975, Russell and Woodbury 1941
EMDI	10	western flycatcher	Brodkorb 1949, Davis et al. 1963, Trimble 1975b
COVIR	9	eastern wood pewee	Bent 1963c

Letter code	Life form	Species	Selected references
		BIRDS	
COSO	11	western wood pewee	Bent 1963c, Bertrand and Scott 1973, Trimble 1975b
NUBO	10	olive-sided flycatcher	Bent 1963c, Gabrielson and Jewett 1970, Trimble 1975b
ERAL	5	horned lark	Beason and Franks 1974, Pickwell 1931, Verbeek 1967
TATH	14	violet-green swallow	Balda 1975, Bent 1963c, Combellack 1954, Jackman 1974a, Trimble 1975b
IRBI	14	tree swallow	Austin and Low 1932; Chapman 1935, 1955; Jackman 1974a; Kuerzi 1940-41; McClelland and Frissell 1975; Trimble 1975b
RIRI	16	bank swallow	Gaunt 1965, Petersen 1955, Stoner 1936
STRU	16	rough-winged swallow	Bent 1963c, Lunk 1962, Trimble 1975b
HIRU	4	barn swallow	Henny 1972, Mason 1953, Snapp 1973
PEPY	4	cliff swallow	Behle 1976; Emlen 1952, 1954
PECA	11	gray jay	Aldrich 1943, Ouellet 1970, Rutter 1969
CYCR	9	blue jay	Bent 1964d, Trimble 1975b
CYST	11	Steller's jay	Bent 1964d, Gabrielson and Jewett 1970, Trimble 1975b
PIPI	7	black-billed magpie	Bent 1964d, Gabrielson and Jewett 1970, Trimble 1975b
COCOR	4	common raven	Bent 1964d, Larsen and Dietrich 1970, Trimble 1975b
COBR	11	common crow	Bent 1964e, Gabrielson and Jewett 1970, Trimble 1975b
GYCY	10	pinyon jay	Balda and Bateman 1971, Bateman and Balda 1973, Ligon and Martin 1974
NUCO	10	Clark's nutcracker	Gabrielson and Jewett 1970, Mewaldt 1956, Trimble 1975b
PAAT	14	black-capped chickadee	Dixon 1961; Henny 1972; Jackman 1974a; Kessel 1976; Kluyver 1961; McClelland and Frissell 1975; Odum 1941a, 1941b; Smith 1974b; Stefanski 1967; Sturman 1968
PAGA	14	mountain chickadee	Balda 1975, Dixon 1961, Jackman 1974a, Kluyver 1961, Trimble 1975b
PARU	14	chestnut-backed chickadee	Jackman 1974a, Sturman 1968, Trimble 1975b, Williams 1941
PSMI	8	bushtit	Bent 1964e, Dixon 1949, Trimble 1975b
SICA	13	white-breasted nuthatch	Anderson 1972; Balda 1975; Bent 1964f; Jackman 1974a; Kilham 1968b, 1971a, 1972; Tyler 1916
SICAN	13	red-breasted nuthatch	Anderson 1970, 1976; Bent 1964f; Jackman 1974a; Kilham 1973; Stallcup 1968
SIPY	13	pygmy nuthatch	Balda 1975, Barefield 1943, Bent 1964f, Bock 1969, Jackman 1974a, Knorr 1957, Norris 1958

Letter code	Life form	Species	Selected references
		BIRDS	
CEFA	14	brown creeper	Bent 1964f, Bradbury 1919, McClelland 1975, McClelland and Frissell 1975
CIME	3	dipper	Parsons 1975, Price and Bock 1973, Thut 1970
TRAE	14	house wren	Balda 1975, Jackman 1974a, Kendeigh 1941, Kroodsma 1973, Trimble 1975b
TRTR	3	winter wren	Armstrong 1956, Evenden 1950, Trimble 1975b
TEPA	3	long-billed marsh wren	Verner 1975a, 1975b; Verner and Engelsen 1970
CAMEX	4	canyon wren	Gabrielson and Jewett 1970, Grinnell and Behle 1935, Trimble 1975b
SAOB	4	rock wren	Bent 1964f, Kroodsma 1975, Trimble 1975b
MIPO	7	mockingbird	Hailman 1960, Michener and Michener 1935, Sooter 1941b
DUCA	7	gray catbird	Bent 1964f, Harcus 1973, Trimble 1975b
ORMO	7	sage thrasher	Bent 1964f, Gabrielson and Jewett 1970, Trimble 1975b
TUMI	7	American robin	Farner 1949, James and Shugart 1974, Young 1955
IXNA	11	varied thrush	Bent 1964g, Martin 1970, Trimble 1975b
CAGU	5	hermit thrush	Cochran et al. 1967, Morse 1972, Trimble 1975b
CAUS	7	Swainson's thrush	Gabrielson and Jewett 1970, Morse 1972, Trimble 1975b
CAFU	5	veery	Aldrich 1939, Gabrielson and Jewett 1970, Trimble 1975b
SIME	14	western bluebird	Balda 1975; Bent 1964g, 1968c; Donahue 1939; Hamilton 1943; Jackman 1974a; Jackman and Scott 1975; Miller 1970; Myers 1912; Peakall 1970; Pinkowski and Zeleny 1975
SICU	14	mountain bluebird	Balda 1975, Bent 1968c, Criddle 1927, Haecker 1948, Jackman 1974a, Jackman and Scott 1975, Miller 1970, Power 1966
MYTO	6	Townsend's solitaire	Lederer 1977a, 1977b; Trimble 1975b
RESA	10	golden-crowned kinglet	Bent 1964g, Gabrielson and Jewett 1970, Trimble 1975b
RECA	10	ruby-crowned kinglet	Bent 1964g, Gabrielson and Jewett 1970, Trimble 1975b
ANSP	5	water pipit	Bent 1965a, Trimble 1975b, Verbeek 1970
BOGA	8	Bohemian waxwing	Bent 1965a, Gabrielson and Jewett 1970, Trimble 1975b
BOCE	9	cedar waxwing	Bent 1965a, Burleigh 1963, Trimble 1975b
LAEX	7	northern shrike	Cade 1962, 1967; Davis 1974
LALU	7	loggerhead shrike	Porter et al. 1975; Smith 1973a, 1973b
STVU	14	starling	Amadon 1956, Beebe 1974, Bray et al. 1975, DeHaven and DeHaven 1973, Howard 1959, Hoyt 1957, Planck 1967

Letter code	Life form	Species	Selected references
		BIRDS	
VISO	11	solitary vireo	Hamilton 1962; James 1973, 1976
VIOL	11	red-eyed vireo	Lawrence 1953, Lemon 1971, Williamson 1971
VIGI	11	warbling vireo	Bent 1965a, James 1976, Trimble 1975b
VECE	6	orange-crowned warbler	Bent 1963d, Ficken and Ficken 1962, Griscom and Sprunt 1957
VERU	6	Nashville warbler	Gabrielson and Jewett 1970, Lawrence 1948, Trimble 1975b
PAAM	10	northern parula	Bent 1963d, Bertrand and Scott 1973
DEPE	8	yellow warbler	Bent 1963d, Gabrielson and Jewett 1970, Trimble 1975b
DECO	10	yellow-rumped warbler	Bent 1963d, Hubbard 1969, Trimble 1975b
DENI	10	black-throated gray warbler	Bent 1963d, Gabrielson and Jewett 1970, Trimble 1975b
DETO	10	Townsend's warbler	Bent 1963d, Gabrielson and Jewett 1970, Trimble 1975b
SENO	3	northern waterthrush	Bent 1963e, Gabrielson and Jewett 1970, Trimble 1975b
OPTO	7	MacGillivray's warbler	Bent 1963e, Gabrielson and Jewett 1970, Trimble 1975b
GETR	3	common yellowthroat	Behle 1950, Behle and Aldrich 1947, Hofslund 1959
ICVI	8	yellow-breasted chat	Bent 1963e, Gabrielson and Jewett 1970, Trimble 1975b
WIPU	5	Wilson's warbler	Bent 1963e, Gabrielson and Jewett 1970, Trimble 1975b
SERUT	9	American redstart	Ficken 1963, Quaintance 1942, Trimble 1975b
PADO	14	house sparrow	Jackman 1974a; Kendeigh 1973; Summers-Smith 1963, 1967; Summers-Smith and Pinowski 1968; Weaver 1939
DOOR	5	bobolink	Bent 1965b, Martin 1974, Trimble 1975b
STNEG	5	western meadowlark	Falls and Krebs 1975; Lanyon 1956, 1957
XAXA	7	yellow-headed blackbird	Crase and DeHaven 1975, Verner 1975b, Willson 1966, Willson and Orians 1963
AGPH	7	red-winged blackbird	Cutright 1973, Dolbeer 1976, Holm 1973
ICSP	9	orchard oriole	Bent 1965b, Browning 1975, Trimble 1975b
ICGA	9	northern oriole	Bent 1965b, Browning 1975, Trimble 1975b
EUCY	7	Brewer's blackbird	Hansen and Carter 1963, Horn 1968, Stepney 1975
QUQU	7	common grackle	Bent 1965b, Maxwell 1965, Trimble 1975b
MOAT	7	brown-headed cowbird	Friedmann 1963, Hill 1976, Norman and Robertson 1975
PILU	10	western tanager	Bent 1965b, Gabrielson and Jewett 1970, Trimble 1975b
PHME	11	black-headed grosbeak	Bent 1968a, Kroodsma 1974, Trimble 1975b

Letter code	Life form	Species	Selected references
		BIRDS	
PAAMO	7	lazuli bunting	Emlen et al. 1975, Thompson 1976, Trimble 1975b
HEVE	11	evening grosbeak	Blais and Parks 1964, Dexter 1975, Trimble 1975b
CAPU	11	purple finch	Bent 1968a, Pulliam and Enders 1971, Trimble 1975b
CACAS	11	Cassin's finch	Bent 1968a, Herman 1971, Trimble 1975b
CAMEXI	9	house finch	Bent 1968a, Gabrielson and Jewett 1970, Trimble 1975b
PIEN	11	pine grosbeak	Bent 1968a, Trimble 1975b
LETE	4	gray-crowned rosy finch	King and Wales 1964, Miller 1939a, Trimble 1975b
LEAT	4	black rosy finch	Bent 1968a, Gabrielson and Jewett 1970, Trimble 1975b
SPPI	11	pine siskin	Bent 1968a, Gashwiler and Ward 1966, Trimble 1975b
SPTR	8	American goldfinch	Holcomb 1969, Trimble 1975b, Wiseman 1975
SPPS	7	lesser goldfinch	Bent 1968a, Gabrielson and Jewett 1970, Trimble 1975b
LOCUR	10	red crossbill	Griscom 1937; Pulliainen 1971, 1972
LOLE	10	white-winged crossbill	Bent 1968a, Jewett 1954, Trimble 1975b
CHCH	7	green-tailed towhee	Bent 1968a, Gabrielson and Jewett 1970, Trimble 1975b
PIER	7	rufous-sided towhee	Adams 1947, Davis 1960, Roberts 1969
PASA	5	savannah sparrow	Bradley 1973, Swarth 1936, Welsh 1975
AMSA	5	grasshopper sparrow	Smith 1963, Trimble 1975b, Wiens 1966
POGRA	5	vesper sparrow	Bent 1968b, Best 1972, Trimble 1975b
CHGR	5	lark sparrow	Bent 1968b, Gabrielson and Jewett 1970, Trimble 1975b
AMBE	7	sage sparrow	Moldenhauer 1970, Moldenhauer and Wiens 1970, Trimble 1975b
JUHY	5	dark-eyed junco	Gashwiler and Ward 1968, Gottfried and Franks 1975, Sabine 1959
SPAR	7	tree sparrow	Heydweiller 1935, Trimble 1975b, Weeden 1965
SPPA	7	chipping sparrow	Hebrand 1974, Klopfer 1965, Trimble 1975b
SPBR	7	Brewer's sparrow	Best 1972, Schroeder and Sturges 1975, Trimble 1975b
ZOLE	7	white-crowned sparrow	Blanchard 1941, Lewis 1975, Morton et al. 1972
ZOAT	5	golden-crowned sparrow	Bent 1968c, Gabrielson and Jewett 1970, Trimble 1975b
ZOAL	5	white-throated sparrow	Falls 1969, Rees 1973, Wythe 1938
PAIL	7	fox sparrow	Bent 1968c, Gabrielson and Jewett 1970, Trimble 1975b
MELI	6	Lincoln's sparrow	Miller 1939b, Miller and McCabe 1935, Trimble 1975b

Letter code	Life form	Species	Selected references
		BIRDS	
MEMEL	7	song sparrow	Knapton and Krebs 1974, Nice 1943, Tompa 1962
CALA	5	Lapland longspur	Bent 1968c, Gabrielson and Jewett 1970, Trimble 1975b
PLNI	5	snow bunting	Nethersole-Thompson 1966, Tinbergen 1939, Trimble 1975b
		MAMMALS	
DIMA	5	opossum	Fitch and Sandidge 1953, Jewett and Dobyns 1929, Lay 1942, Palmer 1954, Stout and Sonenshine 1974
SOPR	15	Malheur shrew	Armstrong 1957, Bailey 1936, Hansen 1956
SOVA	15	vagrant shrew	Clothier 1955, Hooven et al. 1975, Ingles 1961
SOOB	15	dusky shrew	Hawes 1975, Ingles 1960, Whitaker and Maser 1976
SOPA	16	northern water shrew	Bailey 1936, Conaway 1952, Sorenson 1962
SOME	15	Merriam shrew	Gashwiler 1976, Johnson and Clanton 1954, Lindsay and Perry 1977
SCOR	15	coast mole	Arlton 1936, Bailey 1936, Moore 1933
MYLU	14	little brown myotis	Bailey 1936, Barbour and Davis 1969, Buchler 1976, Fenton 1970, O'Farrell and Studier 1973
MYYU	14	Yuma myotis	Bailey 1936, Barbour and Davis 1969, Dalquest 1947a
MYEV	14	long-eared myotis	Bailey 1936, Barbour and Davis 1969, Dalquest 1948, Murray L. Johnson (personal communication about zoological specimen 218 located at Puget Sound Museum of Natural History, University of Puget Sound, Tacoma, Wash. 98416)
MYVO	14	long-legged myotis	Bailey 1936, Barbour and Davis 1969, Maser (unpublished, see "References Cited"), Whitaker et al. 1977
MYCA	14	California myotis	Barbour and Davis 1969, Krutzsch 1954, Whitaker et al. 1977
MYLE	4	small-footed myotis	Barbour and Davis 1969, Fenton 1972, Tuttle and Heaney 1974
LANO	14	silver-haired bat	Bailey 1936, Barbour and Davis 1969, Cowan and Guiguet 1965, Novakowski 1956, Saul et al. [1977], Whitaker et al. 1977
PIHE	4	western pipistrelle	Barbour and Davis 1969, Bradley and O'Farrell 1969, Cross 1965
EPFU	14	big brown bat	Bailey 1936, Barbour and Davis 1969, Christian 1956, Davis et al. 1968, Geohring 1972, Mills et al. 1975
LACI	11	hoary bat	Constantine 1966, Dalquest 1943, Jones 1965
EUMA	4	spotted bat	Barbour and Davis 1969, Easterla 1971, Snow 1974c
PLTO	4	western big-eared bat	Dalquest 1947b, Humphrey and Kunz 1976, Pearson et al. 1952
ANPA	4	pallid bat	Barbour and Davis 1969, Beck and Rudd 1960, Orr 1954
OCPR	4	pika	Johnson 1967, Kawamichi 1976, Smith 1974a

Letter code	Life form	Species	Selected references
		MAMMALS	
SYID	15	pygmy rabbit	Bailey 1936, Orr 1940, Severaid 1950
SYNU	15	mountain cottontail	Bailey 1936, Orr 1940, Powers and Verts 1971
LEAM	5	snowshoe hare	Dolbeer and Clark 1975, Keith and Surrendi 1971, Wood and Munroe 1977
LETO	5	whitetail jackrabbit	Bear and Hansen 1966; James and Seabloom 1969a, 1969b
LECA	5	blacktail jackrabbit	Hansen 1972, Haskell and Reynolds 1947, Sparks 1968
EUMI	15	least chipmunk	Sheppard 1965, Skryja 1974, States 1976
EUAM	15	yellow pine chipmunk	Brand 1974; Broadbooks 1958, 1970a, 1970b; Gordon 1943; Meredith 1976; Sheppard 1965; States 1976
MAFL	4	yellow-bellied marmot	Armitage 1973, 1974; Armitage and Downhower 1974
SPTO	15	Townsend ground squirrel	Bailey 1936, Dalquest 1948, Shaw 1921
SPWA	15	Washington ground squirrel	Bailey 1936, Dalquest 1948
SPBE	15	Belding ground squirrel	Morton and Gallup 1975, Morton and Tung 1971, Turner 1972
SPCO	15	Columbian ground squirrel	Shaw 1926, Steiner 1971, Turner 1972
SPLA	15	mantled ground squirrel	Gordon 1943, Tevis 1952, Yousef and Bradley 1971
SCGRI	10	western gray squirrel	Bailey 1936, Dalquest 1948, Ingles 1947
SCNI	14	eastern fox squirrel	Adams 1973, Allen 1943, Donohoe 1975
TAHU	10	red squirrel	Fitzwater 1941, Hatt 1943, Kilham 1954, Klugh 1927, Krasnowski 1969, Streubel 1968, Wolff and Zasada 1975, Zirul and Fuller 1970
TADO	10	chickaree	Bailey 1936, Burt and Grossenheider 1964, Dalquest 1948
GLSA	14	northern flying squirrel	Bailey 1936, Cowan 1936, Jackson 1961, McKeever 1960, Maser (unpublished, see "References Cited")
THTO	15	Townsend pocket gopher	Bailey 1936, Hall 1946, Horn 1923
THTA	15	northern pocket gopher	Criddle 1930, Hansen and Beck 1968, Moore and Reid 1951
PEPA	15	Great Basin pocket mouse	Hedlund et al. 1975, O'Farrell et al. 1975, Scheffer 1938
DIOR	15	Ord kangaroo rat	Blaustein and Risser 1976, Schroder and Rosenzweig 1975, Whitford 1976
CACAN	16	beaver	Brenner 1967, Johnson 1927, Warren 1926
REME	15	western harvest mouse	Birkenholz 1967, Fisler 1971, Whitaker and Mumford 1972
PECR	4	canyon mouse	Bailey 1936, Hall 1946, Lechleitner 1969
PEMA	15	deer mouse	Bailey 1936, Blair 1942, King 1968, Maser (unpublished, see "References Cited"), Wirtz and Pearson 1960

Letter code	Life form	Species	Selected references
		MAMMALS	
PETR	4	pinyon mouse	Bailey 1936; Bradford 1974, 1975
ONLE	15	northern grasshopper mouse	Bailey and Sperry 1929, Hansen 1975, Ruffer 1965
NECI	4	bushy-tailed woodrat	Bailey 1936, Dalquest 1948, Jackson 1961, Maser (unpublished, see "References Cited"), Maser and Franklin 1974
CLGA	15	Gapper red-backed vole	Butsch 1954; Miller and Getz 1972, 1973
PHIN	15	heather vole	Edwards 1955, Pruitt 1954, Shaw 1924
MIMO	15	mountain vole	Hodgson 1972, Murie 1971, Murray 1965
MILO	15	long-tailed vole	Bailey 1936, Beck and Anthony 1971, Conley 1976
MIRI	16	water vole	Anderson et al. 1976, Bailey 1936, Maser and Storm 1970
LACU	15	sagebrush vole	Clanton et al. 1971, Johnson et al. 1948, Maser et al. 1974
ONZI	16	muskrat	Johnson 1925, Sather 1958, Willner et al. 1975
RANO	15	Norway rat	Bailey 1936, Calhoun 1963, Jackson 1961
MUMU	15	house mouse	Lloyd 1975, Schwarz and Schwarz 1943, Sheppe 1967
ZAPR	3	western jumping mouse	Brown 1967, Clark 1971, Jones et al. 1978
ERDO	6	porcupine	Shapiro 1949, Struthers 1928, Taylor 1935
MYCO	16	nutria	Evans 1970, Larrison 1943, Schitoskey et al. 1972
CALAT	15	coyote	Gier 1968, Knowlton 1972, Mathwig 1973, Murie 1940
CALU	15	gray wolf	Mech and Frenzel 1971, Van Ballenberghe et al. 1975, Wolfe and Allen 1973
VUVU	15	red fox	Sheldon 1949, Stanley 1963, Storm et al. 1976
URCI	15	gray fox	Bailey 1936, Sullivan 1956, Wood 1958
URAM	15	black bear	Jonkel and Cowan 1971, Lindzey and Meslow 1976, Poelker and Hartwell 1973
PRLO	14	raccoon	Berner and Gysel 1967, Dorney 1954, Johnson 1939, Schneider et al. 1971, Schnell 1969-70, Urban 1970
MAAM	14	marten	Hawley and Newby 1957, Ingram 1973, Jackson 1961, Jonkel 1959, Koehler et al. 1975, Yocom 1974b
MAPE	14	fisher	Coulter 1966, Ingram 1973, Seton 1928, Vos 1952
MUER	15	short-tailed weasel	Bailey 1936, Bishop 1923, Hall 1951, Hamilton 1933, Ingles 1939, Maser (unpublished, see "References Cited")
MUFR	15	long-tailed weasel	Bailey 1936, Crabb 1948, Hall 1951, Heidt et al. 1976, Ingles 1939, Maser (unpublished, see "References Cited")

Letter code	Life form	Species	Selected references
		MAMMALS	
MUVI	16	mink	Errington 1943, Northcott et al. 1974, Shump et al. 1976a
GUGU	5	wolverine	Johnson 1977, Rausch and Pearson 1972, Yocom 1974a
TATA	15	badger	Lindzey 1976, Sargeant and Warner 1972, Snead and Hendrickson 1942
SPPU	15	spotted skunk	Bailey 1936, Baker and Baker 1975, Crabb 1948, Patton 1974
MEMEP	15	striped skunk	Bailey 1971, Shump et al. 1975, Verts 1967
LUCA	16	river otter	Shump et al. 1976b, Tabor 1974, Toweill 1974
FECO	4	puma	Hornocker 1970, Robinette et al. 1961, Seidensticker et al. 1973
FECA	5	feral house cat	Bailey 1936, Christian 1975, Errington 1936
LYCA	5	lynx	Brand et al. 1976, Nellis and Keith 1968, Nellis et al. 1972
LYRU	4	bobcat	Crowe 1975, Gashwiler et al. 1961, Nussbaum and Maser 1975
EQCA	5	feral horse	Zarn et al. 1977a, 1977b
CEEL	5	elk	Flook 1970, Franklin et al. 1975, Kirsch and Greer 1968, Knight 1970
ODHE	5	mule deer	Dixon 1934, Julander et al. 1961, Terrel 1973, Tueller and Monroe [1975]
ODVI	5	white-tailed deer	Allen 1968, Hood and Inglis 1974, Southern Forest Experiment Station 1969
ANAME	5	pronghorn	Autenrieth and Fichter 1975, Sundstrom et al. 1973, Yoakum 1967
ORAM	4	mountain goat	Brandborg 1955, Hibbs 1966, Vaughan 1975
OVCA	4	big-horned sheep	Johnson 1974, Spalding and Mitchell 1970, Stelfox 1976

References Cited

Abercrombie, Michael, C. J. Hickman, and M. L. Johnson. 1964. A dictionary of biology. 254 p. Aldine Publ. Co., Chicago, Ill.

Adams, Clark Edward. 1973. Population dynamics of fox squirrels, *Sciurus niger,* in selected areas in Seward County, Nebraska. Ph. D. thesis. 165 p. Univ. Nebr., Lincoln.

Adams, Lowell. 1947. Food habits of three common Oregon birds in relation to reforestation. J. Wildl. Manage. 11(3): 281-282.

Aho, Paul E. 1966. Defect estimation for grand fir, Engelmann spruce, Douglas-fir, and western larch in the Blue Mountains of Oregon and Washington. USDA For. Serv. 26 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Aho, Paul E. 1974. Decay. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. Q-1 to Q-17. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Aitchison, Stewart W., Steven W. Carothers, and R. Roy Johnson. 1977. Some ecological considerations associated with river recreation management. *In* Proceedings: Symposium on river recreation management and research. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 222-225. North Cent. For. Exp. Stn., St. Paul, Minn.

Aldrich, John W. 1939. Geographic variation of the veery. Auk 56(3):338-340.

Aldrich, John W. 1943. Relationships of the Canada jays in the Northwest. Wilson Bull. 55(4): 217-222.

Aldrich, John W., and Allen J. Duvall. 1958. Distribution and migration of races of the mourning dove. Condor 60(2):108-128.

Alexander, Robert R., and Carleton B. Edminster. 1977. Regulation and control of cut under uneven-aged management. USDA For. Serv. Res. Pap. RM-182, 7 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Allen, Durward Leon. 1943. Michigan fox squirrel management. 404 p. Game Div., Dep. Conserv., Lansing, Mich.

Allen, Durward Leon, Ed. 1956. Pheasants in North America. 490 p. Stackpole Co., Harrisburg, Pa., and Wildl. Manage. Inst., Washington, D.C.

Allen, Eugene O. 1968. Range use, foods, condition, and productivity of white-tailed deer in Montana. J. Wildl. Manage. 32(1):130-141.

Allen, Robert P., and Frederick P. Mangels. 1938-39. Studies of the nesting behavior of the black-crowned night heron. Linnaean Soc. N.Y. Proc. 50, 51: 1-28.

Amadon, Dean. 1956. Remarks on the starlings, family Sturnidae. Am. Mus. Novit. 1803, 41 p. Am. Mus. Nat. Hist., New York.

American Geological Institute. 1962. Dictionary of geological terms. 542 p. Dolphin Books, Doubleday and Co., Inc., Garden City, N.Y.

American Ornithologists' Union. 1957. Check-list of North American birds. 5th ed. 691 p. Port City Press, Inc., Baltimore, Md.

American Ornithologists' Union. 1973a. Thirty-second supplement to the American Ornithologists' Union check-list of North American birds. Auk 90(2):411-419.

American Ornithologists' Union. 1973b. Corrections and additions to the "Thirty-second supplement to the check-list of North American birds." Auk 90(4):887.

Ames, Charles R. 1977. Wildlife conflicts in riparian management: Grazing. *In* Importance, preservation and management of riparian habitat: A symposium. USDA For. Serv. Gen. Tech. Rep. RM-43, p. 49-51. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Anderson, David R., and Charles J. Henny. 1972. Population ecology of the mallard: I. A review of previous studies and the distribution and migration from breeding areas. U.S. Dep. Inter. Bur. Sport Fish. and Wildl. Resour. Publ. 105, 166 p.

Anderson, David R., Patricia Ann Skaptason, Kathleen G. Fahey, and Charles J. Henny. 1974. Population ecology of the mallard: III. Bibliography of published research and management findings. U.S. Dep. Inter. Bur. Sport Fish. and Wildl. Resour. Publ. 119, 46 p.

Anderson, E. William, and Richard J. Scherzinger. 1975. Improving quality of winter forage for elk by cattle grazing. J. Range Manage. 28(2):120-125.

Anderson, James D. 1967. A comparison of the life histories of coastal and montane populations of *Ambystoma macrodactylum* in California. Am. Midl. Nat. 77(2):323-355.

Anderson, James D. 1968. A comparison of the food habits of *Ambystoma macrodactylum sigillatum, Ambystoma macrodactylum croceum,* and *Ambystoma tigrinum californiense.* Herpetologica 24(4):273-284.

Anderson, N. H., J. R. Sedell, L. M. Roberts, and F. J. Triska. 1978. The role of aquatic invertebrates in processing of wood debris in coniferous forest streams. Am. Midl. Nat. 100(1):64-82.

Anderson, Paul K., Paul H. Whitney, and Jean-Pierre Huang. 1976. *Arvicola richardsoni:* Ecology and biochemical polymorphism in the front ranges of southern Alberta. Acta Theriologica 21(31):425-468.

Anderson, Ralph G. [n.d.] Unpublished data on file at U.S. Dep. Agric., Forest Service, Bear Sled Ranger District, Wallowa, Oreg. 97885. Used with permission.

Anderson, Stanley H. 1972. Seasonal variations in forest birds of western Oregon. Northwest Sci. 46(3):194-206.

Anderson, Stanley H. 1976. Comparative food habits of Oregon nuthatches. Northwest Sci. 50(4):213-221.

Anderson, Stanley Helmer. 1970. Ecological relationships of birds in forests of western Oregon. Ph. D. thesis. 147 p. Oreg. State Univ., Corvallis.

Anthony, Robert. 1970. Ecology and reproduction of California quail in southeastern Washington. Condor 72(3):276-287.

Appel, O., and M. Schwartz. 1921. Die bedeutung des vogelschutzes für den pflanzenschutz. Nachrichtenbl. Dtsch. Pflanzenschutzdienst (Berlin). 1:49-50.

Apslund, Kenneth K. 1974. Body size and habitat utilization in whiptail lizards (*Cnemidophorus*). Copeia 1974(3):695-703.

Arbib, Robert. 1975. The blue list for 1976. Am. Birds 29(6):1067-1072.

Arlton, A. V. 1936. An ecological study of the mole. J. Mammal. 17(4):349-371.

Armitage, Kenneth B. 1973. Population changes and social behavior following colonization by the yellow-bellied marmot. J. Mammal. 54(4):842-854.

Armitage, Kenneth B. 1974. Male behaviour and territoriality in the yellow-bellied marmot. J. Zool., Lond. 172(2): 233-265.

rmitage, Kenneth B., and Jerry F. Downhower. 1974. Demography of yellow-bellied marmot populations. Ecology 55(6):1233-1245.

rmstrong, E. A. 1956. Territory in the wren, *Troglodytes troglodytes*. Ibis 98(3):430-437.

rmstrong, F. H. 1957. Notes on *Sorex preblei* in Washington State. Murrelet 38(1):6.

rmstrong, Joseph T. 1965. Breeding home range in the nighthawk and other birds; its evolutionary and ecological significance. Ecology 46(5):619-629.

rmstrong, William H. 1958. Nesting and food habits of the long-eared owl in Michigan. Mich. State Univ. Mus. Publ. Biol. Ser. 1(2):63-96. East Lansing.

rnett, James Thomas. 1974. Microhabitat resource utilization by *Sceloporus undulatus hyacinthinus*. Ph. D. thesis. 77 p. Univ. Arkansas, Monticello.

rrhenius, Olof. 1921. Species and area. J. Ecol. 9(1):95-99.

shmole, N. Philip. 1968. Competition and interspecific territoriality in *Empidonax* flycatchers. Syst. Zool. 17(2):210-212.

usmus, Beverly S. 1977. Regulation of wood decomposition rates by arthropod and annelid populations. *In* Soil organisms as components of ecosystems. Proc. 6th Int. Soil Zool. Colloq. U. Lohm and T. Persson, eds. Ecol. Bull. [Stockholm] 25:180-192.

usmus, Beverly S., Gladys J. Dodson, and Don G. Todd. 1975. Microbial-invertebrate interactions: The mechanism of wood decomposition. Ecol. Soc. Am. Bull. 56(2):42.

ustin, Oliver L., Jr., and Seth H. Low. 1932. Notes on the breeding of the tree swallow. Bird-Banding 3(2):39-44.

utenrieth, Robert E., and Edson Fichter. 1975. On the behavior and socialization of pronghorn fawns. Wildl. Monogr. 42, 111 p.

aglien, John William. 1975. Biology and habitat requirements of the nesting golden eagle in southwestern Montana. USDA For. Serv. and Mont. State Univ., Bozeman, 53 p., typescript.

ailey, Robert G. 1978. Description of the ecoregions of the United States. 77 p. USDA For. Serv., Intermt. Reg., Ogden, Utah.

ailey, Theodore N. 1971. Biology of striped skunks on a southwestern Lake Erie marsh. Am. Midl. Nat. 85(1):196-207.

Bailey, Vernon. 1936. The mammals and life zones of Oregon. North Am. Fauna 55, 416 p. USDA Bur. Biol. Surv., Washington, D.C.

Bailey, Vernon, and Charles C. Sperry. 1929. Life history and habits of grasshopper mice, genus Onychomys. U.S. Dep. Agric. Tech. Bull. 145, 19 p. Washington, D.C.

Baker, Rollin H., and Mary W. Baker. 1975. Montane habitat used by the spotted skunk (*Spilogale putorius*) in Mexico. J. Mammal. 56(3):671-673.

Balda, Russell P. 1975. The relationships of secondary cavity nesters to snag densities in western coniferous forests. USDA For. Serv. Wildl. Habitat Tech. Bull. 1, 37 p. Albuquerque, N. M.

Balda, Russell P., and Gary C. Bateman. 1971. Flocking and annual cycle of the piñon jay, *Gymnorhinus cyanocephalus*. Condor 73(3):287-302.

Balda, Russell P., Barbara Clark McKnight, and Clarence D. Johnson. 1975. Flammulated owl migration in the Southwestern United States. Wilson Bull. 87(4):520-533.

Baldwin, Ewart Merlin. 1964. Geology of Oregon. 2d ed. 165 p. Edwards Brothers, Inc., Ann Arbor, Mich.

Baldwin, Paul H. 1960. Overwintering of woodpeckers in bark beetle-infested spruce-fir forests in Colorado. 12th Int. Ornithol. Congr. Proc., p. 71-84.

Baldwin, Paul H., and William F. Hunter. 1963. Nesting and nest visitors of the Vaux's swift in Montana. Auk 80(1):81-85.

Baldwin, Paul H., and Nick K. Zaczkowski. 1963. Breeding biology of the Vaux swift. Condor 65(5):400-406.

Banfield, A. W. F. 1947. A study of the winter feeding habits of the short-eared owl (*Asio flammeus*) in the Toronto region. Can. J. Res. Sect. D. 25(2):45-65.

Barbour, Roger William, and Wayne H. Davis. 1969. Bats of America. 286 p. Univ. Press, Ky., Lexington.

Barefield, Floy. 1943. Brown-headed nuthatches. Raven 14(9-10):34-37.

Barr, Thomas C., Jr. 1967. Observations on the ecology of caves. Am. Nat. 101(922):475-491.

Barrett, James W. 1973. Northwestern ponderosa pine. *In* Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric. Handb. 445, p. 17-19. Washington, D.C.

Barry, Thomas W. 1956. Observations of a nesting colony of American brant. Auk 73(2):193-202.

Barry, Thomas W. 1964. Brant, Ross' goose and emperor goose. *In* Waterfowl tomorrow, p. 145-154. J. P. Linduska, ed. U.S. Bur. Sport Fish. and Wildl. U.S. Dep. Inter., Washington, D.C.

Bassett, Patricia M., and Grover A. Choate. 1974a. Timber resource statistics for Oregon: January 1, 1973. USDA For. Serv. Resour. Bull. PNW-56, 32 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Bassett, Patricia M., and Grover A. Choate. 1974b. Timber resource statistics for Washington: January 1, 1973. USDA For. Serv. Resour. Bull. PNW-53, 31 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Bateman, Gary C., and Russell P. Balda. 1973. Growth, development, and food habits of young piñon jays. Auk 90(1): 39-61.

Baumgartner, Frederick M. 1939a. Territory and population in the great horned owl. Auk 56(3):274-282.

Baumgartner, Luther L. 1939b. Fox squirrel dens. J. Mammal. 20(4):456-465.

Baxter, Dow Vawter. 1943. Pathology in forest practice. 618 p., illus. John Wiley & Sons, New York.

Beal, F. E. L. 1906. Birds as conservators of the forests. N. Y. For. Fish and Game Comm. Rep. 1902-1903, 8th and 9th Rep., p. 236-274.

Beal, F. E. L. 1911. Food of the woodpeckers of the United States. U.S. Dep. Agric. Biol. Surv. Bull. 37, 64 p.

Beall, Robert C. 1974. Winter habitat selection and use by a western Montana elk herd. Ph. D. thesis. 209 p. Univ. Mont., Missoula.

Beall, Robert C. 1976. Elk habitat selection in relation to thermal radiation. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 97-100. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Bear, G. D., and R. M. Hansen. 1966. Food habits, growth and reproduction of white-tailed jackrabbits in southern Colorado. Agric. Exp. Stn. Tech. Bull. 90, 59 p. Colo. State Univ., Fort Collins.

Beason, Robert C., and Edwin C. Franks. 1974. Breeding behavior of the horned lark. Auk 91(1):65-74.

Beaufait, William R. 1966. Prescribed fire planning in the intermountain West. USDA For. Serv. Res. Pap. INT-26, 27 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Beaufait, William R., Charles E. Hardy, and William C. Fischer. 1975. Broadcast burning in larch-fir clearcuts: The Miller Creek-Newman Ridge study. USDA For. Serv. Res. Pap. INT-175, 53 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Beaver, Donald L., and Paul H. Baldwin. 1975. Ecological overlap and the problem of competition and sympatry in the western and Hammond's flycatchers. Condor 77(1):1-13.

Beck, Albert J., and Robert L. Rudd. 1960. Nursery colonies in the pallid bat. J. Mammal. 41(2):266-267.

Beck, Lee R., and Robert G. Anthony. 1971. Metabolic and behavioral thermoregulation in the long-tailed vole, *Microtus longicaudus.* J. Mammal. 52(2): 404-412.

Beebe, Spencer B. 1974. Relationships between insectivorous hole-nesting birds and forest management. Yale Univ. Sch. For. Environ. Stud., New Haven, Conn. 49 p. [Multilithed.]

Behle, William H. 1950. Clines in the yellow-throats of western North America. Condor 52(5):193-219.

Behle, William H. 1976. Systematic review, intergradation, and clinal variation in cliff swallows. Auk 93(1):66-77.

Behle, William H., and John W. Aldrich. 1947. Description of a new yellowthroat (*Geothlypis trichas*) from the northern Rocky Mountain-Great Plains region. Biol. Soc. Wash. Proc. 60:69-72.

Beidleman, Richard G. 1954. The cottonwood river-bottom community as a vertebrate habitat. Ph. D. thesis. 358 p. Univ. Colo., Boulder.

Beidleman, Richard Gooch. 1948. The vertebrate ecology of a Colorado plains cottonwood river bottom. M.S. thesis. 351 p. Univ. Colo., Boulder.

Bellrose, Frank C., Kenneth L. Johnson, and T. Udell Meyers. 1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Manage. 28(4):661-676.

Bendell, J. F., and P. W. Elliott. 1967. Behaviour and the regulation of numbers in blue grouse. Can. Wildl. Serv. Rep. Ser. 4, 76 p. Ottawa.

Benson, Robert E., and Cameron M. Johnston. 1976. Logging residues under different stand and harvesting conditions, Rocky Mountains. USDA For. Serv. Res. Pap. INT-181, 15 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Bent, Arthur Cleveland. 1926. Life histories of North American marsh birds: Orders *Odontoglossae, Herodiones,* and *Paludicolae.* Smithson. Inst. U.S. Nat. Mus. Bull. 135, 490 p.

Bent, Arthur Cleveland. 1961. Life histories of North American birds of prey. Part 1, 409 p.; Part 2, 482 p. Dover Publ. Inc., New York.

Bent, Arthur Cleveland. 1962a. Life histories of North American wildfowl. Part 1. 224 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1962b. Life histories of North American wildfowl. Part 2. 314 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1962c. Life histories of North American shorebirds. Part 2. 340 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1962d. Life histories of North American shorebirds. Part I. 359 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1963a. Life histories of North American diving birds. 239 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1963b. Life histories of North American gulls and terns. 337 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1963c. Life histories of North American flycatchers, larks, swallows, and their allies. 555 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1963d. Life histories of North American wood warblers. Part 1. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1963e. Life histories of North American wood warblers. Part 2. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1964a. Life histories of North American petrels and pelicans and their allies. 335 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1964b. Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. Part 2. 261 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1964c. Life histories of North American woodpeckers. 334 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1964d. Life histories of North American jays, crows, and titmice. Part 1. 214 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1964e. Life histories of North American jays, crows, and titmice. Part 2. 280 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1964f. Life histories of North American nuthatches, wrens, thrashers, and their allies 475 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1964g. Life histories of North American thrushes, kinglets, and their allies. 452 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1965a. Life histories of North American wagtails, shrikes, vireos, and their allies. 411 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1965b. Life histories of North American blackbirds, orioles, tanagers, and allies. 549 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1968a. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies, order Passeriformes: Family Fringillidae. Part 1. 602 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1968b. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies, order Passeriformes: Family Fringillidae. Part 2. 646 p. Dover Publ., Inc., New York.

Bent, Arthur Cleveland. 1968c. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies, order Passeriformes: Family Fringillidae. Part 3. 640 p. Dover Publ., Inc., New York.

Berger, John M. 1964. 1963 Washington log production. Misc. Publ., 2 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland Oreg.

Berner, A., and L. W. Gysel. 1967. Raccoon use of large tree cavities and ground burrows. J. Wildl. Manage. 31(4): 706-714.

Bertrand, Gerard A., and J. Michael Scott. 1973. Check-list of the birds of Oregon. 17 p. Mus. Nat. Hist., Oreg. State Univ. Dep. Zool., Corvallis.

Best, Louis B. 1972. First-year effects of sagebrush control on two sparrows. J. Wildl. Manage. 36(2):534-544.

Beuter, J. H. 1962. 1961 Oregon log production. For. Surv. Rep. 146, 2 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Beuter, John H. 1963. 1961 Washington log production. USDA For. Serv. Resour. Bull. PNW-1, 2 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Bevins, Collin Douglas. 1976. An evaluation of the slash fuel model of the 1972 National Fire Danger Rating System. M.S. thesis. 104 p. Univ. Wash., Seattle.

Billard, Ruth S. 1947. An ecological study of the Virginia rail (*Rallus limicola limicola*) and the sora (*Porzana carolina*) in some Connecticut swamps. M.S. thesis. 84 p. Iowa State Univ., Ames.

Birkenholz, Dale E. 1967. The harvest mouse (*Reithrodontomys megalotis*) in central Illinois. Trans. Ill. State Acad. Sci. 60(1):49-53.

Bishop, Sherman C. 1923. Note on the nest and young of the small brown weasel. J. Mammal. 4(1):26-27.

Black, Hugh C. 1970a. Animal damage to forest regeneration in the ponderosa pine region of Oregon and Washington. Regener. Ponderosa Pine Proc. 1969: 105-118, illus. Oreg. State Univ., Corvallis.

Black, Hugh, Richard Scherzinger, and Jack Ward Thomas. 1976. Relationships of Rocky Mountain elk and Rocky Mountain mule deer habitat to timber management in the Blue Mountains of Oregon and Washington. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 11-31. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Black, Jeffrey H. 1970b. Turtles of Montana. Mont. Wildl., Nov., p. 26-32. Mont. Fish and Game Dep. Off. Publ.

Black, Jeffrey Howard, and Robert M. Storm. 1970. Notes on the herpetology of Grant County, Oregon. Great Basin Nat. 30(1):9-12.

Blackford, John L. 1955. Woodpecker concentration in burned forest. Condor 57(1):28-30.

Blackford, John L. 1958. Territoriality and breeding behavior of a population of blue grouse in Montana. Condor 60(3):145-158.

Blair, W. Frank. 1942. Size of home range and notes on the life history of the woodland deer-mouse and eastern chipmunk in northern Michigan. J. Mammal. 23(1):27-36.

Blais, J. R., and G. H. Parks. 1964. Interaction of evening grosbeak (*Hesperiphona vespertina*) and spruce budworm (*Choristoneura fumiferana* (Clem)) in a localized budworm outbreak treated with DDT in Quebec. Can. J. Zool. 42(6): 1017-1024.

Blanchard, Barbara P. 1941. The white-crowned sparrows (*Zonotrichia leucophrys*) of the Pacific seaboard: Environment and annual cycle. Univ. Calif. Publ. Zool. 46(1):1-178.

Blanchard, Frank Nelson. 1942. The ring-neck snakes, genus *Diadophis*. Chicago Acad. Sci. Bull. 7(1)5-144.

Blaustein, Andrew R., and Arthur C. Risser, Jr. 1976. Interspecific interactions between three sympatric species of kangaroo rats (*Dipodomys*). Anim. Behav. 24(2):381-385.

Bleich, Vernon C. 1975. Diving times and distances in the pied-billed grebe. Wilson Bull. 87(2):278-280.

Bock, Carl E. 1969. Intra- vs. interspecific aggression in pygmy nuthatch flocks. Ecology 50(5):903-905.

Bock, Carl E. 1970. The ecology and behavior of the Lewis woodpecker. Univ. Calif. Publ. Zool. 92, 100 p.

Bock, Carl E., and Jane H. Bock. 1974. On the geographical ecology and evolution of the three-toed woodpeckers, *Picoides tridactylus* and *P. arcticus*. Am. Midl. Nat. 92(2):397-405.

Bock, Carl E., Harlo H. Hadow, and Preston Somers. 1971. Relations between Lewis' and red-headed woodpeckers in southeastern Colorado. Wilson Bull. 83(3):237-248.

Boeker, Erwin L. 1972. A survey of white pelican nesting colonies in 1971. Am. Birds 26(1):24, 125.

Bollen, W. B., K. C. Lu, and R. F. Tarrant. 1970. Effect of Zectran on microbial activity in a forest soil. USDA For. Serv. Res. Note PNW-124, 11 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Bollen, W. B., Logan A. Norris, and Kathleen L. Stowers. 1977. Effect of cacodylic acid and MSMA on nitrogen transformations in forest floor and soil. J. Environ. Qual. 6(1):1-3.

Bolsinger, Charles L., and John M. Berger. 1975. The timber resources of the Blue Mountain area, Oregon. USDA For. Serv. Resour. Bull. PNW-57, 62 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Bones, James T., and James E. Simonson. 1960. Forest statistics for southeast Washington. For. Surv. Rep. 136, 40 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Bottorff, Richard L. 1974. Cottonwood habitat for birds in Colorado. Am. Birds 28(6):975-979.

Boyce, John S., and J. W. Bruce Wagg. 1953. Conk rot of old-growth Douglas-fir in western Oregon. Oreg. State Univ. For. Res. Lab. Bull. 4, 96 p. Corvallis.

Bradbury, W. C. 1919. Nesting notes on the Rocky Mountain creeper. Condor 21(2):49-52.

Bradford, David F. 1974. Water stress of free-living *Peromyscus truei*. Ecology 55(6):1407-1414.

Bradford, David F. 1975. The effects of an artificial water supply on free-living *Peromyscus truei*. J. Mammal. 56(3): 705-707.

Bradley, Richard A. 1973. A population census of the Belding's savannah sparrow, *Passerculus sandwichensis beldingi*. West. Bird Bander 48:40-43.

Bradley, W. Glen, and Michael J. O'Farrell. 1969. Temperature relationships of the western pipistrelle (*Pipistrellus hesperus*). *In* Physiological Systems in semiarid environments, p. 85-96. C. Clayton Hoff and Marvin L. Riedesel, eds. Univ. N. M. Press, Albuquerque.

Bragg, Arthur N. 1945. The spadefoot toads in Oklahoma with a summary of our knowledge of the group. II. Am. Nat. 79(780):52-72.

Brand, Christopher J., Lloyd B. Keith, and Charles A. Fischer. 1976. Lynx responses to changing snowshoe hare densities in central Alberta. J. Wildl. Manage. 40(3):416-428.

Brand, Leonard R. 1974. Tree nests of California chipmunks (*Eutamias*). Am. Midl. Nat. 91(2):489-491.

Brandborg, Stewart M. 1955. Life history and management of the mountain goat in Idaho. State Idaho Dep. Fish and Game Wildl. Bull. 2, 142 p. Boise.

Braun, Clait E., and Glenn E. Rogers. 1971. The white-tailed ptarmigan in Colorado. Colo. Div. Game, Fish, and Parks Tech. Publ. 27, 80 p. Denver.

Bray, Olin E., Kenneth H. Larsen, and Donald F. Mott. 1975. Winter movements and activities of radio-equipped starlings. J. Wildl. Manage. 39(4):795-801.

Brenner, Fred J. 1967. Spatial and energy requirements of beavers. Ohio J. Sci. 67(4):242-246.

Broadbooks, Harold E. 1958. Life history and ecology of the chipmunk, *Eutamias amoenus,* in eastern Washington. Univ. Mich. Misc. Publ. 103, 49 p. Mus. Zool., Ann Arbor.

Broadbooks, Harold E. 1961. Ring-billed gulls nesting on Columbia River islands. Murrelet 42(1):7-8.

Broadbooks, Harold E. 1970a. Home ranges and territorial behavior of the yellow-pine chipmunk, *Eutamias amoenus.* J. Mammal. 51(2):310-326.

Broadbooks, Harold E. 1970b. Populations of the yellow-pine chipmunk, *Eutamias amoenus.* Am. Midl. Nat. 83(2):472-488.

Brodkorb, Pierce. 1949. Variation in the North American forms of western flycatcher. Condor 51(1):35-39.

Brown, Bobby W. 1973a. The big lake wood duck: A two-year study of its preflight mortality, nesting population growth and migration, 1970-71. Southeast. Assoc. Game and Fish Comm. 26th Annu. Conf. Proc., p. 195-202.

Brown, George W. 1974a. Fish habitat. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. E-1 to E-15. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Brown, George W., and James T. Krygier. 1967. Changing water temperatures in small mountain streams. J. Soil and Water Conserv. 22(6):242-244.

Brown, George W., Gerald W. Swank, and Jack Rothacher. 1971. Water temperature in the Steamboat drainage. USDA For. Serv. Res. Pap. PNW-119, 17 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Brown, Herbert A. 1975a. Temperature and development of the tailed frog, *Ascaphus truei.* Comp. Biochem. Physiol. 50(2A):397-405.

Brown, Herbert A. 1975b. Embryonic temperature adaptations of the Pacific treefrog, *Hyla regilla.* Comp. Biochem. Physiol. 51(4A):863-873.

Brown, James K. 1970. Physical fuel properties of ponderosa pine forest floors and cheatgrass. USDA For. Serv. Res. Pap. INT-74, 16 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K. 1974b. Handbook for inventorying downed woody material. USDA For. Serv. Gen. Tech. Rep. INT-16, 24 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, Larry N. 1967. Seasonal activity patterns and breeding of the western jumping mouse (*Zapus princeps*) in Wyoming. Am. Midl. Nat. 78(2):460-470.

Brown, Leslie, and Dean Amadon. 1968. Eagles, hawks, and falcons of the world. Vols. 1 and 2. 945 p. McGraw-Hill Book Co., New York.

Brown, Woodward H. 1973b. Winter population trends in the marsh, Cooper's and sharp-shinned hawks. Am. Birds 27(1):6-7.

Browning, M. Ralph. 1974. Comments on the winter distribution of the Swainson's hawk (*Buteo swainsoni*) in North America. Am. Birds 38(5):865-867.

Browning, M. Ralph. 1975. First Oregon specimen of *Icterus galbula galbula.* Auk 92(1):162-163.

Bruns, Herbert. 1960. The economic importance of birds in forests. Bird Study 7(4):193-208.

Buchler, Edward R. 1976. Prey selection by *Myotis lucifugus,* Am. Nat. 110(974): 619-628.

Buckner, C. H. 1971. Vertebrate predators. *In* Toward integrated control, p. 21-31. USDA For. Serv. Res. Pap. NE-194. Northeast. For. Exp. Stn., Upper Darby, Pa.

Buckner, C. H., and W. J. Turnock. 1965. Avian predation on the larch sawfly (*Pristiphora erichsonii*). Ecology 46(3): 223-236.

Buckner, Charles H. 1966. The role of vertebrate predators in the biological control of forest insects. Annu. Rev. Entomol. 11:449-470.

Bull, Evelyn L., and Ralph G. Anderson. 1978. Notes on flammulated owls in northeastern Oregon. Murrelet 59(1):26-28.

Bull, Evelyn Louise. 1975. Habitat utilization of the pileated woodpecker, Blue Mountains, Oregon. M.S. thesis. 58 p. Oreg. State Univ., Corvallis.

Bull, Evelyn Louise. [n.d.] Unpublished data on file at U.S. Dep. Agric., Forest Service, Range and Wildlife Habitat Laboratory, "C" & Gekeler Lane, Route 2, Box 2315, La Grande, Oreg. 97850. Used with permission.

Bump, Gardiner, R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. The ruffed grouse: Life history, propagation, management. 915 p. N. Y. State Conserv. Dep., Albany.

Bunnell, F. L. 1976a. Forestry-wildlife: Whither the future. For. Chron. 52(3): 147-149.

Bunnell, F. L. 1976b. The myth of the omniscient forester. For. Chron. 52(3): 150-152.

Bunni, Munir Kiriacose. 1959. The killdeer, *Charadrius vociferus* (Linn.), in the breeding season: Ecology, behavior, and the development of homoiothermism. Sc. D. diss. 366 p. Univ. Mich., Ann Arbor.

Burger, Joanna, and Marshall Howe. 1975. Notes on winter feeding behavior and molt in Wilson's phalaropes. Auk 92(3): 442-451.

Burke, Melvin H. 1965. M-Watershed: General memorandum to K. W. Lindstedt. On file at Pacific Northwest Region, USDA For. Serv., Portland, Oreg.

Burkholder, Gary L., and J. M. Walker. 1973. Habitat and reproduction of the desert whiptail lizard, *Cnemidophorus tigris* Baird and Girard, in southwestern Idaho at the northern part of its range. Herpetologica 29(1):76-83.

Burleigh, Thomas D. 1963. Geographic variation in the cedar waxwing (*Bombycilla cedrorum*). Biol. Soc. Wash. Proc. 76:177-180.

Burns, Frank L. 1900. A monograph of the flicker. Wilson Bull. 7(2):1-82.

Burt, William Henry, and Richard Philip Grossenheider. 1964. A field guide to the mammals: Field marks of all species found north of the Mexican boundary. 2d ed. 284 p. Houghton Mifflin, Boston.

Burton, John A., Ed. 1973. Owls of the world: Their evolution, structure, and ecology. 216 p. Dutton, New York.

Buss, Iwen O., and Eugene S. Dziedzic. 1955. Relation of cultivation to the disappearance of the Columbian sharp-tailed grouse from southeastern Washington. Condor 57(3):185-187.

Buss, Iwen Otto. 1939. The upland plover at Faville Grove, Wisconsin. M.S. thesis. 23 p. Univ. Wis., Madison.

Butsch, Robert Stearns. 1954. The life history and ecology of the red-backed vole, *Clethrionomys gapperi gapperi* Vigors, in Minnesota. Ph. D. thesis. 161 p. Univ. Mich., Ann Arbor.

Cade, Tom J. 1962. Wing movements, hunting, and displays of the northern shrike. Wilson Bull. 74(2):386-408.

Cade, Tom J. 1967. Ecological and behavioral aspects of predation by the northern shrike. Living Bird 6:43-86.

Cagle, Fred R. 1954. Observations on the life cycles of painted turtles (genus *Chrysemys*). Am. Midl. Nat. 52(1):225-235.

Cain, Stanley Adair, and G. M. de Oliveira Castro. 1959. Manual of vegetation analysis. 325 p. Harper and Brothers, New York.

Calder, William A. 1971. Temperature relationships and nesting of the calliope hummingbird. Condor 73(3):314-321.

Calder, William A. 1973. Microhabitat selection during nesting of hummingbirds in the Rocky Mountains. Ecology 54(1):127-134.

Calder, William A., and Joanna Booser. 1973. Hypothermia of broad-tailed hummingbirds during incubation in nature with ecological correlations. Science 180(4087):751-753.

Calhoun, John B. 1963. The ecology and sociology of the Norway rat. U.S. Dep. Health, Education, and Welfare. Public Health Serv. Publ. 1008, 288 p. Bethesda, Md.

Campbell, James B. 1970. Life history of *Bufo boreas boreas* in the Colorado Front Range. Ph. D. thesis. 124 p. Univ. Colo., Boulder.

Carothers, Steven W., and R. R. Johnson. 1975. Water management practices and their effects on nongame birds in range habitats. *In* Proceedings of the symposium on management of forest and range habitats for nongame birds. D. R. Smith, ed. USDA For. Serv. Gen. Tech. Rep. WO-1. p. 210-222. Washington, D.C.

Carpenter, Charles C. 1952. Comparative ecology of the common garter snake (*Thamnophis s. sirtalis*), the ribbon snake (*Thamnophis s. sauritus*), and Butler's garter snake (*Thamnophis butleri*) in mixed populations. Ecol. Monogr. 22(4):235-258.

Carr, Catherine M., and Patrick T. Gregory. 1976. Can tongue flicks be used to measure niche sizes? Can. J. Zool. 54(8):1389-1394.

Chapman, Lawrence B. 1935. Studies of a tree swallow colony. Bird-Banding 6(2):45-57.

Chapman, Lawrence B. 1955. Studies of a tree swallow colony. Bird-Banding 26(2):45-70.

Choate, Thomas S. 1963. Habitat and population dynamics of white-tailed ptarmigan in Montana. J. Wildl. Manage. 27(4):684-699.

Christensen, Glen C. 1952. An ecological study of the chuckar partridge in western Nevada. M.S. thesis. 83 p. Univ. Nev., Reno.

Christian, Donald P. 1975. Vulnerability of meadow voles, *Microtus pennsylvanicus*, to predation by domestic cats. Am. Midl. Nat. 93(2):498-502.

Christian, John J. 1956. The natural history of a summer aggregation of the big brown bat, *Eptesicus fuscus fuscus*. Am. Midl. Nat. 55(1):66-95.

Clanton, C. Wesley, Marion Bacon, and W. R. Giedt. 1971. Campestral plague in central Washington with particular observations of plague in the sagebrush vole. 74 p. Dep. Soc. and Health Serv., Health Serv. Div. Public Health Lab. [Wash. Dep. Health,] Seattle.

Clark, Donald R., Jr., and Carl S. Lieb. 1973. Notes on reproduction of the night snake (*Hypsiglena torquata*). Southwest. Nat. 18(2):248-255.

Clark, Richard J. 1975. A field study of the short-eared owl, *Asio flammeus* (Pontoppidan), in North America. Wildl. Monogr. 47, 67 p. Wild. Soc., Washington, D.C.

Clark, Richard J., and James G. Ward. 1974. Interspecific competition in two species of open country raptors *Circus cyaneus* and *Asio flammeus*. Pa. Acad. Sci. Proc. 48:79-87.

Clark, Tim W. 1971. Ecology of the western jumping mouse in Grand Teton National Park, Wyoming. Northwest Sci. 45(4):229-238.

Clarke, Raymond D. 1974a. Food habits of toads, genus *Bufo* (Amphibia: Bufonidae). Am. Midl. Nat. 91(1):140-147.

Clarke, Raymond D. 1974b. Activity and movement patterns in a population of Fowler's toad, *Bufo woodhousei fowleri*. Am. Midl. Nat. 92(2):257-274.

Clothier, Ronald R. 1955. Contribution to the life history of *Sorex vagrans* in Montana. J. Mammal. 36(2):214-221.

Cochran, W. W., G. G. Montgomery, and R. R. Graber. 1967. Migratory flights of *Hylocichla* thrushes in spring: A radiotelemetry study. Living Bird 6:213-225.

Coggins, Victor. 1976. Controlled vehicle access during elk season in the Chesnimnus area, Oregon. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 58-61. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Cole, Bert L. [n.d.] Forest management project: Birds as forest protection agents. Wash. [State] Dep. Nat. Resour. Resour. Manage. Rep. 2, 18 p. Olympia.

Cole, Leon J. 1943. Behavior of northern phalarope with young. Condor 45(1):39.

Coles, Victor. 1938. Studies in the life history of the turkey vulture (*Cathartes aura septentrionalis*. Wied). Ph. D. thesis. 632 p. Cornell Univ., Ithaca, N. Y.

Combellack, C. R. B. 1954. A nesting of violet-green swallows. Auk 71(4):435-442.

Commoner, Barry. 1971. The closing circle: Nature, man, and technology. 326 p. Alfred A. Knopf, New York.

Conaway, Clinton H. 1952. Life history of the water shrew (*Sorex palustris navigator*). Am. Midl. Nat. 48(1):219-248.

Conley, Walt. 1976. Competition between *Microtus*: A behavioral hypothesis. Ecology 57(2):224-237.

Conner, Richard N. 1978. Snag management for cavity nesting birds. *In* Proceedings of the workshop on management of southern forests for nongame birds. Richard M. DeGraaf, ed. p. 120-128. USDA For. Serv. Southeast. For. Exp. Stn., Asheville, N.C.

Conner, Richard N., Robert G. Hooper, Hewlette S. Crawford, and Henry S. Mosby. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39(1):144-150.

Conner, Richard N., Orson K. Miller, Jr., and Curtis S. Adkisson. 1976. Woodpecker dependence on trees infected by fungal heart rots. Wilson Bull. 88(4): 575-581.

Conner, Richard Neil. 1973. Woodpecker utilization of cut and uncut woodlands. M.S. thesis. 82 p. Va. Polytechnic Inst. and State Univ., Blacksburg.

Constantine, Denny G. 1966. Ecological observations on Lasiurine bats in Iowa. J. Mammal. 47(1):34-41.

Cooch, Frederick Graham. 1958. The breeding biology and management of the blue goose (*Chen caerulescens*). Ph. D. thesis. 246 p. Cornell Univ., Ithaca, N. Y.

Coppel, Harry C., and Norman F. Sloan. 1970. Avian predation, an important adjunct in the suppression of larch casebearer and introduced pine sawfly populations in Wisconsin forests. *In* Tall Timbers conference on ecological animal control by habitat management proceedings, No. 2, p. 259-272. Tall Timbers Res. Stn., Tallahassee, Fla.

Cornaby, Barney W., and Jack B. Waide. 1973. Nitrogen fixation in decaying chestnut logs. Plant and Soil 39(2):445-448.

Coulombe, Harry N. 1971. Behavior and population ecology of the burrowing owl, *Speotyto cunicularia*, in the Imperial Valley of California. Condor 73(2): 162-176.

Coulter, Malcolm Wilford. 1966. Ecology and management of fishers in Maine. Ph. D. thesis. 196 p. State Univ. Coll. For. Syracuse Univ., Syracuse, N. Y.

Cowan, Ian McTaggart. 1936. Nesting habits of the flying squirrel *Glaucomys sabrinus*. J. Mammal. 17(1):58-60.

Cowan, Ian McTaggart, and Charles J. Guiguet. 1965. The mammals of British Columbia. 3d ed. 414 p. B.C. Prov. Mus., Dep. Recreation and Conserv., Victoria, B.C.

Cowan, John B. 1952. Life history and productivity of a population of western mourning doves in California. Calif. Fish and Game 38(4):505-521.

Crabb, Wilfred D. 1948. The ecology and management of the prairie spotted skunk in Iowa. Ecol. Monogr. 18(2):201-232.

Craighead, F. C. 1950. Insect enemies of eastern forests. U.S. Dep. Agric. Misc. Publ. 657, 679 p. Washington, D.C.

Craighead, John J., Frank C. Craighead, Jr., Robert L. Ruff, and Bart W. O'Gara. 1973. Home ranges and activity patterns of nonmigratory elk of the Madison drainage herd as determined by biotelemetry. Wildl. Monogr. 33, 50 p.

Craighead, John Johnson, and Frank C. Craighead, Jr. 1969. Hawks, owls, and wildlife. 443 p. Dover Publ., Inc., New York. [Originally published in 1956 by Stackpole Co., Harrisburg, Pa.]

Cramer, Owen P. 1974. Air quality influences. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. F-1 to F-51. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Crase, Frederick T., and Richard W. DeHaven. 1975. Selected bibliography on the food habits of North American blackbirds. U.S. Dep. Inter. Fish and Wildl. Serv. Spec. Sci. Rep. Wildl. 192, 20 p.

Criddle, Norman. 1927. Habits of the mountain bluebird in Manitoba. Can. Field-Nat. 41(2):40-44.

Criddle, Stuart. 1930. The prairie pocket gopher, *Thomomys talpoides rufescens*. J. Mammal. 11(3):265-280.

Crockett, Allen B. and Harlo H. Hadow. 1975. Nest site selection by Williamson and red-naped sapsuckers. Condor 77(3):365-368.

Cromack, Kermit, Jr., Robert L. Todd, and Carl D. Monk. 1975. Patterns of Basidiomycete nutrient accumulation in conifer and deciduous forest litter. Soil Biol. Biochem. 7(4-5):265-268.

Cronemiller, Fred P., and Paul S. Bartholomew. 1950. The California mule deer in chaparral forests. Calif. Fish and Game 36(4):343-365.

Cross, Stephen P. 1965. Roosting habits of *Pipistrellus hesperus*. J. Mammal. 46(2):270-279.

Crouch, Glenn L. 1969. Animal damage to conifers on National Forests in the Pacific Northwest Region. USDA For. Serv. Resour. Bull. PNW-28, 13 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Crouch, Glenn L., and M. A. Radwan. 1971. Evaluation of R-55 and mestranol to protect Douglas-fir seed from deer mice. USDA For. Serv. Res. Note PNW-170, 6 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Crouse, Carl N. 1941. The value of small reserves in pheasant management in Whitman County, Washington. M.S. thesis. 36 p. Wash. State Coll., Pullman.

Crowe, Douglas M. 1975. A model for exploited bobcat populations in Wyoming. J. Wildl. Manage. 39(2):408-415.

Culver, David C. 1970. Analysis of simple cave communities. I. Caves as islands. Evolution 24(2):463-474.

Curtis, Robert L., and Thomas H. Ripley. 1975. Water management practices and their effect on nongame bird habitat values in a deciduous forest community. *In* Proceedings of the symposium on management of forest and range habitats for nongame birds. D. R. Smith, ed. USDA For. Serv. Gen. Tech. Rep. WO-1, p. 128-141. Washington, D.C.

Cutright, Noel J. 1973. A bibliography on the red-winged blackbird. Dep. Nat. Resour., 24 p. Cornell Univ., Ithaca, N.Y.

Dahlsten, D. L., and S. G. Herman. 1965. Birds as predators of destructive forest insects. Calif. Agric. 19(9):8-10.

Dahms, Walter G. 1949. How long do ponderosa pine snags stand? USDA For. Serv. Pac. Northwest For. and Range Exp. Stn. Res. Note 57, 3 p., illus. Portland, Oreg.

Dalquest, Walter W. 1943. Seasonal distribution of the hoary bat along the Pacific coast. Murrelet 24(1):20-24.

Dalquest, Walter W. 1947a. Notes on the natural history of the bat, *Myotis yumanensis*, in California, with a description of a new race. Am. Midl. Nat. 38(1):224-247.

Dalquest, Walter W. 1947b. Notes on the natural history of the bat *Corynorhinus rafinesquii* in California. J. Mammal. 28(1):17-30.

Dalquest, Walter W. 1948. Mammals of Washington. Kans. Univ. Mus. Nat. Hist. Publ. 2:1-444.

Dambach, Charles A. 1944. A ten-year ecological study of adjoining grazed and ungrazed woodlands in northeastern Ohio. Ecol. Monogr. 14(3):255-270.

Darham, Leonard, and George W. Bennett. 1963. Age, growth, and homing in the bullfrog. J. Wildl. Manage. 27(1):107-123.

Dasmann, Raymond F., and Richard D. Taber. 1956. Behavior of Columbian black-tailed deer with reference to population ecology. J. Mammal. 37(2):143-164.

Daubenmire, R. 1976. The use of vegetation in assessing the productivity of forest lands. Bot. Rev. 42(2):115-143.

Daubenmire, Rexford F. 1968. Plant communities: A textbook of plant synecology. 300 p. Harper and Row Publ., New York.

Davidson, Ross W., W. A. Campbell, and Dorothy Blaisdell Vaughn. 1942. Fungi causing decay of living oaks in the Eastern United States and their cultural identification. U.S. Dep. Agric. Tech. Bull. 785, 65 p.

Davis, David E. 1954. The breeding biology of Hammond's flycatcher. Auk 71(2):164-171.

Davis, David E. 1974. Emigrations of northern shrikes 1959-1970. Auk 91(4): 821-825.

Davis, James L. 1970. Elk use of spring and calving range during and after controlling logging. M.S. thesis. 51 p. Univ. Idaho, Moscow.

Davis, John. 1960. Nesting behavior of the rufous-sided towhee in coastal California. Condor 62(6):434-456.

Davis, John, George F. Fisler, and Betty S. Davis. 1963. The breeding biology of the western flycatcher. Condor 65(5): 337-382.

Davis, John, and Nicholas A. M. Verbeek. 1972. Habitat preferences and the distribution of *Uta stansburiana* and *Sceloporus occidentalis* in coastal California. Copeia 1972(4):643-649.

Davis, Kenneth P. 1959. Comments on "What is unit area control?" J. For. 57(7):517-518.

Davis, Peter R. 1977. Cervid response to forest fire and clearcutting in southeastern Wyoming. J. Wildl. Manage. 41(4):785-788.

Davis, Wayne H., Roger W. Barbour, and Marion D. Hassell. 1968. Colonial behavior of *Eptesicus fuscus*. J. Mammal. 49(1):44-50.

Day, Frank P., Jr., and Carl D. Monk. 1974. Vegetation patterns on a southern Appalachian watershed. Ecology 55(5): 1064-1074.

Dealy, John Edward. 1975. Ecology of curlleaf mountain-mahogany (*Cercocarpus ledifolius* Nutt.) in eastern Oregon and adjacent areas. Ph. D. thesis. 173 p. Oreg. State Univ., Corvallis.

Deeming, John E., Robert E. Burgan, and Jack D. Cohen. 1978. The national fire-danger rating system. USDA For. Serv. Gen. Tech. Rep. INT-39, 63 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

DeGraaf, Richard M., H. Ross Pywell, and Jack Ward Thomas. 1975. Relationships between songbird nest height, vegetation and housing density in New England suburbs. Northeast Sec. Wildl. Soc. Trans. 1975:130-150.

DeGraaf, Richard Matthew. 1976. Suburban habitat associations of birds. Ph.D. thesis. 317 p. Univ. Mass., Amherst.

DeHaven, Richard W., and Phyllis J. DeHaven. 1973. A contribution toward a bibliography on the starling (*Sturnus vulgaris*). 92 p. U.S. Dep. Inter. Bur. Sport. Fish. and Wildl., Denver Wildl. Res. Cent., Denver, Colo.

Dell, John D., and Franklin R. Ward. 1971. Logging residues on Douglas-fir region clearcuts-weights and volumes. USDA For. Serv. Res. Pap. PNW-115, 10 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Delson, Jeffrey Hale. 1974. The ecology of the desert dwelling salamander, *Ambystoma tigrinum*. Ph.D. thesis. 97 p. N. M. State Univ., Las Cruces.

Dennis, J. V. 1969. The yellow-shafted flicker (*Colaptes auratus*) on Nantucket Island, Massachusetts. Bird-Banding 40(4):290-308.

Dennis, John V. 1971. Species using red-cockaded woodpecker holes in northeastern South Carolina. Bird-Banding 42(2):79-87.

Denton, Samuel Jonathon. 1976. Status of prairie falcon breeding in Oregon. M.S. thesis. 58 p. Oreg. State Univ., Corvallis.

Derickson, W. Kenneth. 1976. Ecological and physiological aspects of reproductive strategies in two lizards. Ecology 57(3):445-458.

deVos (see Vos)

Dexter, Ralph W. 1975. Further studies on the incursions of evening grosbeaks into northeastern Ohio, 1972-1974. Inland Bird Banding News 47(3):102-107.

Deyrup, Mark Amidon. 1975. The insect community of dead and dying Douglas-fir. 1. The Hymenoptera. Coniferous For. Biome, Ecosyst. Anal. Stud. Bull. 6, 104 p. Univ. Wash., Seattle.

Dice, Lee R. 1931. The relation of mammalian distribution to vegetation types. Sci. Mon. 33(4):312-317.

Dick, James A., and James D. Rising. 1965. A comparison of foods eaten by eastern kingbirds and western kingbirds in Kansas. Kans. Ornithol. Soc. Bull. 16(4):23-24.

Dicken, Samuel Newton. 1973. Oregon geography: The people, the place, and the times. 5th ed. 147 p. Edwards Brothers, Ann Arbor, Mich.

Dimock, Edward J., II. 1974. Animal populations and damage. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. 0-1 to 0-28. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Dimock, Edward J., II, and Hugh C. Black. 1969. Scope and economic aspects of animal damage in California, Oregon, and Washington. *In* Wildlife and reforestation in the Pacific Northwest proceedings, p. 10-14. Hugh C. Black, ed. Oreg. State Univ., Corvallis.

Dirschl, Herman J. 1969. Foods of lesser scaup and blue-winged teal in the Saskatchewan River delta. J. Wildl. Manage. 33(1):77-87.

Ditmars, Raymond Lee. 1936. The reptiles of North America: A review of the crocodilians, lizards, snakes, turtles and tortoises inhabiting the United States and northern Mexico. 476 p. Doubleday, Doran, Garden City, New York.

Dixon, Joseph S. 1934. A study of the life history and food habits of mule deer in California. Calif. Fish and Game 20(3):181-282; 20(4):315-354.

Dixon, Keith L. 1949. Behavior of the plain titmouse. Condor 51(3):110-136.

Dixon, Keith L. 1961. Habitat distribution and niche relationships in North American species of *Parus*. *In* Vertebrate speciation: A University of Texas symposium, p. 179-216, W. F. Blair, ed. Univ. Tex. Press, Austin.

Doerr, Phillip D., Lloyd B. Keith, and Donald H. Rusch. 1970. Effects of fire on a ruffed grouse population. 10th Annu. Tall Timbers Fire Ecol. Conf. Proc., p. 25-46. Tall Timbers Res. Stn., Tallahassee, Fla.

Dolbeer, Richard A. 1976. Reproductive rate and temporal spacing of nesting of red-winged blackbirds in upland habitat. Auk 93(2):343-355.

Dolbeer, Richard A., and William R. Clark. 1975. Population ecology of snowshoe hares in the central Rocky Mountains. J. Wildl. Manage. 39(3):535-549.

Donahue, Maynard Walter. 1939. A study of the nesting habits and development of the eastern bluebird, *Sialia sialis sialis*. M.S. thesis. 62 p. Univ. Tenn., Knoxville.

Donaldson, J. L., and A. T. Bergerud. 1974. Behavior and habitat selection of an insular population of blue grouse. Syesis 7:115-127.

Donohoe, Robert W. 1975. Evaluation of the effects of regeneration cuts on squirrels. Performance Rep. Ohio For. Wildl. Ecol. Res. and Manage. Proj. Fed. Aid Proj. W-105-R-15, 41 p. Ohio Dep. Nat. Resour. Div. Wildl., Columbus.

Dorney, Robert S. 1954. Ecology of marsh raccoons. J. Wildl. Manage. 18(2):217-225.

Dowden, Philip B., and V. M. Carolin. 1950. Natural control factors affecting the spruce budworm in the Adirondacks during 1946-1948. J. Econ. Entomol. 43(6):774-783.

Dowden, Philip B., H. A. Haynes, and V. M. Carolin. 1953. The role of birds in a spruce budworm outbreak in Maine. J. Econ. Entomol. 46(2):307-312.

Drewien, Roderick C., and Elwood G. Bizeau. 1974. Status and distribution of greater sandhill cranes in the Rocky Mountains. J. Wildl. Manage. 38(4):720-742.

Dunker, Henning. 1974. Habitat selection and territory size of the black-throated diver, *Gavia arctica* (L.) in south Norway. Norw. J. Zool. 22(1):15-29.

Dunstan, Thomas C., and Steve D. Sample. 1972. Biology of barred owls in Minnesota. Loon 44(4):111-115.

Dyrness, C. T., Jerry F. Franklin, Chris Maser, Stanton A. Cook, James D. Hall, and Glenda Faxon. 1975. Research Natural Area needs in the Pacific Northwest: A contribution to land-use planning. ["Yellow Book."] USDA For. Serv. Gen. Tech. Rep. PNW-38, 231 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Dzubin, A., H. Boyd, and W. J. D. Stephen. 1975. Blue and snow goose distribution in the Mississippi and central flyways, 1951-71. Can. Wildl. Serv. Prog. Notes 54, 34 p. Ottawa.

Easterla, David A. 1971. Notes on young and adults of the spotted bat, *Euderma maculatum*. J. Mammal. 52(2):475-476.

Edgerton, Paul J., and Burt R. McConnell. 1976. Diurnal temperature regimes of logged and unlogged mixed conifer stands on elk summer range. USDA For. Serv. Res. Note PNW-277, 7 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Edwards, R. Y. 1955. The habitat preferences of the boreal *Phenacomys*. Murrelet 36(3):35-38.

Einarsen, Arthur Skogman. 1941. The effect upon the black tern of a change in its habitat. Murrelet 22(1):19.

Einarsen, Arthur Skogman. 1956. Life of the mule deer. *In* The deer of North America, p. 363-390. W. P. Taylor, ed. Stackpole Co., Harrisburg, Pa., and Wildl. Manage. Inst., Washington, D.C.

Einarsen, Arthur Skogman. 1965. Black brant: Sea goose of the Pacific coast. 142 p. Univ. Wash. Press, Seattle.

Eisenmann, Eugene. 1971. Range expansion and population increase in North and Middle America of the white-tailed kite (*Elanus leucurus*). Am. Birds 25(3): 529-536.

Eklund, Carl. R. 1942. Ecological and mortality factors affecting the nesting of the Chinese pheasant in the Willamette Valley, Oregon. J. Wildl. Manage. 6(3):225-230.

Elton, Charles Sutherland. 1966. Dying and dead wood. *In* The pattern of animal communities. p. 279-305. John Wiley & Sons, Inc., New York.

Emlen, John T., Jr. 1952. Territory, nest building, and pair formation in the cliff swallow. Auk 71(1):16-35.

Emlen, John T., Jr. 1954. Social behavior in nesting cliff swallows. Condor 54(4): 177-199.

Emlen, Stephen T., James D. Rising, and William L. Thompson. 1975. A behavioral and morphological study of sympatry in the indigo and lazuli buntings of the Great Plains. Wilson Bull. 87(2): 145-179.

Enderson, James Harris. 1960. A population study of the sparrow hawk in east-central Illinois. Wilson Bull. 72(3):222-231.

Environmental Protection Agency. 1976. Forest harvest, residue treatment, reforestation and protection of water quality. EPA 910/9-76-020. Reg. 10, 273 p. Natl. Tech. Inf. Serv., Springfield, Va.

Erickson, Ray Charles. 1948. Life history and ecology of the canvas-back, *Nyroca valisineria* (Wilson), in southeastern Oregon. Iowa State Coll. J. Sci. 23(1): 30-32.

Errington, Paul L. 1936. Notes on food habits of southern Wisconsin house cats. J. Mammal. 17(1):64-65.

Errington, Paul L. 1943. An analysis of mink predation upon muskrats in north-central United States. Iowa Agric. Exp. Stn. Res. Bull. 320, p 797-924. Ames.

Erskine, A. J., and W. D. McLaren. 1972. Sapsucker nest holes and their use by other species. Can. Field Nat. 86(4):357-361.

Erskine, Anthony J. 1961. Nest-site tenacity and homing in the bufflehead. Auk 78(3):389-396.

Erskine, Anthony John. 1960. A discussion of the distributional ecology of the bufflehead (*Bucephala albeola*; Anatidae; Aves) based upon breeding biology studies in British Columbia. M.S. thesis. 116 p. Univ. B.C., Vancouver.

Erskine, Anthony John. 1972. Populations, movements and seasonal distribution of mergansers in northern Cape Breton Island. Can. Wildl. Serv. Rep. Ser. 17, 36 p.

Evans, James. 1970. About nutria and their control. Denver Wildl. Res. Cent. Resour. Publ. 86, 65 p. U.S. Bur. Sport Fish. and Wildl., Denver, Colo.

Evans, Keith E. 1968. Characteristics and habitat requirements of the greater prairie chicken and sharp-tailed grouse: A review of the literature. USDA For. Serv. Conserv. Res. Rep. 12, 32 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Evans, Ray D. 1974. Wildlife habitat management program: A concept of diversity for the public forests of Missouri. *In* Timber-wildlife management symposium. John P. Slusher and Thomas M. Hinckley, eds. Mo. Acad. Sci. Occas. Pap. 3, p. 73-83. Columbia.

Evenden, Fred G., Jr. 1950. Unusual singing perches of the winter wren. Murrelet 31(2):32-33.

Faaborg, John. 1976. Habitat selection and territorial behavior of the small grebes of North Dakota. Wilson Bull. 88(3):390-399.

Falls, J. Bruce. 1969. 10. Functions of territorial song in the white-throated sparrow. *In* Bird vocalizations: Their relations to current problems in biology and psychology. *Essays presented to W. H. Thorpe*, p. 207-232. R. A. Hinde, ed. Univ. Press, Cambridge.

Falls, J. Bruce, and John R. Krebs. 1975. Sequence of songs in repertoires of western meadowlarks (*Sturnella neglecta*). Can. J. Zool. 53(8):1165-1178.

Farner, Donald S. 1949. Age groups and longevity in the American robin: Comments, further discussion, and certain revisions. Wilson Bull. 61(2):68-81.

Fenton, M. Brock. 1970. Population studies of *Myotis lucifugus* (Chiroptera: Vespertilionidae) in Ontario. Life Sci. Contrib. 77, 34 p. R. Ont. Mus.

enton, M. Brock. 1972. Distribution and overwintering of *Myotis leibii* and *Eptesicus fuscus* (Chiroptera: Vespertilionidae) in Ontario. R. Ont. Mus., Life Sci. Occas. Pap. 21:1-8. Toronto.

erguson, Denzel E. 1952. The distribution of amphibians and reptiles of Wallowa County, Oregon. Herpetologica 8(3):66-68.

icken, Millicent S. 1963. Courtship of the American redstart. Auk 80(3):307-317.

icken, Millicent S., and Robert W. Ficken. 1962. The comparative ethology of the wood warblers: A review. Living Bird 1:103-122.

isler, George F. 1971. Age structure and sex ratio in populations of *Reithrodontomys*. J. Mammal. 52(4):653-662.

itch, Henry S. 1963. Natural history of the racer *Coluber constrictor*. Kans. Univ. Mus. Nat. Hist. Publ. 15(8):351-468.

itch, Henry S., Freeman Swenson, and Daniel F. Tillotson. 1946. Behavior and food habits of the red-tailed hawk. Condor 48(5):205-237.

itch, Henry Sheldon. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. Univ. Kans. Univ. Mus. Nat. Hist. Publ. 15(10):493-564. Lawrence.

itch, Henry Sheldon. 1975. A demographic study of the ringneck snake (*Diadophis punctatus*) in Kansas. Kans. Univ. Mus. Nat. Hist. Misc. Publ. 62, 53 p. Lawrence.

itch, Henry Sheldon, and Lewis L. Sandidge. 1953. Ecology of the opossum on a natural area in northeastern Kansas. Kans. Univ. Mus. Nat. Hist. Publ. 7(2):305-338. Lawrence.

itzwater, William D., Jr. 1941. The red squirrel: Territorialism, activity, census methods. M.S. thesis. 117 p. N. Y. State Coll. For., Syracuse.

look, Donald R. 1970. Causes and implications of an observed sex differential in the survival of wapiti. Can. Wildl. Serv. Rep. Ser. 11, 71 p.

ogel, Robert, and Kermit Cromack, Jr. 1977. Effect of habitat and substrate quality on Douglas-fir litter decomposition in western Oregon. Can. J. Bot. 55(12):1632-1640.

ogel, Robert, M. Ogawa, and J. M. Trappe. 1973. Terrestrial decomposition: A synopsis. Rep. 135, 12 p. Coniferous For. Biome, Seattle.

Forbes, James E., and Dwain W. Warner. 1974. Behavior of a radio-tagged sawwhet owl. Auk 91(4):783-795.

Forbush, Edward Howe. 1907. Useful birds and their protection. 437 p. Mass. State Board Agric., Boston.

Ford-Robertson, F. C., Ed. 1971. Terminology of Forest Science technology practice and products: English-language version. Multilingual For. Term. Ser. 1, 349 p. Soc. Am. For., Washington, D.C.

Forsman, Eric D. 1975. A preliminary investigation of the spotted owl in Oregon. M.S. thesis. 127 p. Oreg. State Univ., Corvallis.

Fox, Glen A. 1971. Recent changes in the reproductive success of the pigeon hawk. J. Wildl. Manage. 35(1):122-128.

Fox, Wade. 1948. Effect of temperature on development of scutellation in the garter snake, *Thamnophis elegans atratus*. Copeia 1948(4):252-262.

Fox, Wade. 1951. Relationships among the garter snakes of the *Thamnophis elegans* Rassenkreis. Univ. Calif. Publ. Zool. 50(5):485-530.

Franklin, Jerry F. 1976. Effects of uneven-aged management on species composition. *In* Uneven-aged silviculture and management in the Western United States. p. 64-70. Proc., In-Service Workshop, Redding, Calif. USDA For. Serv., Timber Manage. Res., Washington, D.C.

Franklin, Jerry F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8, 417 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Franklin, W. L., A. S. Mossman, and M. Dole. 1975. Social organization and home range of Roosevelt elk. J. Mammal. 56(1):102-118.

Franz, J. M. 1961. Biological control of pest insects in Europe. Annu. Rev. Entomol. 6:183-200.

Freiberger, Wilhelm. 1926-27. Zur Vogelschutzfrage, insbesondere zur wissenschaftlichen Begründung des wirtschaftlichen Vogelschutzes. Allg. Forst. Jagdztg., vol. 102. Dec. 1926, p. 425-430; vol. 103, Jan. 1927, p. 19-30; Feb. 1927, p. 49-63; Mar. 1927, p. 92-115.

Friedmann, Herbert. 1963. Host relations of the parasitic cowbirds. U.S. Nat. Mus. Bull. 233, 276 p.

Fuller, Robert W. 1953. Studies in the life history and ecology of the American pintail (*Anas acuta tzitzihoa* Vieillot) in Utah. M.S. thesis. 181 p. Utah State Univ., Logan.

Furman, R. William. 1975. Estimating moisture content of heavy forest fuels. For. Sci. 21(2):135-139.

Furniss, R. L., and V. M. Carolin. 1977. Western forest insects. U.S. Dep. Agric. Misc. Publ. 1339, 654 p. Washington, D.C.

Gabrielson, Ira Noel, and Stanley G. Jewett. 1940. Birds of Oregon. 650 p. Oreg. State Coll., Corvallis.

Gabrielson, Ira Noel, and Stanley G. Jewett. 1970. Birds of the Pacific Northwest: With special reference to Oregon. 650 p. Dover Publ., Inc., New York.

Galbreath, Donald S., and Raleigh Moreland. 1953. The chuckar partridge in Washington. Wash. State Game Dep. Biol. Bull. 11, 55 p. Olympia.

Gale, Robert M. 1973. Snags, chainsaws and wildlife: One aspect of habitat management. *In* Cal-Neva wildlife 1973 transactions, p. 97-112. Jim Yoakum, ed. (Copies available from Editor, P.O. Box 9098, University Station, Reno, Nevada 89507.)

Gale, Robert M., Warren F. Kelly, and John A. Lorenzana. 1973. Snag management: Coordination guidelines for wildlife habitat, number 1. USDA For. Serv. Calif. Reg., 13 p. (Rev. 1975 by Warren F. Kelley, Steve Loe, Richard Hubbell, and Lisa Shikany.)

Galli, Anne E., Charles F. Leck, and Richard T. T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. Auk 93(2):356-364.

Garrison, G. A. 1960. Recovery of ponderosa pine range in eastern Oregon and eastern Washington by seventh year after logging. *In* Forestry's expanding horizons. Soc. Am. For. Proc. 1960:137-139. Washington, D.C.

Garrison, G. A., J. M. Skovlin, C. E. Poulton, and A. H. Winward. 1976. Northwest plant names and symbols for ecosystem inventory and analysis, fourth edition. USDA For. Serv. Gen. Tech. Rep. PNW-46, 263 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Garrison, George A., Ardell J. Bjugstad, Don A. Duncan, Mont E. Lewis, and Dixie R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. U.S. Dep. Agric. Handb. 475, 68 p. Washington, D.C.

Garrison, George A., and Justin G. Smith. 1974. Habitat of grazing animals. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. P-1 to P-10. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Gashwiler, Jay S. 1961. Notes on the harlequin duck. Murrelet 42(1):4-5.

Gashwiler, Jay S. 1976. A new distribution record of Merriam's shrew in Oregon. Murrelet 57(1):13-14.

Gashwiler, Jay S., W. Leslie Robinette, and Owen W. Morris. 1961. Breeding habits of bobcats in Utah. J. Mammal. 42(1):76-84.

Gashwiler, Jay S., and A. Lorin Ward. 1966. Western redcedar seed, a food of pine siskins. Murrelet 47(3):73-75.

Gashwiler, Jay S., and A. Lorin Ward. 1968. Oregon junco foods in coniferous forests. Murrelet 49(3):29-36.

Gass, Clifton Lee, George Angehr, and Janice Centa. 1976. Regulation of food supply by feeding territoriality in the rufous hummingbird. Can. J. Zool. 54(12):2046-2054.

Gass, Clifton Leroy. 1974. Feeding territoriality in postbreeding migratory rufous hummingbirds. Ph. D. thesis. 148 p. Oreg. State Univ., Corvallis.

Gates, John M. 1958. A study of the breeding behavior of the gadwall in northern Utah. M.S. thesis. 124 leaves. Utah State Univ., Logan.

Gates, John M. 1962. Breeding biology of the gadwall in northern Utah. Wilson Bull. 74(1):43-67.

Gates, John M. 1972. Red-tailed hawk populations and ecology in east-central Wisconsin. Wilson Bull. 84(4):421-433.

Gaunt, Abbott S. 1965. Fossorial adaptations in the bank swallow, *Riparia riparia* (Linnaeus). Univ. Kans. Sci. Bull. 46(2): 99-146. Lawrence.

Gedney, D. R. 1962. 1960 Oregon log production. For. Surv. Rep. 138, 2 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Gehrman, Kenneth Henry. 1951. An ecological study of the lesser scaup duck (*Aythya affinis eyton*) at West Medical Lake, Spokane County, Washington. M.S. thesis. 94 p. Wash. State Univ., Pullman.

Geohring, Harry H. 1972. Twenty-year study of *Eptesicus fuscus* in Minnesota. J. Mammal. 53(1):201-207.

George, John L., and Robert T. Mitchell. 1948. Calculations on the extent of spruce budworm control by insectivorous birds. J. For. 46(6):454-455.

Gerstenberg, R. H., and R. M. Jurek, Compilers. 1972. Selected references on shorebirds. Calif. Dep. Fish and Game, 47 p., typescript.

Getz, Lowell L., and Victoria Ginsberg. 1968. Arboreal behaviour of the red-backed vole, *Clethrionomys gapperi*. Anim. Behav. 16(4):418-424.

Gibb, J. A. 1958. Predation by tits and squirrels on the Eucosmid *Ernarmonia conicolana* (Hyel.). J. Anim. Ecol. 27(2): 375-396.

Gibb, John A. 1960. Populations of tits and goldcrests and their food supply in pine plantations. Ibis 102(2):163-208.

Gibbs, Richard M. 1961. Breeding ecology of the common goldeneye, *Bucephala clangula americana*, in Maine. M.S. thesis. 113 p. Univ. Maine, Orono.

Gier, H. T. 1968. Coyotes in Kansas. Agric. Exp. Stn. Bull. 393, 96 p. Kans. State Coll. Agric. and Appl. Sci., Manhattan.

Giles, Robert H., Jr. 1962. Timber-wildlife coordination concepts for eastern forests. North Am. Wildl. and Nat. Resour. Conf. Trans. 27:402-412.

Giles, Robert H., Jr., Ed. 1971. Wildlife management techniques. 3d ed. 633 p. Wildl. Soc., Wildl. Techniques Comm., Washington, D.C.

Gill, John D., Robert E. Radtke, and Jack Ward Thomas. 1976. Forest wildlife habitat management: Ecological and management systems. *In* The scientific base for silviculture and management decisions in the National Forest System. USDA For. Serv., p. 52-58. Washington, D.C.

Girard, George L. 1939. Notes on life history of the shoveler. North Am. Wildl. Conf. Trans. 4:364-371.

Gleason, Henry Allan. 1922. On the relationship between species and area. Ecology 3(2):158-162.

Glover, Fred A. 1953. Nesting ecology of the pied-billed grebe in northwestern Iowa. Wilson Bull. 65(1):32-39.

Glover, Fred A. 1956. Nesting and production of the blue-winged teal (*Anas discors* Linnaeus) in northwest Iowa. J. Wildl. Manage. 20(1):28-46.

Godin, Alfred J. 1964. A review of the literature on the mountain beaver. U.S. Dep. Inter. Fish and Wildl. Serv., Bur. Sport Fish. and Wildl. Spec. Sci. Rep.-Wildl. 78, 52 p.

Goldberg, Stephen R. 1971. Reproduction in the short-horned lizard *Phrynosoma douglassi* in Arizona. Herpetologica 27(3):311-314.

Goldberg, Stephen R., and William S. Parker. 1975. Seasonal testicular histology of the Colubrid snakes, *Masticophis taeniatus* and *Pituophis melanoleucus*. Herpetologica 31(3):317-322.

Gordon, Kenneth. 1943. The natural history and behavior of the western chipmunk and the mantled ground squirrel. Oreg. State Monogr., Stud. Zool. 5, 104 p. Oreg. State Coll. [Univ.] Press, Corvallis.

Gordon, T. J., and Olaf Helmer-Hirschberg. 1964. Report on a long-range forecasting study. Rand Corp., P-2982, 45 p. Santa Monica, Calif.

Gottfried, Bradley M., and Edwin C. Franks. 1975. Habitat use and flock activity of dark-eyed juncos in winter. Wilson Bull. 87(3):374-383.

Gould, Gordon I., Jr. 1974. The status of the spotted owl in California. 56 p. State Calif. Resour. Agency, Dep. Fish and Game and USDA For. Serv. Reg. 5.

Graham, Richard E. 1966. Observations on the roosting habits of the big-eared bat, *Plecotus townsendii*, in California limestone caves. Cave Notes 8(3):17-22.

Graham, S. A. 1925. The felled tree trunk as an ecological unit. Ecology 6(4):397-411.

Graul, Walter D. 1975. Breeding biology of the mountain plover. Wilson Bull. 87(1):6-31.

Gray, Gene Mack. 1967. An ecological study of sage grouse broods with reference to nesting, movements, food habits, and sagebrush strip spraying in the Medicine Lodge drainage, Clark County, Idaho. M.S. thesis. 200 p. Univ. Idaho, Moscow.

Greenhalgh, Clifton M. 1952. Food habits of the California gull in Utah. Condor 54(5):302-308.

Greenwald, O. E. 1974. Thermal dependence of striking and prey capture by gopher snakes. Copeia 1974(1):141-148.

Gregory, Patrick Thomas. 1973. Life history parameters of a population of red-sided garter snakes (*Thamnophis sirtalis parietalis*) adapted to a rigorous and fluctuating environment. Ph. D. thesis. 98 p. Univ. Manit., Winnipeg, Manit.

Greig-Smith, Peter. 1964. Quantitative plant ecology. 2d ed. 256 p. Butterworths, London.

Grice, David, and John P. Rogers. 1965. The wood duck in Massachusetts: Final report, Federal aid in wildlife restoration, project no. W-19-R. 96 p. illus. Mass. Div. Fish. and Game, Westboro [Boston].

Grier, Charles C., and Robert S. Logan. 1978. Old-growth *Pseudotsuga menziesii* communities of a western Oregon watershed: Biomass distribution and production budgets. Ecol. Monogr. 47(4):373-400.

Griffee, W. E. 1954. Some Oregon nesting records. Murrelet 35(3):48-49.

Griffee, W. E. 1958. Notes on nesting of American merganser and Barrow's golden-eye. Murrelet 39(2):26.

Griffee, W. E. 1961. Bufflehead nesting records for Oregon. Murrelet 42(1):5.

Griner, Lynn A. 1939. A study of the sage grouse, *Centrocercus urophasianus*, with special reference to life history, habitat requirements and numbers and distribution. M.S. thesis. 111 p. Utah State Univ., Logan.

Grinnell, J., and Wm. H. Behle. 1935. Comments upon the subspecies of *Catherpes mexicanus*. Condor 37(5): 247-251.

Griscom, Ludlow. 1937. A monograph study of the red crossbill. Boston Soc. Nat. Hist. Proc. 41(5):77-210.

Griscom, Ludlow, and Alexander Sprunt, Jr. 1957. The warblers of America: A popular account of the wood warblers as they occur in the western hemisphere. 356 p. Devin-Adair Co., New York.

Grosz, Terry. 1966. Food habits and parasites of the Pacific white-wing scoter (*Melanitta fusca dixoni*) in the Humboldt Bay area. M.S. thesis. 44 p. Humboldt State Coll., Arcata, Calif.

Gunderson, Harvey L. 1959. Red-backed vole habitat studies in central Minnesota. J. Mammal. 40(3):405-412.

Gutierrez, R. J. 1975. Literature review and bibliography of the mountain quail (*Oreortyx pictus*). USDA For. Serv. Calif. Reg. 5, 33 p. San Francisco.

Gysel, Leslie W. 1961. An ecological study of tree cavities and ground burrows in forest stands. J. Wildl. Manage. 25(1):12-20.

Haapanen, Antti. 1965. Bird fauna of the Finnish forests in relation to forest succession. I. Ann. Zool. Fenn. 2(3):153-196.

Haapanen, Antti. 1966. Bird fauna of the Finnish forests in relation to forest succession. II. Ann. Zool. Fenn. 3(3): 176-200.

Haas, George Hartmann. 1974. Habitat selection, reproduction, and movements in female spruce grouse. Ph. D. thesis. 134 p. Univ. Minn., St. Paul.

Haecker, Fred W. 1948. A nesting study of the mountain bluebird in Wyoming. Condor 50(5):216-219.

Hähnle, Hermann. 1936. Das Schutzgebiet Behr-Steckby (Anhalt) des Reichsbundes für Vogelschutz. Württemberger Landesstelle für Naturschutz. Veröffentlichungen 12, p. 167-183. Stuttgart.

Hailman, Jack P. 1960. A field study of the mockingbird's wing-flashing behavior and its association with foraging. Wilson Bull. 72(4):346-357.

Hall, Claude H. 1977. Land owner objectives: Public lands; forest industry lands; other private lands. *In* Integration of forest resource management in the Blue Mountains, p. 19-20. John Herbst, ed. Oreg. State Univ. Ext. Serv. and Blue Mt. Chapter Soc. Am. For., Corvallis.

Hall, E. Raymond. 1951. American weasels. Kans. Univ. Mus. Nat. Hist. Publ. 4:1-466.

Hall, Eugene Raymond. 1946. Mammals of Nevada. 710 p. Univ. Calif. Press, Berkeley.

Hall, Eugene Raymond, and Keith R. Kelson. 1959. The mammals of North America. 2 vols. Ronald Press Co., New York.

Hall, Frederick C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. USDA For. Serv. Reg. 6 Area Guide 3-1, 62 p. Portland, Oreg.

Hall, Frederick C. 1978. Pacific Northwest ecoclass vegetation identification concepts and codes. USDA For. Serv. Reg. 6 Reg. Guide 1-3, 60 p. Portland, Oreg.

Hamas, Michael J. 1974. Human incursion and nesting sites of the belted kingfisher. Auk 91(4):835-836.

Hamilton, Terrell H. 1962. Species relationships and adaptations for sympatry in the avian genus *Vireo*. Condor 64(1): 40-68.

Hamilton, W. J., Jr. 1933. The weasels of New York: Their natural history and economic status. Am. Midl. Nat. 14(4): 289-344.

Hamilton, W. J., Jr. 1943. Nesting of the eastern bluebird. Auk 60(1):91-94.

Hannum, Gordon, Wayne Anderson, and Morlan Nelson. 1974. Birds of prey. Northwest Electr. Light and Power Eng. and Oper. Conf., April 22-23, 1974, Yakima, Wash., 21 p., typescript.

Hansen, Charles Goodman. 1956. An ecological survey of the vertebrate animals on Steen's Mountain, Harney County, Oregon. Ph. D. thesis. 199 p. Oreg. State Univ., Corvallis.

Hansen, Edward L., and Bernie E. Carter. 1963. A nesting study of Brewer's blackbirds in Klamath County, Oregon. Murrelet 44(2):18-21.

Hansen, R. M. 1972. Estimation of herbage intake from jackrabbit feces. J. Range Manage. 25(6):468-471.

Hansen, R. M., and R. F. Beck. 1968. Habitat of pocket gophers in Cochetopa Creek drainage, Colorado. Am. Midl. Nat. 79(1):103-117.

Hansen, Richard M. 1975. Plant matter in the diet of *Onychomys*. J. Mammal. 56(2):530-531.

Hanson, Harold Carsten. 1965. The giant Canada goose. 225 p. South. Ill. Univ. Press, Carbondale.

Hanson, Herbert Christian. 1962. Dictionary of ecology. 382 p. Philos. Libr., New York.

Hanson, W. C., and L. L. Eberhardt. 1971. A Columbia River Canada goose population, 1950-1970. Wildl. Monogr. 28, 61 p. Wildl. Soc., Washington, D.C.

Harcus, John Leslie. 1973. Song studies in the breeding biology of the catbird, *Dumetella carolinensis* (Aves: Mimidae). Ph. D. thesis. 329 p. Univ. Toronto, Toronto.

Harley, John Lake. 1969. The biology of mycorrhiza. 2d ed. 344 p. Leonard Hill, London.

Harper, James A. 1969. Relationship of elk to reforestation in the Pacific Northwest. *In* Wildlife and reforestation in the Pacific Northwest, p. 67-71. Hugh C. Black, ed. Sch. For., Oreg. State Univ., Corvallis.

Harris, J. A. 1970. Bat-guano cave environment. Science 169(3952):1342-1343.

Harvey, A. E., M. J. Larsen, and M. F. Jurgensen. 1976. Distribution of ectomycorrhizae in a mature Douglas-fir/larch forest soil in western Montana. For. Sci. 22(4):393-398.

Hasbrouck, Edwin M. 1944. Apparent status of the European widgeon in North America. Auk 6(1):93-104.

Haskell, Horace S., and Hudson G. Reynolds. 1947. Growth, developmental food requirements, and breeding activity of the California jack rabbit. J. Mammal. 28(2):129-136.

Hatt, R. T. 1943. The pine squirrel in Colorado. J. Mammal. 24(3):311-345.

Hatt, Robert T. 1929. The red squirrel: Its life history and habits, with special reference to the Adirondacks of New York and the Harvard Forest. Roosevelt Wild Life Ann. 2(1):11-146.

Hawbecker, Albert C. 1942. A life history study of the white-tailed kite. Condor 44(6):267-276.

Hawes, Myrnal Leong. 1975. Ecological adaptations in two species of shrews. Ph. D. thesis. 211 p. Univ. B. C., Vancouver.

Hawley, Ralph C., and David M. Smith. 1954. The Practice of silviculture. 6th ed. 525 p., illus. John Wiley & Sons, Inc., New York.

Hawley, Vernon D., and Fletcher E. Newby. 1957. Marten home ranges and population fluctuations. J. Mammal. 38(2):174-184.

Heath, A. G. 1975. Behavioral thermoregulation in high altitude tiger salamanders, *Ambystoma tigrinum*. Herpetologica 31(1):84-93.

Hebrand, James Jack. 1974. Habitat partitioning in two species of *Spizella* (Aves: Emberizidae): A concurrent laboratory and field study. Ph. D. thesis. 39 p. Clemson Univ., Clemson, S.C.

Hedin, Al, and Tom Turner. 1977. What is burned in a prescribed fire? Dep. Nat. Resour. Note 16, 7 p. Olympia, Wash.

Hedlund, J. D., D. T. McCullugh, and W. H. Rickard. 1975. Mouse populations on knob and kettle topography in south-central Washington. Northwest Sci. 49(4):253-260.

Hedrick, D. W., B. R. Eller, J. A. B. McArthur, and R. D. Pettit. 1969. Steer grazing on mixed coniferous forest ranges in northeastern Oregon. Range Manage. 22(5):322-325.

Hedrick, D. W., J. A. Young, J. A. B. McArthur, and R. F. Keniston. 1968. Effects of forest and grazing practices on mixed coniferous forests of northeastern Oregon. Oreg. Agric. Exp. Stn. Tech. Bull. 103, 24 p., illus. Oreg. State Univ., Corvallis.

Heidt, Gary A., Ann U. Shump, Karl A. Shump, Jr., and Richard J. Aulerich. 1976. A bibliography of mustelids, part IV: Weasels. Mich. Agric. Exp. Stn. 7662, 47 p. Mich. State Univ., East Lansing.

Helmer-Hirschberg, Olaf, and Nicholas Rescher. 1960. On the epistemology of the inexact sciences. Rand Rep. R-353. Rand Corp., Santa Monica, Calif.

Henny, Charles J. 1969. Geographical variation in mortality rates and production requirements of the barn owl (*Tyto alba* ssp.). Bird-Banding 40(4):277-356.

Henny, Charles J. 1972. An analysis of the population dynamics of selected avian species, with special reference to changes during the modern pesticide era. U.S. Dep. Inter., Fish and Wildl. Serv., Bur. Sport Fish. and Wildl. Res. Rep. 1, 99 p.

Henny, Charles J. 1977. Birds of prey, DDT, and tussock moths in the Pacific Northwest. *In* 42d North Am. Wildl. and Nat. Resour. Conf. Trans., p. 397-411. Wildl. Manage. Inst., Washington, D.C.

Hepting, George H. 1935. Decay following fire in young Mississippi Delta hardwoods. U.S. Dep. Agric. Tech. Bull. 494, 32 p.

Hepting, George H. 1971. Diseases of forest and shade trees of the United States. U.S. Dep. Agric. Agric. Handb. 386, 658 p.

Hepting, George H., and George G. Hedgcock. 1937. Decay in merchantable oak, yellow poplar, and basswood in the Appalachian region. U.S. Dep. Agric. Tech. Bull. 570, 30 p.

Herberg, M. 1965. Bird protection for control of injurious insects and its results. Anz. Schädlingsk. 38(9):137-142. (Summary in Rev. Appl. Entomol. 55: 497, 1967.)

Herman, Steven G. 1971. The functional and numerical responses of the Cassin finch, *Carpodacus cassinii* Baird, to epidemic numbers of the lodgepole needleminer, *Coleotechnites milleri* (Busck). Wasmann J. Biol. 29(1):71-80.

Hermann, Richard K. 1969. Animal damage problems and their relation to reforestation. *In* Wildlife and reforestation in the Pacific Northwest proceedings, p. 6-9. Hugh C. Black, ed. Oreg. State Univ., Corvallis.

Hershey, Terry J., and Thomas A. Leege. 1976. Influences of logging on elk on summer range in north-central Idaho. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 73-80. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Herzog, Harold A., Jr., and Gordon M. Burghardt. 1974. Prey movement and predatory behavior of juvenile western yellow-bellied racers, *Coluber constrictor mormon*. Herpetologica 30(3):285-289.

Hespenheide, Henry A. 1964. Competition and the genus *Tyrannus*. Wilson Bull. 76(3):265-281.

Hewitt, Oliver H., Ed. 1967. The wild turkey and its management. 589 p. Wildl. Soc., Washington, D.C.

Heydweiller, A. Marguerite. 1935. A comparison of winter and summer territories and seasonal variations of the tree sparrow (*Spizella arborea*). Bird-Banding 6(1):1-11.

Hibbs, L. Dale. 1966. A literature review on mountain goat ecology. Spec. Rep. 8, 23 p. Colo. Dep. Game, Fish, and Parks and Coop. Wildl. Res. Unit.

Hickey, Joseph J., Ed. 1969. Peregrine falcon populations: Their biology and decline. 596 p. Univ. Wis. Press, Madison.

Higgins, Kenneth F., and Leo M. Kirsh. 1975. Some aspects of the breeding biology of the upland sandpiper in North Dakota. Wilson Bull. 87(1):96-102.

Hill, Richard A. 1976. Host-parasite relationships of the brown-headed cowbird in a prairie habitat of west-central Kansas. Wilson Bull. 88(4):555-565.

Hinds, Thomas E., Frank G. Hawksworth, and Ross W. Davidson. 1965. Beetle-killed Engelmann spruce: Its deterioration in Colorado. J. For. 63(7):536-542.

ine, Ruth L., Betty L. Les, Bruce F. Hellmich, and Richard C. Vogt. 1975. Preliminary report on leopard frog (*Rana pipiens*) populations in Wisconsin. Dep. Nat. Resour. Res. Rep. 81, 31 p. Madison, Wis.

o, I., and J. M. Trappe. 1973. Translocation of C^{14} from *Festuca* plants to their endomycorrhizal fungi. Nature New Biol. 244(131):30-31.

ochbaum, Hans Albert. 1944. The canvasback on a prairie marsh. 201 p. Am. Wildl. Inst., Washington, D.C.

odgson, James R. 1972. Local distribution of *Microtus montanus* and *M. pennsylvanicus* in southwestern Montana. J. Mammal. 53(3):487-499.

ofslund, P. B. 1959. A life history study of the yellow throat, *Geothlypis trichas*. Minn. Acad. Sci. Proc. 27:144-174.

oglund, Nils H., and Erik Lansgren. 1968. The great grey owl and its prey in Sweden. Viltrevy (Swed. Wildl.) 5(7): 364-421.

öhn, E. Otto. 1967. Observations on the breeding biology of Wilson's phalarope. (*Steganopus tricolor*) in central Alberta. Auk 84(2):220-244.

öhn, E. Otto. 1971. Observations on the breeding behaviour of grey and red-necked phalaropes. Ibis 113(3):335-348.

olcomb, Larry C. 1969. Breeding biology of the American goldfinch in Ohio. Bird-Banding 40(1):26-44.

ollenbeck, Robert Rudolph. 1974. Growth rates and movements within a population of *Rana pretiosa pretiosa* Baird and Girard in south central Montana. Ph. D. thesis. 74 p. Mont. State Univ., Bozeman.

olm, Celia Haigh. 1973. Breeding sex ratios, territoriality, and reproductive success in the red-winged blackbird (*Agelaius phoeniceus*). Ecology 54(2): 356-365.

lood, R. E., and J. M. Inglis. 1974. Behavioral responses of white-tailed deer to intensive ranching operations. J. Wildl. Manage. 38(3):488-498.

Hooper, Robert G., and Hewlette S. Crawford. 1969. Woodland habitat research for nongame birds. 34th North Am. and Nat. Resour. Conf. Trans., p. 201-207. Wildl. Manage. Inst., Washington, D.C.

Hooven, E. F., R. F. Hoyer, and R. M. Storm. 1975. Notes on the vagrant shrew, *Sorex vagrans*, in the Willamette Valley of western Oregon. Northwest Sci. 49(3):163-173.

Hooven, Edward F. 1966. A test of Thiram on two rabbit-infested areas of Oregon. Tree Plant. Notes 79:1-3.

Hooven, Edward F. 1969. The influence of forest succession on populations of small animals in western Oregon. *In* Wildlife and reforestation in the Pacific Northwest: Symposium of September 1968, p. 30-34. Hugh C. Black, compiler and ed. Oreg. State Univ. Sch. For., Corvallis.

Hooven, Edward F. 1970. Animal damage to seed and seedlings. *In* Regeneration of ponderosa pine: Symposium proceedings, September 11-12, 1969, p. 36-39. R. K. Hermann, compiler and ed. Oreg. State Univ. Sch. For., Corvallis.

Hooven, Edward F. 1973. A wildlife brief for the clearcut logging of Douglas-fir. J. For. 71(4):210-214.

Hooven, Edward F. 1975. Baiting to reduce losses of conifer seeds to small forest mammals. For. Res. Lab., Sch. For. Res. Note 55, 3 p. Oreg. State Univ., Corvallis.

Hopkins, Brian. 1955. The species-area relations of plant communities. J. Ecol. 43(2):409-426.

Horak, Gerald Joseph. 1964. A comparative study of Virginia and sora rails with emphasis on foods. M.S. thesis. 73 p. Iowa State Univ., Ames.

Horn, Everett. E. 1923. Some notes concerning the breeding habits of *Thomomys townsendi*, observed near Vale, Malheur County, Oregon, during the spring of 1921. J. Mammal. 4(1):37-39.

Horn, Henry S. 1968. The adaptive significance of colonial nesting in the Brewer's blackbird (*Euphagus cyanocephalus*). Ecology 49(4):682-694.

Horn, Kirk M., and David B. Marshall. 1975. Status of poor-will in Oregon and possible extension due to clearcut timber harvest methods. Murrelet 56(1):4-5.

Hornocker, Maurice G. 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho primitive area. Wildl. Monogr. 21, 39 p.

Horvath, Otto. 1964. Seasonal differences in rufous hummingbird nest height and their relation to nest climate. Ecology 45(2):235-241.

Houston, Douglas B. 1963. A contribution to the ecology of the band-tailed pigeon, *Columba fasciata*, Say. M.A. thesis. 74 p. Univ. Wyo., Laramie.

Hout, Jerry L. 1967. Contribution toward a bibliography on brant. U.S. Dep. Inter., Fish and Wildl. Serv., Bur. Sport Fish. and Wildl. Spec. Sci. Rep. Wildl. 103, 15 p.

Howard, James O. 1973. Logging residue in Washington, Oregon, California: Volume and characteristics. USDA For. Serv. Resour. Bull. PNW-44, 26 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Howard, Walter E. 1959. The European starling in California. Calif. Dep. Agric. Bull. 48(3):171-179.

Hoyt, Sally F. 1957. The ecology of the pileated woodpecker. Ecology 38(2): 246-256.

Hubbard, John P. 1969. The relationships and evolution of the *Dendroica coronata* complex. Auk 86(3):393-432.

Hubert, Ernest E. 1955. Decay—a problem in the future management of grand fir. For. 53(6):409-411.

Humphrey, Stephen R., and Thomas H. Kunz. 1976. Ecology of a Pleistocene relict, the western big-eared bat (*Plecotus townsendii*), in the southern Great Plains. J. Mammal. 57(3):470-494.

Hylander, Clarence John. 1966. Wildlife communities from the tundra to the tropics in North America. 342 p. Houghton Mifflin Co., Boston, Mass.

Ingles, Lloyd G. 1939. Observations on a nest of the long-tailed weasel. J. Mammal. 20(2):253-254.

Ingles, Lloyd G. 1947. Ecology and life history of the California gray squirrel. Calif. Fish and Game 33(3):139-158.

Ingles, Lloyd G. 1960. A quantitative study of the activity of the dusky shrew (*Sorex vagrans obscurus*). Ecology 41(4):656-660.

Ingles, Lloyd G. 1961. Home range and habitats of the wandering shrew. J. Mammal. 42(4):455-462.

Ingram, Rod. 1973. Wolverine, fisher, and marten in central Oregon. Oreg. State Game Comm., Cent. Reg. Adm. Rep. No. 73-2, 39 p.

Irwin, L. L. 1976. Effects of intensive silviculture on big game forage resources in northern Idaho. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 135-142. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Jackman, Siri. 1974a. Some characteristics of cavity nesters: Can we ever leave enough snags? Oreg. Coop. Wildl. Res. Unit, Oreg. State Univ., Corvallis. 10 p.

Jackman, Siri M., and J. Michael Scott. 1975. Literature review of twenty three selected forest birds of the Pacific Northwest. 382 p. USDA For. Serv. Reg. 6, Portland, Oregon.

Jackman, Siri Marion. 1974b. Woodpeckers of the Pacific Northwest; their characteristics and their role in the forests. M.S. thesis. 147 p. Oreg. State Univ., Corvallis.

Jackson, Hartley Harrad Thompson. 1961. Mammals of Wisconsin. 504 p. Univ. Wis. Press, Madison.

Jackson, Jerome A. 1970. A quantitative study of the foraging ecology of downy woodpeckers. Ecology 51(2):318-323.

Jackson, Jerome A. 1977. Red-cockaded woodpeckers and pine red heart disease. Auk 94(1):160-163.

Jahn, Laurence Roy. 1965. Duck and coot ecology and management in Wisconsin. Ph. D. thesis. 856 p. Univ. Wis., Madison.

James, Frances C., and H. H. Shugart, Jr. 1974. The phenology of the nesting season of the American robin (*Turdus migratorius*) in the United States. Condor 76(2):159-168.

James, Ross D. 1976. Foraging behavior and habitat selection of three species of vireos in southern Ontario. Wilson Bull. 88(1):62-75.

James, Ross David. 1973. Ethological and ecological relationships of the yellow-throated and solitary vireos (Aves: Vireonidae) in Ontario. Ph. D. thesis. 274 p. Univ. Toronto, Toronto.

James, Ted R., and Robert W. Seabloom. 1969a. Reproductive biology of the white-tailed jack rabbit in North Dakota. J. Wildl. Manage. 33(3):558-568.

James, Ted R., and Robert W. Seabloom. 1969b. Aspects of growth in the white-tailed jack rabbit. N. D. Acad. Sci. Proc. 23:7-14.

Jameson, David L. 1956. Growth, dispersal and survival of the Pacific tree frog. Copeia 1956(1):25-29.

Jameson, David L., William Taylor, and John Mountjoy. 1970. Metabolic and morphological adaptation to heterogenous environments by the Pacific tree toad, *Hyla regilla*. Evolution 24(1): 75-89.

Jenny, Hans, S. P. Gessel, and F. T. Bingham. 1949. Comparative study of decomposition rates of organic matter in temperate and tropical regions. Soil Sci. 68(6):419-432.

Jensen, G. Hortin. 1949. Migration of the gadwall. *In* Migration of some North American waterfowl. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.—Wildlife 1:9-10.

Jewett, Stanley G. 1946. A Ross goose taken in Wallowa County, Oregon. Condor 48(4):181.

Jewett, Stanley G. 1949. The Franklin gull in Oregon. Condor 51(4):189-190.

Jewett, Stanley G. 1954. The white-winged crossbill in the Cascade Mountains of Oregon. Condor 56(3):165.

Jewett, Stanley G., and Harold W. Dobyns. 1929. The Virginia opossum in Oregon. J. Mammal. 10(4):351.

Johns, J. E. 1969. Field studies of Wilson's phalarope. Auk 86(4):660-670.

Johnson, Charles Eugene. 1925. The muskrat in New York: Its natural history and economics. Roosevelt Wild Life Bull. 3(2):205-320. Syracuse Univ., N. Y. State Coll. For. Roosevelt Wild Life For. Exp. Stn.

Johnson, Charles Eugene. 1927. The beaver in the Adirondacks: Its economics and natural history. Roosevelt Wild Life Bull. 4(4):501-641. Syracuse Univ. N. Y. State Coll. For. Roosevelt Wild Life For. Exp. Stn.

Johnson, Donald E. 1951. The biology of the elk calf, *Cervus canadensis nelsoni*. J. Wildl. Manage. 15(4):396-410.

Johnson, Donald R. 1967. Diet and reproduction of Colorado pikas. J. Mammal. 48(2):311-315.

Johnson, Murray L., and C. Wesley Clanton. 1954. Natural history of *Sorex merriami* in Washington State. Murrelet 35(1):1-4.

Johnson, Murray L., C. Wesley Clanton, and John Girard. 1948. The sagebrush vole in Washington State. Murrelet 29(3):44-47.

Johnson, Murray L., and Burton T. Ostenson. 1959. Comments on the nomenclature of some mammals of the Pacific Northwest. J. Mammal. 40(4):571-577.

Johnson, Ned K. 1963. Biosystematics of sibling species of flycatchers in the *Empidonax hammondii-oberholseri-wrightii* complex. Univ. Calif. Publ. Zool. 66(2):79-238. Berkeley.

Johnson, Ned K. 1966. Bill size and the question of competition in allopatric and sympatric populations of dusky and gray flycatchers. Syst. Zool. 15(1): 70-87.

Johnson, Richard E. 1977. An historical analysis of wolverine abundance and distribution in Washington. Murrelet 58(1):13-16.

Johnson, Robert Holm. 1939. Life history and management studies of raccoons in Maine. M.S. thesis. 67 p. Univ. Maine, Orono.

Johnson, Rolf L. 1974. Bighorn sheep, 1973: A biological evaluation of the Tucannon bighorn with notes on other Washington sheep. 69 p. Wash. Dep. Game, Olympia.

Johnson, Wendel J., and John A. Coble. 1967. Notes on the food habits of pigeon hawks. Jack-Pine Warbler 45(3): 97-98.

Jones, Clyde. 1965. Ecological distribution and activity periods of bats of the Mogollon Mountains area of New Mexico and adjacent Arizona. Tulane Stud. Zool. 12(4):93-100.

Jones, Gwilym S., John O. Whitaker, Jr., and Chris Maser. 1978. Food habits of jumping mice (*Zapus trinotatus* and *Z. princeps*) in western North America. Northwest Sci. 52(1):57-60.

Jones, J. C. 1940. Food habits of the American coot with notes on distribution. U.S. Dep. Inter. Biol. Surv. Bur. Wildl. Res. Bull. 2, 52 p.

Jonkel, Charles J., and Ian McT. Cowan. 1971. The black bear in the spruce-fir forest. Wildl. Mongr. 27, 57 p.

Jonkel, Charles Joseph. 1959. Ecological and physiological study of the pine marten. M.S. thesis. 81 p. Mont. State Univ., Missoula.

Julander, Odell. 1966. How mule deer use mountain rangeland in Utah. Utah Acad. Sci., Arts, and Lett. Proc. 43(2): 22-28.

Julander, Odell, W. Leslie Robinette, and Dale A. Jones. 1961. Relation of summer range condition to mule deer herd productivity. J. Wildl. Manage. 25(1):54-60.

Kawamichi, Takeo. 1976. Hay territory and dominance rank of pikas (*Ochotona princeps*). J. Mammal. 57(1):133-148.

Kebbe, Chester E. 1958. Nesting records of the red-necked grebe in Oregon. Murrelet 39(1):14.

Kebbe, Chester E. 1959. Nesting records of saw-whet owls in Oregon. Murrelet 40(2):21.

Keen, F. P. 1929. How soon do yellow pine snags fall? J. For. 27(6):735-737.

Keen, F. P. 1955. The rate of natural falling of beetle-killed ponderosa pine snags. J. For. 53(10):720-723.

Keith, John Anthony. 1966. Reproduction in a population of herring gulls (*Larus argentatus*) contaminated by DDT. M.S. thesis. 31 p. Univ. Wis., Madison.

Keith, Lloyd B., and Dennis C. Surrendi. 1971. Effects of fire on a snowshoe hare population. J. Wildl. Manage. 35(1):16-26.

Kelker, George Hills. 1964. Appraisal of ideas advanced by Aldo Leopold thirty years ago. J. Wildl. Manage. 28(1):180-185.

Kelleher, Kevin Edmond. 1963. A study of hole nesting avifauna of southwestern British Columbia. M.S. thesis. 169 p. Univ. B. C., Vancouver.

Kelly, Warren, Richard Hubbell, Steve Loe, and Lisa Shikany. 1975. Management of riparian habitats: Coordination guidelines for wildlife habitats, number 9. USDA For. Serv. Calif. Reg., 9 p.

Kempton, Russell Marshall. 1927. Notes on the home life of the turkey vulture. Wilson Bull. 39(3):142-145.

Kendeigh, S. Charles. 1941. Territorial and mating behavior of the house wren. Ill. Biol. Monogr. 18(3), 120 p.

Kendeigh, S. Charles. 1947. Bird population studies in the coniferous forest biome during a spruce budworm outbreak. Biol. Bull. 1, 100 p. Ont. Dep. Lands and For., Div. Biol. Res., Ontario.

Kendeigh, S. Charles, Chairman. 1973. A symposium on the house sparrow (*Passer domesticus*) and European tree sparrow (*P. montanus*) in North America. Ornithol. Monogr. 14, 121 p. Am. Ornithol. Union. [Anchorage, Ky.]

Kerbes, R. H. 1975. The nesting population of lesser snow geese in the eastern Canadian arctic: A photographic inventory of June 1973. Can. Wildl. Serv. Rep. Ser. 35, 47 p. Ottawa.

Kessel, Brina. 1976. Winter activity patterns of black-capped chickadees in interior Alaska. Wilson Bull. 88(1):36-61.

Kilham, Lawrence. 1954. Territorial behaviour of red squirrel. J. Mammal. 35(2):252-253.

Kilham, Lawrence. 1968a. Reproductive behavior of hairy woodpeckers: II. Nesting and habitat. Wilson Bull. 80(3):286-305.

Kilham, Lawrence. 1968b. Reproductive behavior of white-breasted nuthatches: I. Distraction display, bill-sweeping, and nest hole defense. Auk 85(3):477-492.

Kilham, Lawrence. 1971a. Roosting habits of white-breasted nuthatches. Condor 73(1):113-114.

Kilham, Lawrence. 1971b. Reproductive behavior of yellow-bellied sapsuckers: I. Preference for nesting in *Fomes*-infected aspens and nest hole interrelations with flying squirrels, raccoons, and other animals. Wilson Bull. 83(2):159-171.

Kilham, Lawrence. 1972. Reproductive behavior of white-breasted nuthatches: II. Courtship. Auk 89(1):115-129.

Kilham, Lawrence. 1973. Reproductive behavior of the red-breasted nuthatch: I. Courtship. Auk 90(3)597-609.

Kilham, Lawrence. 1974. Biology of young belted kingfishers. Am. Midl. Nat. 92(1):245-247.

Kimmey, J. W., and R. L. Furniss. 1943. Deterioration of fire-killed Douglas-fir. U.S. Dep. Agric. Tech. Bull. 851, 61 p. Washington, D.C.

Kindschy, Robert R., Jr. 1964. Ecological studies on the rock dove in southeastern Oregon. Northwest Sci. 38(4):138-140.

King, James R. 1955. Notes on the life history of Traill's flycatcher (*Empidonax traillii*) in southeastern Washington. Auk 72(2):148-173.

King, James R., and Eugene E. Wales, Jr. 1964. Observations on migration, ecology, and population flux of wintering rosy finches. Condor 66(1):24-31.

King, John Arthur, Ed. 1968. Biology of *Peromyscus* (Rodentia). Am. Soc. Mammal. Spec. Publ. 2, 593 p. Stillwater, Okla.

King, Ralph T. 1966. Wildlife and man. N. Y. State Conserv. 20(6):8-11.

Kirby, Ronald E. 1976. Breeding chronology and interspecific relations of pied-billed grebes in northern Minnesota. Wilson Bull. 88(3):493-495.

Kirsch, John B., and K. R. Greer. 1968. Bibliography: Wapiti-American elk and European red deer. Mont. Fish and Game Dep. Spec. Rep. 2, 147 p.

Kirsch, John Ballard. 1962. Range use, relationship to logging, and food habits of the elk in the Little Belt Mountains, Montana. M.S. thesis. 44 p. Mont. State Coll., Bozeman.

Kitchen, David Wayne. 1968. Brood habitat selection of the hooded merganser (*Lophodytes cucullatus*) in northeastern Wisconsin. M.S. thesis. 80 p. Univ. Mich., Ann Arbor.

Klauber, Lawrence Monroe. 1972. Rattlesnakes: Their habits, life histories, and influence on mankind. 2d ed. 2 vols., 1,533 p. Univ. Calif. Press, Berkeley.

Klimstra, W. D., and John L. Roseberry. 1975. Nesting ecology of the bobwhite in southern Illinois. Wildl. Monogr. 41, 37 p. Wildl. Soc., Washington, D.C.

Klock, Glen O., Arthur R. Tiedemann, and William Lopushinsky. 1975. Seeding recommendations for disturbed mountain slopes in north central Washington. USDA For. Serv. Res. Note PNW-244, 8 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Klopfer, Peter H. 1965. Behavioral aspects of habitat selection: A preliminary report on stereotypy in foliage preferences of birds. Wilson Bull. 77(4):376-381.

Klugh, A. Brooker. 1927. Ecology of the red squirrel. J. Mammal. 8(1):1-32.

Kluyver, H. N. 1961. Food consumption in relation to habitat in breeding chickadees. Auk 78(4):532-550.

Knapton, Richard W., and John R. Krebs. 1974. Settlement patterns, territory size, and breeding density in the song sparrow (*Melospiza melodia*). Can. J. Zool. 52(11):1413-1420.

Knight, F. B. 1958. The effects of woodpeckers on populations of the Engelmann spruce beetle. J. Econ. Entomol. 51(5):603-607.

Knight, Richard R. 1970. The Sun River elk herd. Wildl. Monogr. 23, 66 p.

Knorr, Owen A. 1957. Communal roosting of the pygmy nuthatch. Condor 59(6):398.

Knowlton, Frederick F. 1972. Preliminary interpretations of coyote population mechanics with some management implications. J. Wildl. Manage. 36(2): 369-382.

Koehler, Gary M., William R. Moore, and Alan R. Taylor. 1975. Preserving the pine marten: Management guidelines for western forests. West. Wildlands 2(3):31-36.

Koplin, James R. 1969. The numerical response of woodpeckers to insect prey in a subalpine forest in Colorado. Condor 71(4):436-438.

Kothmann, M. M., Ed. 1974. A glossary of terms used in range management. 2d ed. 36 p. Soc. Range Manage., Denver, Colo.

Krasnowski, Paul Vincent. 1969. Aspects of red squirrel (*Tamiasciurus hudsonicus*) population ecology in interior Alaska. M.S. thesis. 77 p. Univ. Alaska, Fairbanks.

Krauch, Hermann. 1945. Influence of rodents on natural regeneration of Douglas Fir in the Southwest. J. For. 43(8):585-589.

Krear, Harry Robert. 1965. An ecological and ethological study of the pika (*Ochotona princeps saxatilis* Bangs) in the Front Range of Colorado. Ph. D. thesis. 352 p. Univ. Colo., Boulder.

Krebs, John R. 1974. Colonial nesting and social feeding as strategies for exploiting food resources in the great blue heron (*Ardea herodias*). Behaviour 51(1-2):99-134.

Kroodsma, Donald E. 1973. Coexistence of Bewick's wrens and house wrens in Oregon. Auk 90(2):341-352.

Kroodsma, Donald E. 1975. Song patterning in the rock wren. Condor 77(3): 294-303.

Kroodsma, Roger L. 1974. Species-recognition behavior of territorial male rose-breasted and black-headed grosbeaks (*Pheucticus*). Auk 91(1):54-64.

Krutzsch, Philip H. 1954. Notes on the habits of the bat, *Myotis californicus*. J. Mammal. 35(4):539-545.

Küchler, A. W. 1964. Manual to accompany the map, potential natural vegetation of the conterminous United States. Am. Geogr. Soc. Spec. Publ. 36. [152 p., 2d ed. Map, 1975.] New York.

Küchler, A. W. 1970. Potential natural vegetation. [Map, 1966.] *In* The national atlas of the United States of America, p. 90-91. U.S. Dep. Inter., Geol. Surv., Washington, D.C.

Kuerzi, Richard Gottron. 1940-41. Life history studies of the tree swallow. Linn. Soc. N. Y. Proc. 52-53, p. 1-52.

Lack, David. 1933. Habitat selection in birds, with special reference to the effects of afforestation on the Breckland avifauna. J. Anim. Ecol. 2(2):239-262.

Lack, David. 1945. The ecology of closely related species with special reference to cormorant (*Phalacrocorax carbo*) and shag (*P. aristotelis*). J. Anim. Ecol. 14(1):12-16.

Lahnum, Willard H. 1944. A study of the mountain quail with suggestions for management in Oregon. Ph. D. diss. 127 p. Oreg. State Coll., Corvallis.

Lanyon, Wesley E. 1956. Territory in the meadowlarks, genus *Sturnella*. Ibis 98(3):485-489.

Lanyon, Wesley E. 1957. The comparative biology of the meadowlarks (*Sturnella*) in Wisconsin. Nuttall Ornithol. Club 1, 67 p. Cambridge, Mass.

Larrison, Earl J. 1943. Feral coypus in the Pacific Northwest. Murrelet 24(1): 3-9.

Larsen, Kenneth H., and John H. Dietrich. 1970. Reduction of a raven population on lambing grounds with DRC-1339. J. Wildl. Manage. 34(1):200-204.

Laun, Charles H. 1957. A life history study of the mountain plover, *Eupoda montana*, Townsend, on the Laramie Plains, Albany County, Wyoming. M.S. thesis. 71 p. Univ. Wyo., Laramie.

Lavers, Norman. 1975. The status of the gray flycatcher in Washington State. West. Birds 6(1):25-27.

Lawrence, George Edwin. 1950. The diving and feeding activity of the western grebe on the breeding grounds. Condor 52(1):3-16.

Lawrence, Louise de Kiriline. 1948. Comparative study of the nesting behavior of chestnut-sided and Nashville warblers. Auk 65(2):204-219.

Lawrence, Louise de Kiriline. 1953. Nesting life and behaviour of the red-eyed vireo. Can. Field Nat. 67(2):47-77.

Lawrence, Louise de Kiriline. 1967. A comparative life-history study of four species of woodpeckers. Ornithol. Monogr. 5, 156 p. Am. Ornithol. Union, Anchorage, Ky.

Lay, David W. 1942. Ecology of the opossum in eastern Texas. J. Mammal. 23(2):147-159.

Lechleitner, R. R. 1969. Wild mammals of Colorado: Their appearance, habits, distribution, and abundance. 254 p. Pruett Publ. Co., Boulder, Colo.

Lederer, Roger J. 1977a. Winter feeding territories in the Townsend's solitaire. Bird-Banding 48(1):11-18.

Lederer, Roger J. 1977b. Winter territoriality and foraging behavior of the Townsend's solitaire. Am. Midl. Nat. 97(1):101-109.

Leege, Thomas A. 1976. Relationship of logging to decline of the Pete King elk herd. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 6-10. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Legler, John M. 1954. Nesting habits of the western painted turtle, *Chrysemys picta belli* (Gray). Herpetologica 10(3): 137-144.

Lemon, Robert E. 1971. Analysis of song of red-eyed vireos. Can. J. Zool. 49(6): 847-854.

Lenington, Sarah, and Terry Mace. 1975. Mate fidelity and nesting site tenacity in the killdeer. Auk 92(1):149-151.

Leopold, Aldo. 1933. Game management. 481 p. Charles Scribner Sons, New York.

Leopold, Aldo. 1949. A Sand County almanac, and sketches here and there. 226 p. Oxford Univ. Press, New York.

Lewis, Robert A. 1975. Reproductive biology of the white-crowned sparrow. II. Environmental control of reproductive and associated cycles. Condor 77(2): 111-124.

Licht, Lawrence E. 1975. Comparative life history features of the western spotted frog, *Rana pretiosa*, from low- and high-elevation populations. Can. J. Zool. 53(9):1254-1257.

Lies, Michael F., and William H. Behle. 1966. Status of the white pelican in the United States and Canada through 1964. Condor 68(3):279-292.

Ligon, J. David. 1970. Behavior and breeding biology of the red-cockaded woodpecker. Auk 87(2):255-278.

Ligon, J. David. 1973. Foraging behavior of the white-headed woodpecker in Idaho. Auk 90(4):862-869.

Ligon, J. David., and Dennis J. Martin. 1974. Piñon seed assessment by the piñon jay, *Gymnorhinus cyanocephalus*. Anim. Behav. 22(2):421-429.

Lillywhite, Harvey B., Paul Licht, and Pamela Chelgren. 1973. The role of behavioral thermoregulation in the growth energetics of the toad, *Bufo boreas*. Ecology 54(2):375-383.

Lind, Gordon S. 1976. Production, nest site selection, and food habits of ospreys on Deschutes National Forest, Oregon. M.S. thesis. 64 p. Oreg. State Univ., Corvallis.

Lindsay, Stephen L., and Alfred E. Perry. 1977. An additional Merriam's shrew (*Sorex m. merriami*) specimen from Oregon. Murrelet 58(1):17.

Lindzey, Frederick G. 1976. Characteristics of the natal den of the badger. Northwest Sci. 50(3):178-180.

Lindzey, Frederick G., and E. Charles Meslow. 1976. Characteristics of black bear dens on Long Island, Washington. Northwest Sci. 50(4):236-242.

Linsdale, Jean Myron, and P. Quentin Tomich. 1953. A herd of mule deer: A record of observations made on the Hastings Natural History Reservation. 567 p. Univ. Calif. Press., Berkeley.

Lloyd, J. D., Jr. 1973-78a. Oregon timber harvest. USDA For. Serv. Resour. Bull. PNW-49, PNW-55, PNW-63 (rev.), PNW-69, and PNW-78. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Lloyd, J. D., Jr. 1973-78b. Washington timber harvest. USDA For. Serv. Resour. Bull. PNW-48, PNW-61, PNW-68, PNW-71, and PNW-81. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Lloyd, J. D., Jr. [n.d.] Unpublished timber inventories for counties in Oregon and Washington, 1964 and 1968; on file at Renewable Resources Evaluation Work Unit, Pac. Northwest For. and Range Exp. Stn., P.O. Box 3141, Portland, Oreg. 97208.

Lloyd, James A. 1975. Social structure and reproduction in two freely-growing populations of house mice (*Mus musculus* L.). Anim. Behav. 23(2):413-424.

Lokemoen, John Theodore. 1962. The productivity of the redhead (*Aythya americana*) in the Flathead Valley, Montana. M.S. thesis. 120 p. Univ. Mont., Missoula.

Loveless, Charles M. 1964. Some relationships between wintering mule deer and the physical environment. North Am. Wildl. Nat. Resour. Conf. Trans. 29: 415-431.

Low, Jessop B. 1945. Ecology and management of the redhead, *Nyroca americana*, in Iowa. Ecol. Monogr. 15(1):35-69.

Lunk, William A. 1962. The rough-winged swallow *Stelgidopteryx ruficollis* (Vieillot): A study based on its breeding biology in Michigan. Nuttall Ornithol. Club Publ. 4, 155 p. Cambridge, Mass.

Luttich, Stuart, Donald H. Rusch, E. Charles Meslow, and Lloyd B. Keith. 1970. Ecology of red-tailed hawk predation in Alberta. Ecology 51(2):190-203.

Lyon, L. Jack. 1975. Conduct annual pellet count surveys to describe elk distribution patterns within the Burdette Creek-Deer Creek area, Job II-A, Procedure B-1. *In* Montana cooperative elk-logging study, progress report for the period Jan. 1-Dec. 31, 1974. Reg. 1, USDA For. Serv.; Intermt. For. and Range Exp. Stn.; Mont. Dep. Fish and Game; Bur. Land Manage.; Sch. For., Univ. Mont.

Lyon, L. Jack. 1976. Elk use as related to characteristics of clearcuts in western Montana. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 69-72. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Lyon, L. Jack. 1977. Attrition of lodgepole pine snags on the Sleeping Child burn, Montana. USDA For. Serv. Res. Note INT-219, 4 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

McAllister, Nancy Mahoney. 1955. Reproductive behavior of the eared grebe, *Podiceps caspicus nigricollis*. M.S. thesis. 68 p. Univ. B. C., Vancouver.

McAllister, Nancy Mahoney. 1964. Ontogeny of behaviour in five species of grebes. Ph. D. thesis. 135 p. Univ. B. C., Vancouver.

MacArthur, Robert H., John W. MacArthur, and James Preer. 1962. On bird species diversity: II. Prediction of bird census from habitat measurements. Am. Natur. 96(888):167-174.

MacArthur, Robert H., and Edward O. Wilson. 1967. The theory of island biogeography. 203 p. Princeton Univ. Press, Princeton, N.J.

McAtee, W. L. 1915. Bird enemies of forest insects. Am. For. 21(6):681-691.

McAtee, Waldo Lee. 1911. Woodpeckers in relation to trees and wood products. USDA Biol. Surv. Bull. 39, 99 p.

McAtee, Waldo Lee. 1926. The role of vertebrates in the control of insect pests. *In* Annual report of the Board of Regents of the Smithsonian Institute, 1925, p. 415-437. Gov. Print. Off., Washington, D.C.

McCambridge, William F., and Fred B. Knight. 1972. Factors affecting spruce beetles during a small outbreak. Ecology 53(5):830-839.

McClelland, Bernard Riley. 1975. Effectiveness of brown creeper's concealment behavior. West. Birds 6(1):24.

McClelland, Bernard Riley. 1977. Relationships between hole-nesting birds, forest snags and decay in western larch-Douglas-fir forests of the northern Rocky Mountains. Ph. D. thesis. 498 p. Univ. Mont., Missoula.

McClelland, Bernard Riley, and Sidney S. Frissell. 1975. Identifying forest snags useful for hole-nesting birds. J. For. 73(7):414-417.

McConnell, Burt R., and Justin G. Smith. 1965. Understory response three years after thinning pine. J. Range Manage. 18(3):129-132.

McConnell, Burt R., and Justin G. Smith. 1970. Response of understory vegetation to ponderosa pine thinnings in eastern Washington. J. Range Manage. 23(3):208-212.

McEwan, E. H., and P. E. Whitehead. 1970. Seasonal changes in the energy and nitrogen intake of reindeer and caribou. Can. J. Zool. 48(5):905-913.

McFee, W. W., and E. L. Stone. 1966. The persistence of decaying wood in the humus layers of northern forests. Soil. Sci. Soc. Am. Proc. 30(4):513-516.

McGowan, Jerry D. 1975. Distribution, density and productivity of goshawks in interior Alaska. Final Rep., Fed. Aid Wildl. Restor. Proj. W-17-3, W-17-4, W-17-5, and W-17-6, 59 p. Alaska Dep. Fish and Game, Juneau.

McIntyre, Judith W. 1974. Territorial affinity of a common loon. Bird-Banding 45(2):178.

McKeever, Sturgis. 1960. Food of the northern flying squirrel in northeastern California. J. Mammal. 41(2):270-271.

McKinney, Theodore Duane. 1966. Survival, distribution and reproduction of an introduced gray partridge population. M.S. thesis. 55 p. Colo. State Univ., Fort Collins.

McLaren, William David. 1962. A preliminary study of nest site competition in a group of hole nesting birds. M.S. thesis. 57 p. Univ. B. C., Vancouver.

MacMillan, P., J. Means, G. M. Hawk, K. Cromack, Jr., and R. Fogel. 1977. Log decomposition in an old-growth Douglas-fir forest. Northwest Sci. Assoc. Program and Abstr. of the papers scheduled for presentation at the 50th Annu. Meet., p. 13.

MacMillan, Paul C., Joseph Means, Kermit Cromack, Jr., and Glenn M. Hawk. [n.d.] Unpublished data on file at Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, Oreg. 97331. Used with permission.

McNicholl, Martin Keli. 1971. The breeding biology and ecology of Forster's tern (*Sterna forsteri*) at Delta, Manitoba. M.S. thesis. 652 p. Univ. Manitoba, Winnipeg.

Mackie, Richard J. 1970. Range ecology and relations of mule deer, elk, and cattle in the Missouri River Breaks, Montana. Wildl. Monogr. 20, 79 p.

Mackie, Richard John. 1960. The natural annual cycle of reproduction in chuckar partridge of southeastern Washington. M.S. thesis. 110 p. Wash. State Univ., Pullman.

Manuwal, David A. 1970. Notes on the territoriality of Hammond's flycatcher (*Empidonax hammondi*) in western Montana. Condor 72(3):364-365.

Marcellini, Dale, and James P. Mackey. 1970. Habitat preferences of the lizards, *Sceloporus occidentalis* and *S. graciosus* (Lacertilia, Iguanidae). Herpetologica 26(1):51-56.

March, James Robert. 1967. Dominance relations and territorial behavior of captive shovelers, *Anas clypeata*. M.S. thesis. 47 p. Univ. Minn., Minneapolis.

Marcum, C. Les. 1975. Summer-fall habitat selection and use by a western Montana elk herd. Ph. D. diss. 203 p. Univ. Montana, Missoula.

Marcum, C. Les. 1976. Habitat selection and use during summer and fall months by a western Montana elk herd. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 91-96. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Marcuson, Patrick E. [1977.] The effect of cattle grazing on brown trout in Rock Creek, Montana. Spec. Rep., Proj. F-20-R-21, Job 2-a, 26 p. Mont. Dep. Fish and Game, Fish. Div.

Margalef, Ramón. 1969. Diversity and stability: A practical proposal and a model of interdependence. *In* Diversity and stability in ecological systems. Brookhaven Symp. Biol. 22, p. 25-37. Brookhaven Natl. Lab., Upton, N.Y.

Marks, G. C., and T. T. Kozlowski, Eds. 1973. Ectomycorrhizae: Their ecology and physiology. 444 p. Acad. Press, New York.

Marshall, David B. 1969. Endangered plants and animals of Oregon: III. Birds. Agric. Exp. Stn. Spec. Rep. 278, 23 p. Oreg. State Univ., Corvallis.

Marshall, David B., and Harold F. Duebbert. 1965. Nesting of the ring-necked duck in Oregon in 1963 and 1964. Murrelet 46(3):43.

Marshall, Joe R., Jr. 1939. Territorial behavior of the flammulated screech owl. Condor 41(2):71-78.

Marti, Carl D. 1974. Feeding ecology of four sympatric owls. Condor 76(1):45-61.

Marti, Carl D., and Clait E. Braun. 1975. Use of tundra habitats by prairie falcons in Colorado. Condor 77(2):213-214.

Martin, Alexander C., Herbert S. Zim, and Arnold L. Nelson. 1951. American wildlife & plants: A guide to wildlife food habits; the use of trees, shrubs, weeds, and herbs by birds and mammals of the United States. 500 p. McGraw-Hill Book Co., New York.

Martin, Fant W. 1963. Behavior and survival of Canada geese in Utah. Ph. D. diss. 98 p. Utah State Univ., Logan.

Martin, R. E. [1976.] Prescribed burning for site preparation in the inland Northwest. *In* Tree planting in the inland Northwest, p. 134-156. David M. Baumgartner and Raymond J. Boyd, eds. Wash. State Univ. Coop. Ext. Serv. [Pullman.]

Martin, Robert E., Hal E. Anderson, William D. Boyer, and others. [n.d.] Effects of fire of fuels: State-of-the-knowledge report. 224 p. Unpubl. data, Silviculture Lab., USDA For. Serv., Bend, Oreg.

Martin, Robert E., and John D. Dell. 1978. Planning for prescribed burning in the inland Northwest. USDA For. Serv. Gen. Tech. Rep. PNW-76, 67 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Martin, Stephen G. 1970. The agonistic behavior of varied thrushes (*Ixoreus naevius*) in winter assemblages. Condor 72(4):452-459.

Martin, Stephen G. 1974. Adaptations for polygynous breeding in the bobolink, *Dolichonyx oryzivorus*. Am. Zool. 14(1): 109-119.

Martin, Wm. F., and R. B. Huey. 1971. The function of the epiglottis in sound production (hissing) of *Pituophis melanoleucus*. Copeia 1971(4):752-754.

Marx, Donald H. 1973. Mycorrhizae and feeder root diseases. *In* Ectomycorrhizae: Their ecology and physiology. G. C. Marks and T. T. Kozlowski, eds. p. 351-382. Acad. Press, New York.

Maser, Chris, and Jerry F. Franklin. 1974. Checklist of vertebrate animals of the Cascade Head Experimental Forest. USDA For. Serv. Resour. Bull. PNW-51, 32 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Maser, Chris, and Jay S. Gashwiler. 1978. Interrelationships of wildlife and western juniper. *In* Proceedings of the western juniper ecology and management workshop. USDA For. Serv. Gen. Tech. Rep. PNW-74, p. 37-82. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Maser, Chris, E. Wayne Hammer, and Stanley H. Anderson. 1970. Comparative food habits of three owl species in central Oregon. Murrelet 51(3):29-33.

Maser, Chris, E. Wayne Hammer, and Stanley H. Anderson. 1971. Food habits of the burrowing owl in central Oregon. Northwest Sci. 45(1):19-26.

Maser, Chris, E. Wayne Hammer, Cheri Brown, Robert E. Lewis, Robert L. Rausch, and Murray L. Johnson. 1974. The sage vole, *Lagurus curtatus* (Cope, 1868), in the Crooked River National Grassland, Jefferson County, Oregon. A contribution to its life history and ecology. Säugetierkd. Mitt. 22(3):193-222.

Maser, Chris, and Robert M. Storm. 1970. A key to microtinae of the Pacific Northwest (Oregon, Washington, Idaho). 162 p. Oreg. State Univ. Book Stores, Inc., Corvallis.

Maser, Chris, James M. Trappe, and Ronald A. Nussbaum. 1978. Fungal-small mammal interrelationships with emphasis on Oregon coniferous forests. Ecology 59(6):799-809.

Maser, Chris. [n.d.] Unpublished data on file at Puget Sound Museum of Natural History, University of Puget Sound, Tacoma, Wash. 98416. Used with permission.

Mason, C. F., and S. M. Macdonald. 1976. Aspects of the breeding biology of the snipe. Bird Study 23(1):33-38.

Mason, Edwin A. 1953. Barn swallow life history data based on banding records. Bird-Banding 24(3):91-100.

Mason, Georgia. 1975. Guide to the plants of the Wallowa Mountains of northeastern Oregon. Mus. Nat. Hist. Spec. Publ., 411 p. Univ. Oregon, Eugene.

Massey, Calvin L., and Noel D. Wygant. 1973. Woodpeckers: Most important predators of the spruce beetle. Colo. Field Ornithol. 16, p. 4-8.

Mathwig, Herbert J. 1973. Food and population characteristics of Iowa coyotes. Iowa State J. Res. 47(3):167-189.

Mattson, William J., Fred B. Knight, Douglas C. Allen, and John L. Foltz. 1968. Vertebrate predation on the jack-pine budworm in Michigan. J. Econ. Entomol. 61(1):229-234.

Maxwell, George Ralph, II. 1965. Life history of the common grackle, *Quiscalus quiscala* (Linnaeus). Ph. D. diss. 232 p. Ohio State Univ., Columbus.

Mech, L. David, and L. D. Frenzel, Jr., Eds. 1971. Ecological studies of the timber wolf in northeastern Minnesota. USDA For. Serv. Res. Pap. NC-52, 62 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Meehan, William R. 1970. Some effects of shade cover on stream temperature in southeast Alaska. USDA For. Serv. Res. Note PNW-113, 9 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Melin, Elias, and Harold Nilsson. 1957. Transport of C^{14}-labelled photosynthate to the fungal associate of pine mycorrhiza. Sven. Bot. Tidskr., Sweden 55(1): 166-186.

Mendall, Howard L. 1958. The ring-necked duck in the Northeast. Univ. Maine Bull. 60(16), 2d Ser. 73, 317 p. Orono.

Meng, Heinz K. 1952. The Cooper's hawk, *Accipiter cooperii* (Bonaparte). Ph. D. thesis. 136 p. Cornell Univ., Ithaca, N.Y.

Meredith, Don H. 1976. Habitat selection by two parapatric species of chipmunks (*Eutamias*). Can. J. Zool. 54(4):536-543.

Meslow, E. Charles, and Howard M. Wight. 1975. Avifauna and succession in Douglas-fir forests of the Pacific Northwest. *In* Proceedings of the symposium on management of forest and range habitats for nongame birds. D. R. Smith, ed. USDA For. Serv. Gen. Tech. Rep. WO-1, p. 266-271. Washington, D.C.

Metcalf, M. E. 1963. 1962 Oregon log production. USDA For. Serv. Resour. Bull. PNW-2, 2 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Metcalf, M. E. 1964. 1963 Oregon log production. Misc. Publ., 2 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Metter, Dean E. 1964. A morphological and ecological comparison of two populations of the tailed frog, *Ascaphus truei* Stejneger. Copeia 1964(1):181-195.

Mewaldt, L. Richard. 1956. Nesting behavior of the Clark nutcracker. Condor 58(1):3-23.

Meyer, Walter H. 1961. Yield of even-aged stands of ponderosa pine. Tech. Bull. 630 rev., 59 p. U.S. Dep. Agric., Washington, D.C.

Michael, Chas. W. 1935. Nesting of the Williamson sapsucker. Condor 37(4): 209-210.

Michener, Harold R., and Josephine R. Michener. 1935. Mockingbirds, their territories and individualities. Condor 37(3):97-140.

Mickelson, P. G. 1975. Breeding biology of cackling geese and associated species on the Yukon-Kuskokwim Delta, Alaska. Wildl. Monogr. 45, 35 p.

Mielke, James L. 1950. Rate of deterioration of beetle-killed Engelmann spruce. J. For. 48(12):882-888.

Miller, Alden H. 1939a. The breeding Leucosticetes of the Wallowa Mountains, Oregon. Condor 41(1):34-35.

Miller, Alden H. 1939b. Status of the breeding Lincoln's sparrows of Oregon. Auk 56(3):342-343.

Miller, Alden H., and T. T. McCabe. 1935. Racial differentiation in *Passerella (Melospiza) lincolnii*. Condor 37(3):144-160.

Miller, Don, and Eileen Miller. 1974-75. Snags, partly dead and deformed trees. 47 p. Umatilla Natl. For., Pendleton, Oreg.

Miller, Don E., and John T. Emlen. 1975. Individual chick recognition and family integrity in the ring-billed gull. Behaviour 52(1-2):124-144.

Miller, Donald H., and Lowell L. Getz. 1972. Factors influencing the local distribution of the redback vole, *Clethrionomys gapperi*, in New England. Univ. Conn. Occas. Pap. Biol. Sci. Ser. 2(9): 115-138.

Miller, Donald H., and Lowell L. Getz. 1973. Factors influencing the local distribution of the redback vole, *Clethrionomys gapperi*, in New England: II. Vegetation cover, soil moisture, and debris cover. Univ. Conn. Occas. Pap. Biol. Sci. Ser. 2(11):159-180.

Miller, Howard A., and Lowell K. Halls. 1969. Fleshy fungi commonly eaten by southern wildlife. USDA For. Serv. Res. Pap. SO-49, 28 p. South. For. Exp. Stn., New Orleans, La.

Miller, Steven W., and John S. Barclay. 1974. Predation in warm water reservoirs by wintering common mergansers. *In* Proceedings of the 27th annual conference of the Southeastern Association of Game and Fish Commissioners, Oct. 14-17, 1973, Hot Springs, Ark., p. 243-252. [Columbia, S.C.]

Miller, Wayne. 1970. Factors influencing the status of eastern and mountain bluebirds in southwestern Manitoba. Blue Jay 28(1):38-46.

Mills, Richard S., Gary W. Barrett, and Michael P. Farrell. 1975. Population dynamics of the big brown bat (*Eptesicus fuscus*) in southwestern Ohio. J. Mammal. 56(3):591-604.

Minderman, G. 1968. Addition, decomposition and accumulation of organic matter in forests. J. Ecol. 56(2):355-362.

Minore, Don. 1966. Identification of rotten logs in the coastal forests of Oregon and Washington. USDA For. Serv. Pac. Northwest For. and Range Exp. Stn., 16 p. Portland, Oreg.

Minore, Don. 1970. Seedling growth of eight northwestern tree species over three water tables. USDA For. Serv. Res. Note PNW-115, 8 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Minore, Don, and Clark E. Smith. 1971. Occurrence and growth of four northwestern tree species over shallow water tables. USDA For. Serv. Res. Note PNW-160, 9 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Misterek, David Lloyd. 1974. The breeding ecology of the ruddy duck (*Oxyura jamaicensis*) on Rush Lake, Winnebago County, Wisconsin. M.S. thesis. 82 p. Univ. Wis., Oshkosh.

Mitchell, Glenn E. 1950. Wildlife-forest relationships in the Pacific Northwest region. J. For. 48(1):26-30.

Mitchell, Russel G., and Charles Sartwell. 1974. Insects and other arthropods. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. R-1 to R-22. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Moen, Aaron N. 1973. Wildlife ecology: An analytical approach. 458 p. W. H. Freeman and Co., San Francisco.

Mohler, Levi L. 1974. Threatened wildlife of Idaho. Idaho Wildl. Rev. 26(5):3-5.

Moisan, Gaston. 1966. The green-winged teal: Its distribution, migration and population dynamics. Ph. D. diss. 354 p. Laval Univ., Quebec.

Moldenhauer, Ralph R. 1970. The effects of temperature on the metabolic rate and evaporative water loss of the sage sparrow *Amphispiza belli nevadensis*. Comp. Biochem. Physiol. 36(3):579-587.

Moldenhauer, Ralph R., and John A. Wiens. 1970. The water economy of the sage sparrow, *Amphispiza belli nevadensis*. Condor 72(3):265-275.

Molina, J. J. 1971. Muestreo de nidales para aves insectivoras en pinares de Soria. Bol. Serv. Plagas For. 14(27):56-76. Madrid.

Montana Cooperative Elk-Logging Study. 1975. Progress report for the period Jan. 1-Dec. 31, 1974. Annu. Prog. Rep., Reg. 1, USDA For. Serv.; Intermt. For. and Range Exp. Stn.; Mont. Dep. Fish and Game; Bur. Land Manage.; Sch. For., Univ. Mont.

Montgomery, Marvin L., and Logan A. Norris. 1970. A preliminary evaluation of the hazards of 2,4,5-T in the forest environment. USDA For. Serv. Res. Note PNW-116, 11 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Moore, A. W. 1933. Food habits of Townsend and coast moles. J. Mammal. 14(1):36-40.

Moore, A. W. 1940. Wild animal damage to seed and seedlings on cut-over Douglas-fir lands of Oregon and Washington. U.S. Dep. Agric. Tech. Bull. 706, 28 p. Washington, D.C.

Moore, Albert Watts, and Elbert H. Reid. 1951. The Dalles pocket gopher and its influence on forage production of Oregon mountain meadows. U.S. Dep. Agric. Circ. 884, 36 p.

Moravets, F. L. 1954. Forest statistics for Crook County, Oregon. For. Surv. Rep. 114, 22 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Moravets, F. L. 1955. Forest statistics for Wheeler County, Oregon. For. Surv. Rep. 119, 23 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Morris, R. F., Ed. 1963. The dynamics of epidemic spruce budworm populations. Entomol. Soc. Can. Mem. 31, 332 p.

Morris, R. F., W. F. Cheshire, C. A. Miller, and D. G. Mott. 1958. The numerical response of avian and mammalian predators during a gradation of the spruce budworm. Ecology 39(3):487-494.

Morris, William, Ed. 1976. The American heritage dictionary of the English language. New Coll. ed. 1,550 p. Houghton Mifflin Co., Boston, Mass.

Morse, Douglass H. 1972. Habitat differences of Swainson's and hermit thrushes. Wilson Bull. 84(2):206-208.

Morse, Thomas E., Joel L. Jakabosky, and Vernon P. McCrow. 1969. Some aspects of the breeding biology of the hooded merganser. J. Wildl. Manage. 33(3):596-604.

Morton, Martin L., and John S. Gallup. 1975. Reproductive cycle of the Belding ground squirrel (*Spermophilus beldingi beldingi*): Seasonal and age differences. Great Basin Nat. 35(4):427-433.

Morton, Martin L., Judith L. Horstmann, and Janet M. Osborn. 1972. Reproductive cycle and nesting success of the mountain white-crowned sparrow (*Zonotrichia leucophrys oriantha*) in the central Sierra Nevada. Condor 74(2): 152-163.

Morton, Martin L., and Hsing-chu Lucy Tung. 1971. Growth and development in the Belding ground squirrel (*Spermophilus beldingi beldingi*). J. Mammal. 52(3):611-616.

Moulton, John C., and Phillip V. Vanderschaegen. 1974. Bibliography of the ruffed grouse. Wis. Dep. Nat. Resour., 31 p. Madison.

Munro, J. A. 1939. Studies of water-fowl in British Columbia: No. 9. Barrow's golden-eye, American golden-eye. Trans. R. Can. Inst. 22(48):259-318.

Munro, J. A. 1942. Studies of waterfowl in British Columbia: Buffle-head. Can. J. Res. Sect. D. 20(6):133-160.

Murie, Adolph. 1940. Ecology of the coyote in the Yellowstone. U.S. Natl. Park Serv. Fauna Ser. 4, Fauna of the National Parks of the United States. 206 p. Gov. Print. Off., Washington, D.C.

Murie, Jan O. 1971. Behavioral relationships between two sympatric voles (*Microtus*): Relevance to habitat segregation. J. Mammal. 52(1):181-186.

Murray, Keith F. 1965. Population changes during the 1957-1958 vole (*Microtus*) outbreak in California. Ecology 46(1-2):163-171.

Murton, R. K., C. F. B. Coombs, and R. J. P. Thearle. 1972. Ecological studies of the feral pigeon *Columba livia* var., II. Flock behaviour and social organization. J. Appl. Ecol. 9(3):875-889.

Murton, R. K., R. J. P. Thearle, and C. F. B. Coombs. 1974. Ecological studies of the feral pigeon *Columba livia* var., III. Reproduction and plumage polymorphism. J. Appl. Ecol. 11(3):841-854.

Myers, Harriet Williams. 1912. Nesting habits of the western bluebird. Condor 14(6):221-222.

Myres, Miles Timothy. 1957. An introduction to the behavior of the goldeneyes: *Bucephala islandica* and *B. clangula* (class Aves: family Anatidae). M.S. thesis. 254 p. Univ. B. C., Vancouver.

Navon, Daniel I. 1971. Timber RAM users' manual. Part I: Smokey Forest case study. USDA For. Serv. Pac. Southwest For. and Range Exp. Stn., 36 p. Berkeley, Calif.

Neff, Johnson Andrew. 1926. A study of the economic status of the common woodpeckers in relation to Oregon horticulture. M.S. thesis. 133 p. Oreg. State Coll., Corvallis.

Nellis, Carl H., and Lloyd B. Keith. 1968. Hunting activities and success of lynxes in Alberta. J. Wildl. Manage. 32(4):718-722.

Nellis, Carl H., Stephen P. Wetmore, and Lloyd B. Keith. 1972. Lynx-prey interactions in central Alberta. J. Wildl. Manage. 36(2):320-329.

Nelson, E. E., and G. M. Harvey. 1974. Diseases. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. S-1 to S-11. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Nelson, Theodora. 1939. The biology of the spotted sandpiper, *Actitis macularia* (Linn.). Ph. D. diss. 170 p. Univ. Mich., Ann Arbor.

Nethersole-Thompson, Desmond. 1966. The snow bunting. 316 p. Oliver and Boyd Ltd., London.

Newton, Michael. 1977. Vegetation management alternatives in the practice of silviculture. Soc. Am. For. Proc. 1977: 270-277.

Newton, Michael, and Joel A. Norgren. 1977. Silvicultural chemicals and protection of water quality. U.S. EPA, Reg. 10, EPA Rep. 910/9-77-036, 224 p. Environ. Prot. Agency, Seattle, Wash.

Nice, Margaret Morse. 1943. Studies in the life history of the song sparrow: II. The behavior of the song sparrow and other passerines. Trans. Linn. Soc. New York 6:1-328.

Nicholls, Thomas H., and Dwain W. Warner. 1972. Barred owl habitat use as determined by radiotelemetry. J. Wildl. Manage. 36(2):213-224.

Nickell, Walter P. 1966. The nesting of the black-crowned night heron and its associates. Jack-Pine Warbler 44(3): 130-139.

Nielsen, Richard L. 1963. 1962 Washington log production. USDA For. Serv. Resour. Bull. PNW-6, 2 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Nobles, Mildred K. 1965. Identification of cultures of wood-inhabiting Hymenomycetes. Can. J. Bot. 43(9):1097-1139.

Norman, Richard F., and Raleigh J. Robertson. 1975. Nest-searching behavior in the brown-headed cowbird. Auk 92(3): 610-611.

Norris, Logan A. 1974. The behavior and impact of organic arsenical herbicides in the forest: Final report on cooperative studies. 98 p. Typescript report on file at USDA For. Serv. Pac. Northwest For. and Range Exp. Stn., Corvallis, Oreg.

Norris, Robert A. 1958. Comparative biosystematics and life history of the nuthatches *Sitta pygmaea* and *Sitta pusilla*. Univ. Calif. Publ. Zool. 56(2):119-300.

North Central Forest Experiment Station. 1977. Proceedings-symposium on river recreation management and research. USDA For. Serv. Gen. Tech. Rep. NC-28, 455 p. St. Paul, Minn.

Northcott, Tom H., Neil F. Payne, and Eugene Mercer. 1974. Dispersal of mink in insular Newfoundland. J. Mammal. 55(1):243-248.

Northeastern Forest Experiment Station. [n.d.] 'Shigometer'—new tool for forestry. Photo story 29. [4 p.] Northeast. For. Exp. Stn., Upper Darby, Pa.

Novakowski, N. S. 1956. Additional records of bats in Saskatchewan. Can. Field Nat. 70(3):142.

Nowicki, Timothy. 1974. The census of screech owls (*Otus asio*) using tape-recorded calls. Jack-Pine Warbler 52(3): 98-101.

Nussbaum, Ronald A., and Chris Maser. 1975. Food habits of the bobcat, *Lynx rufus*, in the Coast and Cascade Ranges of western Oregon in relation to present management policies. Northwest Sci. 49(4):261-266.

Odin, Clyde R. 1957. California gull predation on waterfowl. Auk 74(2):185-202.

Odum, Eugene P. 1941a. Annual cycle of the black-capped chickadee-1. Auk 58(3):314-333.

Odum, Eugene P. 1941b. Annual cycle of the black-capped chickadee-2. Auk 58(4):518-535.

Odum, Eugene Pleasants. 1963. Ecology. 152 p. Holt, Rinehart, and Winston, Inc., New York.

Odum, Eugene Pleasants. 1971. Fundamentals of ecology. 3d ed. 574 p. W. B. Saunders Co., Philadelphia, Pa.

Odum, Howard T. 1970. Summary: An emerging view of the ecological system at El Verde. *In* A Tropical rain forest. A study of irradiation and ecology at El Verde, Puerto Rico. Howard T. Odum and Robert F. Pigeon, eds. Book 3. p. I-191 to I-289. U.S. At. Energy Comm. Tech. Inf. Cent., Oak Ridge, Tenn.

Oeming, Albert Frederick. 1955. A preliminary study of the great gray owl in Alberta with observations on some other species of owls. M.S. diss. 129 p. Univ. Alberta, Edmonton.

O'Farrell, Michael J., and Eugene H. Studier. 1973. Reproduction, growth and development in *Myotis thysanodes* and *M. lucifugus* (Chiroptera: Vespertilionidae). Ecology 54(1):18-30.

O'Farrell, Thomas P., Richard J. Olson, Richard O. Gilbert, and John D. Hedlund. 1975. A population of Great Basin pocket mice, *Perognathus parvus*, in the shrub-steppe of south-central Washington. Ecol. Monogr. 45(1):1-28.

Ohlendorf, Harry M. 1974. Competitive relationships among kingbirds (*Tyrannus*) in Trans-Pecos Texas. Wilson Bull. 86(4):357-373.

Ohlendorf, Harry M. 1976. Comparative breeding ecology of phoebes in Trans-Pecos Texas. Wilson Bull. 88(2):255-271.

Olendorff, Richard R. 1972. The large birds of prey of the Pawnee National Grassland: Nesting habits and productivity, 1969-1971. U.S. Int. Biol. Program, Grassland Biome Tech. Rep. 151, 59 p. Nat. Resour. Ecol. Lab., Colo. State Univ., Fort Collins.

Olendorff, Richard R. 1976. The food habits of North American golden eagles. Am. Midl. Nat. 95(1):231-236.

Olson, David Peter. 1964. A study of canvasback and redhead breeding populations: Nesting habitats and productivity. Ph. D. diss. 106 p. Univ. Minn., Minneapolis.

Olson, Jerry S. 1963. Energy storage and the balance of producers and decomposers in ecological systems. Ecology 44(2):322-331.

Olson, Sigurd T., and William H. Marshall. 1952. A common loon in Minnesota. Minn. Mus. Nat. Hist. Occas. Pap. 5, 76 p. Univ. of Minn. Press, Minneapolis.

Olterman, James H., and B. J. Verts. 1972. Endangered plants and animals of Oregon: IV. Mammals. Agric. Exp. Stn. Spec. Rep. 364, 47 p. Oreg. State Univ., Corvallis.

Oregon State Department of Fish and Wildlife. [1977.] Oregon's threatened or endangered wildlife. [Ron Shay, ed.] 13 p. Oregon State Dep. Fish and Wildl., Portland.

Oregon Laws, Statutes, etc. Ch. 316. [HB 1624], June 5, 1971. Oregon Forest [*Conservation*] Practices Act. *In its* Oregon laws. 1971. Vol. 1, p. 455-460. Salem, Oreg. Legis. Assem., 1971.

Ormiston, John H. 1966. Food habits, habitat and movements of mountain quail in Idaho. M.S. thesis. 39 p. Univ. Idaho, Moscow.

Orr, Robert T. 1940. The rabbits of California. Calif. Acad. Sci. Occas. Pap. 19, 227 p.

Orr, Robert T. 1954. Natural history of the pallid bat, *Antrozous pallidus* (LeConte). Proc. Calif. Acad. Sci. Fourth Ser. 28(4):165-246. San Francisco.

Orwell, George. 1946. Animal farm. 118 p. Harcourt, Brace and Co., Inc., New York.

Otvos, Imre S. 1965. Studies on avian predators of *Dendroctonus brevicomis* LeConte (Coleoptera: Scolytidae) with special reference to Picidae. Can. Entomol. 97(11):1184-1199.

Ouellet, Henri. 1970. Further observations on the food and predatory habits of the gray jay. Can. J. Zool. 48(2):327-330.

Owen, Myrfyn. 1973. The winter feeding ecology of wigeon at Bridgewater Bay, Somerset. Ibis 115(2):227-243.

Ozoga, John J., and Leslie W. Gysel. 1972. Response of white-tailed deer to winter weather. J. Wildl. Manage. 36(3): 892-896.

Pace, Ann E. 1974. Systematic and biological studies of the leopard frogs (*Rana pipiens* Complex) of the United States. Univ. Mich. Misc. Publ. Mus. Zool. 148, 140 p. Ann Arbor.

Pacific Northwest Forest and Range Experiment Station. 1962. 1960 Washington log production. For. Surv. Rep. 140, 2 p., illus. Portland, Oreg.

Pacific Northwest Forest and Range Experiment Station, Division of Forest Economics Research. 1955-59a. Timber harvest by ownership in State of Oregon. Unpublished reports on file at Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 97208.

Pacific Northwest Forest and Range Experiment Station, Division of Forest Economics Research. 1955-59b. Timber harvest by ownership in State of Washington. Unpublished reports on file at Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 97208.

Palmer, Ralph Simon. 1954. The mammal guide: Mammals of North America north of Mexico. 384 p. Doubleday and Co., Inc., Garden City, N.Y.

Pank, Larry F. 1974. A bibliography of seed-eating mammals and birds that affect forest regeneration. U.S. Dep. Inter. Fish and Wildl. Serv., Bur. Sport Fish. and Wildl. Spec. Sci. Rep. Wildl. 174, 28 p.

Parker, William S. 1972. Ecological study of the western whiptail lizard, *Cnemidophorus tigris gracilis*, in Arizona. Herpetologica 28(4):360-369.

Parker, William S. 1974a. Home range, growth, and population density of *Uta stansburiana* in Arizona. J. Herpetol. 8(2):135-139.

Parker, William S., and William S. Brown. 1974a. Notes on the ecology of regal ringneck snakes (*Diadophis punctatus regalis*) in northern Utah. J. Herpetol. 8(3):262-263.

Parker, William S., and William S. Brown. 1974b. Mortality and weight changes of Great Basin rattlesnakes (*Crotalus viridis*) at a hibernaculum in northern Utah. Herpetologica 30(3):234-239.

Parker, William S., and Eric R. Pianka. 1975. Comparative ecology of populations of the lizard *Uta stansburiana*. Copeia 1975(4):615-632.

Parker, William Skinker. 1974b. Comparative ecology of two colubrid snakes, *Masticophis t. taeniatus* (Hallowell) and *Pituophis melanoleucus deserticola* (Stejneger), in northern Utah. Ph. D. thesis. 307 p. Univ. Utah, Salt Lake.

Parsons, David R. 1975. Time and energy budgets of a population of dippers (*Cinclus mexicanus*) during winter in the Cascade Range of Oregon. M.S. thesis. 29 p. Oreg. State Univ., Corvallis.

Patton, David R. 1975. A diversity index for quantifying habitat "edge." Wildl. Soc. Bull 3(4):171-173.

Patton, David R. 1978. Run wild: A storage and retrieval system for wildlife habitat information. USDA For. Serv. Gen. Tech. Rep. RM-51, 8 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Patton, Robert Farmer. 1974. Ecological and behavioral relationships of the skunks of Trans-Pecos Texas. Ph. D. thesis. 219 p. Tex. A & M Univ., College Station.

Peabody, Robert B., Judith A. Johnson, and Edmund D. Brodie, Jr. 1975. Intraspecific escape from ingestion of the rubber boa, *Charina bottae*. J. Herpetol. 9(2):237.

Peakall, David B. 1970. The eastern bluebird: Its breeding season, clutch size and nesting success. Living Bird 9:239-255.

Pearson, Oliver P., Mary R. Koford, and Anita K. Pearson. 1952. Reproduction of the lump-nosed bat (*Corynorhinus rafinesquei*) in California. J. Mammal. 33(3):273-320.

Pedersen, Richard J. [n.d.] Unpublished data on file at U.S. Dep. Agric., Forest Service, Range and Wildlife Habitat Laboratory, "C" & Gekeler Lane, Route 2, Box 2315, La Grande, Oreg. 97850. Used with permission.

Pendergast, B. A., and D. A. Boag. 1971. Nutritional aspects of the diet of spruce grouse in central Alberta. Condor 73(4): 437-443.

Pengelly, W. L. 1972. Clearcutting: Detrimental aspects for wildlife resources. J. Soil and Water Conserv. 27(6):255-258.

Perry, Charles, and Robert Overly. 1977. Impact of roads on big game distribution in portions of the Blue Mountains of Washington, 1972-1973. Wash. Game Dep. Appl. Res. Sect., Bull. 11, 39 p. Olympia.

Petersen, Arnold J. 1955. The breeding cycle in the bank swallow. Wilson Bull. 67(4):235-286.

Peterson, Roger Tory. 1961. A field guide to western birds: Field marks of all species found in North America west of the 100th meridian, with a section on the birds of the Hawaiian Islands. 2d ed. 366 p. Houghton Mifflin Co., Boston.

Phillips, Thomas A. 1966. Calf drop ridge elk calving ground survey. USDA For. Serv. Unpublished report, 4 p. Sawtooth Natl. For., Twin Falls, Idaho.

Pianka, Eric R., and William S. Parker. 1975. Ecology of horned lizards: A review with special reference to *Phrynosoma platyrhinos*. Copeia 1975(1):141-162.

Pickwell, Gayle B. 1931. The prairie horned lark. Trans. Acad. Sci. St. Louis, vol. 27, 153 p.

Pielou, E. C. 1975. Ecological diversity. 165 p. John Wiley & Sons, Inc., New York.

Pierovich, John M., Edward H. Clarke, Stewart G. Pickford, and Franklin R. Ward. 1975. Forest residues management guidelines for the Pacific Northwest. USDA For. Serv. Gen. Tech. Rep. PNW-33, 281 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Pinkowski, Ben, and Larry Zeleny. 1975. Bibliography of the North American bluebirds (*Sialia sialis, S. currucoides,* and *S. mexicana*). 11 p., mimeogr.

Pitelka, Frank A. 1959. Numbers, breeding schedule, and territoriality in pectoral sandpipers of northern Alaska. Condor 61(4):233-264.

Planck, Roy Jonathan. 1967. Nest site selection and nesting of the European starling (*Sturnus vulgaris* L.) in California. Ph. D. thesis. 124 p. Univ. Calif., Davis.

Poelker, Richard J., and Harry D. Hartwell. 1973. Black bear of Washington. Wash. State Game Dep. Biol. Bull. 14, 180 p. Olympia.

Porter, David K., Mark A. Strong, J. Brent Giezentanner, and Ronald A. Ryder. 1975. Nest ecology, productivity, and growth of the loggerhead shrike on the shortgrass prairie. Southwest. Nat. 19(4):429-436.

Porter, Richard D., and Clayton M. White. 1973. The peregrine falcon in Utah, emphasizing ecology and competition with the prairie falcon. Brigham Young Univ. Sci. Bull. Biol. Ser. 18(1), 74 p. Provo, Utah.

Pospahala, Richard S., David R. Anderson, and Charles J. Henny. 1974. Population ecology of the mallard: II. Breeding habitat conditions, size of the breeding populations, and production indices. U.S. Bur. Sport Fish. and Wildl. Resour. Publ. 115, 73 p.

Pospelov, S. M. 1956. [The economic importance of woodpeckers in the forests of Leningrad district.] Zool. Zh. 35(4): 600-605. [In Russ.]

Poston, H. J. 1974. Home range and breeding biology of the shoveler. Can. Wildl. Serv. Rep. Ser. 25, 49 p. Ottawa.

Poulson, Thomas L., and David C. Culver. 1969. Diversity in terrestrial cave communities. Ecology 50(1):153-158.

Poulson, Thomas L., and William B. White. 1969. The cave environment. Science 165(3897):971-981.

Power, Harry W., III. 1966. Biology of the mountain bluebird in Montana. Condor 68(4):351-371.

Powers, Roger A., and B. J. Verts. 1971. Reproduction in the mountain cottontail rabbit in Oregon. J. Wildl. Manage. 35(4):605-613.

Poznanin, L. P., Ed. 1956. [Ways and means of using birds in combating noxious insects.] Proceedings of conferences held on Nov. 25-28, 1953, and Dec. 21-23, 1954. 138 p. Izd. Minist. sel'sk Khoz. S.S.R., Moscow, Russia. [In Russ.]

Pratt, Helen M. 1970. Breeding biology of great blue herons and common egrets in central California. Condor 72(4):407-416.

Preston, F. W. 1960. Time and space and the variation of species. Ecology 41(4): 611-627.

Preston, F. W., and R. T. Norris. 1947. Nesting heights of breeding birds. Ecology 28(3):241-273.

Price, Frank E., and Carl E. Bock. 1973. Polygyny in the dipper. Condor 75(4): 457-459.

Pruitt, William O., Jr. 1954. Notes on Colorado Phenacomys and pikas. J. Mammal. 35(3):450-452.

Pulliainen, Erkki. 1971. Winter nutrition of crossbills (*Loxia curvirostra* and *L. leucoptera*) in northeastern Lapland in 1969. Ann. Zool. Fenn. 8(2):326-329.

Pulliainen, Erkki. 1972. Summer nutrition of crossbills (*Loxia pytyopsittacus, L. curvirostra* and *L. leucoptera*) in northeastern Lapland in 1971. Ann. Zool. Fenn. 9(1):28-31.

Pulliam, H. Ronald, and Frank Enders. 1971. The feeding ecology of five sympatric finch species. Ecology 52(4):557-566.

Purdue, James Richard. 1974. Adaptations of the snowy plover, *Charadrius alexandrinus*, to an inland salt plain. Ph. D. thesis. 82 p. Univ. Okla., Norman.

Quaintance, Charles W. 1942. American redstart in eastern Oregon. Condor 44(6):282.

Quaintance, Charles W. 1944. California cuckoo collected in eastern Oregon. Condor 46(2):89-90.

Radwan, M. A. 1963. Protecting forest trees and their seed from wild mammals (A review of the literature). USDA For. Serv. Res. Pap. PNW-6, 28 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Rahn, Hermann. 1942. The reproductive cycle of the prairie rattler. Copeia 1942(4):233-240.

Rausch, R. A., and A. M. Pearson. 1972. Notes on the wolverine in Alaska and the Yukon Territory. J. Wildl. Manage. 36(2):249-268.

Rawls, Charles K., Jr. 1949. An investigation of the life history of the white-winged scoter (*Melanitta fusca deglandi*). M.S. thesis. 128 p. Univ. Minn., Minneapolis.

Rees, William Ernest. 1973. Comparative ecology of three sympatric sparrows of the genus *Zonotrichia*. Ph. D. thesis. 224 p. Univ. Toronto, Toronto.

Reese, Jan G. 1975. Productivity and management of feral mute swans in Chesapeake Bay. J. Wildl. Manage. 39(2):280-286.

Reeve, Wayne L. 1952. Taxonomy and distribution of the horned lizard genus *Phrynosoma*. Univ. Kans. Sci. Bull. Vol. 34, Part 2, No. 14, p. 817-960. Lawrence.

Reeves, Henry M., Compiler. 1975. A contribution to an annotated bibliography of North American cranes, rails, woodcock, snipe, doves, and pigeons. U.S. Dep. Inter. Fish and Wildl. Serv. Natl. Tech. Inf. Serv. Rep. PB-240-999, 527 p. [Off. Migratory Bird Manage., Laurel, Md.]

Reichard, Timothy A. 1974. Barred owl sightings in Washington. West. Birds 5(4):138-140.

Resler, Rexford A. 1972. Clearcutting: Beneficial aspects for wildlife resources. J. Soil and Water Conserv. 27(6):250-254.

Reynolds, Hudson G. 1962. Use of natural openings in a ponderosa pine forest of Arizona by deer, elk, and cattle. USDA For. Serv. Rocky Mt. For. and Range Exp. Stn. Res. Note 78, 4 p. Fort Collins, Colo.

Reynolds, Hudson G. 1966a. Use of openings in spruce-fir forests of Arizona by elk, deer and cattle. USDA For. Serv. Res. Note RM-66, 4 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Reynolds, Hudson G. 1966b. Slash cleanup in a ponderosa pine forest affects use by deer and cattle. USDA For. Serv. Res. Note RM-64, 3 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Reynolds, Richard T. 1970. Nest observations of the long-eared owl (*Asio otus*) in Benton County, Oregon, with notes on their food habits. Murrelet 51(1):8-9.

Reynolds, Richard Truman. 1975. Distribution, density, and productivity of three species of accipiter hawks in Oregon. M.S. thesis. 39 p. Oreg. State Univ., Corvallis.

Robbins, Sam. 1974. The willow and alder flycatchers in Wisconsin: A preliminary description of summer range. Passenger Pigeon 36(4):147-152.

Roberts, Hadley B. 1974. Effects of logging on elk calving habitat, Moyer Creek, Salmon National Forest, Idaho. USDA For. Serv., Salmon Natl. For., 22 p. Salmon, Idaho.

Roberts, Hadley B., and Gordon S. Lind. 1972. Status of the American osprey in Oregon. North Am. Osprey Res. Conf. Trans., 1971, p. 215-222. Oreg. Coop. Wildl. Res. Unit, Corvallis, and USDA For. Serv. Coop. Rep.

Roberts, Joan Beltz. 1969. Vocalizations of the rufous-sided towhee, *Pipilo erythrophthalmus oregonus*. Condor 71(3): 257-266.

Robinette, W. Leslie, Jay S. Gashwiler, and Owen W. Morris. 1961. Notes on cougar productivity and life history. J. Mammal. 42(2):204-217.

Roest, A. I. 1957. Notes on the American sparrow hawk. Auk 74(1):1-19.

Rogers, John Patrick. 1962. The ecological effect of drought on reproduction of the lesser scaup, *Aythya affinis* (Eyton). Ph. D. diss. 109 p. Univ. Mo., Columbia.

Rothacher, Jack, and William W. Lopushinsky. 1974. Soil stability and water yield and quality. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. D-1 to D-23. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Ruben, John A. 1976. Reduced nocturnal heat loss associated with ground litter burrowing by the California red-sided garter snake *Thamnophis sirtalis infernalis*. Herpetologica 32(3):323-325.

Ruffer, David G. 1965. Burrows and burrowing behavior of *Onychomys leucogaster*. J. Mammal. 46(2):241-247.

Ruibal, Rudolfo. 1962. The ecology and genetics of a desert population of *Rana pipiens*. Copeia 1962(1):189-195.

Rundquist, Vaughn Marlan. 1974. Avian ecology on stock ponds in two vegetational types in north-central Montana. Ph. D. thesis. 125 p. Mont. State Univ., Bozeman.

Rusch, Donald H., E. Charles Meslow, Phillip D. Doerr, and Lloyd B. Keith. 1972. Response of great horned owl populations to changing prey densities. J. Wildl. Manage. 36(2):282-296.

Rush, William Marshall. 1932. Northern Yellowstone elk study. 131 p. Mont. Fish and Game Comm. [Missoulian Publ. Co., Missoula, Mont.]

Rushmore, Francis M. 1973. Techniques for calling sapsuckers and finding their nesting territories. USDA For. Serv. Res. Pap. NE-281, 7 p. Northeast. For. Exp. Stn., Upper Darby, Pa.

Russell, Henry N., Jr., and Angus M. Woodbury. 1941. Nesting of the gray flycatcher. Auk 58(1):28-37.

Rust, Henry Judson. 1946. Mammals of northern Idaho. J. Mammal. 27(4):308-327.

Ruth, Robert H., and A. S. Harris. 1975. Forest residues in hemlock-spruce forests of the Pacific Northwest and Alaska: A state-of-knowledge review with recommendations for residue management. USDA For. Serv. Gen. Tech. Rep. PNW-39, 52 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Rutter, Russell J. 1969. A contribution to the biology of the gray jay (*Perisoreus canadensis*). Can. Field Nat. 83(4):300-316.

Ryder, John P. 1972. Biology of nesting Ross's geese. Ardea 60(3-4):185-215.

Ryder, John Pemberton. 1967a. The breeding biology of Ross' goose in the Perry River region, Northwest Territories. Can. Wildl. Serv. Rep. Ser. 3, 56 p. Can. Wildl. Serv., Ottawa.

Ryder, Ronald A. 1967b. Distribution, migration and mortality of the white-faced ibis (*Plegadis chihi*) in North America. Bird-Banding 38(4):257-277.

Sabine, Winifred S. 1959. The winter society of the Oregon junco: Intolerance, dominance, and the pecking order. Condor 61(2):110-135.

Salt, George W., and Daniel E. Willard. 1971. The hunting behavior and success of Forster's tern. Ecology 52(6): 989-998.

Sanderson, Glen C., and Helen C. Schultz, Eds. 1973. Wild turkey management: Current problems and programs. 355 p. Univ. Mo. Press, Columbia.

Sargeant, Alan B., and Dwain W. Warner. 1972. Movements and denning habits of a badger. J. Mammal. 53(1):207-210.

Sather, J. Henry. 1958. Biology of the Great Plains muskrat in Nebraska. Wildl. Monogr. 2, 35 p.

Saul, Scott, Mark Swisher, Cliff Oakley, and others. [1977.] A survey of bat populations and their habitat preferences in southern Oregon. A student-oriented studies project funded by Natl. Sci. Found. through South. Oreg. State Coll., Ashland. 89 p.

Savely, Harvey Epperson, Jr. 1939. Ecological relations of certain animals in dead pine and oak logs. Ecol. Monogr. 9(3):321-385.

Scheffer, Theo. H. 1938. Pocket mice of Washington and Oregon in relation to agriculture. U.S. Dep. Agric. Tech. Bull. 608, 16 p. Washington, D.C.

Schiller, Robert John. 1973. Reproductive ecology of female sharp-tailed grouse (*Pedioecetes phasianellus*) and its relationship to early plant succession in northwestern Minnesota. Ph. D. thesis. 186 p. Univ. Minn., St. Paul.

Schitoskey, Frank, Jr., James Evans, and G. Keith LaVoie. 1972. Status and control of nutria in California. *In* Proceedings: Fifth vertebrate pest conference, Fresno, Calif., p. 15-17. Rex E. Marsh, ed. [Dep. Anim. Physiol., Univ. Calif., Davis.]

Schmidt, Karl Patterson, and D. Dwight Davis. 1941. Field book of snakes of the United States and Canada. 365 p. G. P. Putnam's Sons, New York.

Schmidt, Wyman C., and Raymond C. Shearer. 1971. Ponderosa pine seed-for animals or trees? USDA For. Serv. Res. Pap. INT-112, 14 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Schmidt-Nielsen, Knut, and Bodil Schmidt-Nielsen. 1952. Water metabolism of desert mammals. Physiol. Rev. 32(2): 135-166.

Schneider, Dean G., L. David Mech, and John R. Tester. 1971. Movements of female raccoons and their young as determined by radio tracking. Anim. Behav. Monogr. 4(part 1), 43 p.

Schnell, Gary D. 1968. Differential habitat utilization by wintering rough-legged and red-tailed hawks. Condor 70(4):373-377.

Schnell, Jay H. 1969-70. Rest site selection by radio-tagged raccoons. J. Minn. Acad. Sci. 36(2-3):83-88.

Schroder, Gene D., and Michael L. Rosenzweig. 1975. Perturbation analysis of competition and overlap in habitat utilization between *Dipodomys ordii* and *Dipodomys merriami*. Oecologia (Berl.) 19(1):9-28.

Schroeder, Max H., and David L. Sturges. 1975. The effect on the Brewer's sparrow of spraying big sagebrush. J. Range Manage. 28(4):294-297.

Schwarz, Charles F., Edward C. Thor, and Gary H. Elsner. 1976. Wildland planning glossary. USDA For. Serv. Gen. Tech. Rep. PSW-13, 252 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

Schwarz, Ernest, and Henriette K. Schwarz. 1943. The wild and commensal stocks of the house mouse, *Mus musculus* Linnaeus. J. Mammal. 24(1):59-72.

Scott, J. Michael, Thomas W. Haislip, Jr., and Margaret Thompson. 1972. A bibliography of Oregon ornithology (1935-1970), with a cross-referenced list of the birds of Oregon. Northwest Sci. 46(2):122-139.

Sebetich, Michael John. 1969. Spatial distribution, movement, and growth of the bullfrog, *Rana catesbeiana* Shaw. M.A. thesis. 75 p. Coll. William and Mary, Williamsburg, Va.

Seidel, K. W. 1973. Mixed pine-fir of eastern Oregon and Washington. U.S. Dep. Agric. Handb. 445, p. 15-17. Washington, D.C.

Seidel, K. W. 1974. Natural regeneration of east-side conifer forests. *In* Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. USDA For. Serv. Gen. Tech. Rep. PNW-24, p. L-1 to L-25. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Seidensticker, John C., IV., Maurice G. Hornocker, Wilbur V. Wiles, and John P. Messick. 1973. Mountain lion social organization in the Idaho primitive area. Wildl. Monogr. 35, 60 p.

Selander, Robert K. 1954. A systematic review of the booming nighthawks of western North America. Condor 56(2): 57-82.

Seton, Ernest Thompson. 1928. Lives of game animals. Vol. 2, part 2, 460 p. Charles T. Branford Co., Boston.

Settergren, Carl D. 1977. Impacts of river recreation use on streambank soils and vegetation: State-of-the-knowledge. *In* Proceedings: Symposium on river recreation management and research, p. 55-59. USDA For. Serv. Gen. Tech. Rep. NC-28, North Cent. For. Exp. Stn., St. Paul, Minn.

Severaid, Joye Harold. 1950. The pigmy rabbit (*Sylvilagus idahoensis*) in Mono County, California. J. Mammal. 31(1):1-4.

Shapiro, Jacob. 1949. Ecological and life history notes on the porcupine in the Adirondacks. J. Mammal. 30(3):247-257.

Sharpe, William E. 1975. Timber management influences on aquatic ecosystems and recommendations for future research. Water Resour. Bull. 11(3):546-550.

Shaw, Roger H. 1977. Secondary wind speed maxima inside plant canopies. J. Appl. Meteorol. 16(5):514-521.

Shaw, William T. 1921. Moisture and altitude as factors in determining the seasonal activities of the Townsend ground squirrel in Washington. Ecology 2(3): 189-192.

Shaw, William T. 1924. Alpine life of the heather vole (*Phenacomys olympicus*). J. Mammal. 5(1):12-15.

Shaw, William T. 1926. Age of the animal and slope of the ground surface, factors modifying the structure of hibernation dens of ground squirrels. J. Mammal. 7(2):91-96.

Sheldon, William G. 1949. Reproductive behavior of foxes in New York State. J. Mammal. 30(3):236-246.

Sheppard, David Henry. 1965. Ecology of the chipmunks, *Eutamias amoenus luteiventris* (Allen) and *E. minimus oreocetes* Merriam. Ph.D. thesis. 255 p. Univ. Saskatchewan, Saskatoon.

Sheppe, Walter. 1967. Habitat restriction by competitive exclusion in the mice *Peromyscus* and *Mus*. Can. Field Nat. 81(2):81-98.

Sherwood, Glen A. 1960. The whistling swan in the West with particular reference to Great Salt Lake Valley, Utah. Condor 62(5):370-377.

Shigo, Alex L., and Lawrence Kilham. 1968. Sapsuckers and *Fomes igniarius* var. *populinus*. USDA For. Serv. Res. Note NE-84, 2 p. Northeast. For. Exp. Stn., Upper Darby, Pa.

Shigo, Alex L., and Edwin vH. Larson. 1969. A photo guide to the patterns of discoloration and decay in living northern hardwood trees. USDA For. Serv. Res. Pap. NE-127, 100 p. Northeast. For. Exp. Stn., Upper Darby, Pa.

Short, Lester L. 1974. Habits and interactions of North American three-toed woodpeckers (*Picoides arcticus* and *Picoides tridactylus*). Am. Mus. Novit. 2547, 42 p. Am. Mus. Nat. Hist., New York.

Shump, Ann U., Karl A. Shump, Jr., Gary A. Heidt, and Richard J. Aulerich. 1976a. A bibliography of mustelids, Part II: Mink. Mich. Agric. Exp. Stn. 7390, 156 p. Mich. State Univ., East Lansing.

Shump, Karl A., Jr., Ann U. Shump, Richard J. Aulerich, and Gary A. Heidt. 1976b. A bibliography of mustelids, Part V: Otters. Mich. Agric. Exp. Stn. 7759, 32 p. Mich. State Univ., East Lansing.

Shump, Karl A., Jr., Ann U. Shump, Thomas W. Nelson, Gary A. Heidt, and Richard J. Aulerich. 1975. A bibliography of mustelids, Part III: Skunks. Mich. Agric. Exp. Stn. 7472, 34 p. Mich. State Univ., East Lansing.

Skovlin, Jon M., Robert W. Harris, Gerald S. Strickler, and George A. Garrison. 1976. Effects of cattle grazing methods on ponderosa pine-bunchgrass range in the Pacific Northwest. U.S. Dep. Agric. Tech. Bull. 1531, 40 p. Washington, D.C.

Skryja, David D. 1974. Reproductive biology of the least chipmunk (*Eutamias minimus operarius*) in southeastern Wyoming. J. Mammal. 55(1):221-224.

Slankis, V. 1973. Hormonal relationships in mycorrhizal development. *In* Ectomycorrhizae: Their ecology and physiology. G. C. Marks and T. T. Kozlowski, eds. p. 231-298. Acad. Press, New York.

Sloan, Norman F., and Harry C. Coppel. 1968. Ecological implications of bird predators on the larch casebearer in Wisconsin. J. Econ. Entomol. 61(4): 1067-1070.

Smith, Andrew T. 1974a. The distribution and dispersal of pikas: Influences of behavior and climate. Ecology 55(6): 1368-1376.

Smith, David Martyn. 1962. The practice of silviculture. 7th ed. 578 p. John Wiley and Sons, Inc., New York.

Smith, Dwight G., Charles R. Wilson, and Herbert H. Frost. 1972. The biology of the American kestrel in central Utah. Southwest. Nat. 17(1):73-83.

Smith, Dwight G., Charles R. Wilson, and Herbert H. Frost. 1974. History and ecology of a colony of barn owls in Utah. Condor 76(2):131-136.

Smith, Robert I. 1968a. The social aspects of reproductive behavior in the pintail. Auk 83(3):381-396.

Smith, Robert Leo. 1963. Some ecological notes on the grasshopper sparrow. Wilson Bull. 75(2):159-165.

Smith, Susan M. 1973a. A study of prey-attack behaviour in young loggerhead shrikes, *Lanius ludovicianus* L. Behaviour 44(1-2):113-141.

Smith, Susan M. 1973b. An aggressive display and related behavior in the loggerhead shrike. Auk 90(2):287-298.

Smith, Susan M. 1974b. Nest site selection in black-capped chickadees. Condor 76(4):478-479.

Smith, Walton A. 1968b. The band-tailed pigeon in California. Calif. Fish and Game 54(1):4-16.

Snapp, Barbara D. 1973. The occurrence of colonial breeding in the barn swallow (*Hirundo rustica*) and its adaptive significance. Ph. D. thesis. 209 p. Cornell Univ., Ithaca, N.Y.

Snead, Edwin, and George O. Hendrickson. 1942. Food habits of the badger in Iowa. J. Mammal. 23(4):380-391.

Snow, Carol. 1972. Habitat management series for endangered species: American peregrine falcon *Falco peregrinus anatum* and arctic peregrine falcon *Falco peregrinus tundrius*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 167, Rep. 1, 35 p. Denver, Colo.

Snow, Carol. 1973a. Habitat management series for unique or endangered species: Golden eagle *Aquila chrysaetos*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 239, Rep. 7, 52 p. Denver, Colo.

Snow, Carol. 1973b. Habitat management series for endangered species: Southern bald eagle *Haliaeetus leucocephalus leucocephalus* and northern bald eagle *Haliaeetus leucocephalus alascanus*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note No. 171, Rep. 5, 58 p. Denver, Colo.

Snow Carol. 1974a. Habitat management series for unique or endangered species: Ferruginous hawk *Buteo regalis*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 255, Rep. 13, 23 p. Denver, Colo.

Snow, Carol. 1974b. Habitat management series for unique or endangered species: Prairie falcon *Falco mexicanus*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 240, Rep. 8, 18 p. Denver, Colo.

Snow, Carol. 1974c. Habitat management series for endangered species: Spotted bat *Euderma maculatum*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 170, Rep. 4, 13 p. Denver, Colo.

Snyder, Gordon G., Harold F. Haupt, and George H. Belt, Jr. 1975. Clearcutting and burning slash alter quality of stream water in northern Idaho. USDA For. Serv. Res. Pap. INT-168, 34 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Snyder, L. L. 1949. The snowy owl migration of 1946-47. Wilson Bull. 61(2):99-102.

Soil Science Society of America. 1973. Glossary of soil science terms. 36 p. Madison, Wis.

Solomon, J. D., and R. C. Morris. 1971. Woodpeckers in the ecology of southern hardwood borers. *In* Tall Timbers Conference on Ecological Animal Control by Habitat Management, Proceedings, 1970, No. 2, p. 309-315. Tall Timbers Res. Stn., Tallahassee, Fla.

Solomon, James D. 1969. Woodpecker predation in insect borers in living hardwoods. Ann. Entomol. Soc. Am. 62(5):1214-1215.

Sooter, Clarence A. 1941a. American egret, Treganza heron, and ring-billed gull at Malheur Lake in winter. Condor 43(2):121.

Sooter, Clarence A. 1941b. Additional records of the western mockingbird in Oregon. Condor 43(3):157.

Sooter, Clarence A. 1945. Relations of the American coot with other waterfowl. J. Wildl. Manage. 9(2):96-99.

Sorenson, M. W. 1962. Some aspects of water shrew behavior. Am. Midl. Nat. 68(2):445-462.

Southern, William Edward. 1968. The role of environmental factors in ring-billed and herring gull orientation. Ph. D. diss. 292 p. Cornell Univ., Ithaca, N.Y.

Southern Forest Experiment Station. 1969. White-tailed deer in the southern forest habitat: Proceedings of a symposium at Nacogdoches, Texas, March 25-26, 1969. USDA For. Serv., in cooperation with For. Game Comm. Southeast. Sect. Wildl. Soc. and Sch. For., Stephen F. Austin State Univ. [New Orleans, La.]

Spalding, D. J., and H. B. Mitchell. 1970. Abundance and distribution of California bighorn sheep in North America. J. Wildl. Manage. 34(2):473-475.

Sparks, Donnie R. 1968. Diet of black-tailed jackrabbits on sandhill rangeland in Colorado. J. Range Manage. 21(4): 203-208.

Spencer, Howard E., Jr. 1953. The cinnamon teal (*Anas cyanoptera* Vieillot) its life history, ecology, and management. M.S. thesis. 184 p. Utah State Agric. Coll., Logan.

Springer, Alan M. 1975. Observations on the summer diet of rough-legged hawks from Alaska. Condor 77(3):338-339.

Staebler, Arthur Eugene. 1949. A comparative life history study of the downy and hairy woodpeckers (*Dendrocopos pubescens* and *Dendrocopus villosus*). Ph. D. diss. 234 p. Univ. Mich., Ann Arbor.

Stallcup, Patrick L. 1968. Spatio-temporal relationships of nuthatches and woodpeckers in ponderosa pine forests of Colorado. Ecology 49(5):831-843.

Stanley, William C. 1963. Habits of the red fox in northeastern Kansas. Univ. Kans. Mus. Nat. Hist. Misc. Publ. 34, 31 p. Topeka State Biol. Surv. Kans., Lawrence.

States, James B. 1976. Local adaptations in chipmunk (*Eutamias amoenus*) populations and evolutionary potential at species' borders. Ecol. Monogr. 46(3): 221-256.

Stebbins, Robert C. 1944. Field notes on a lizard, the mountain swift, with special reference to territorial behavior. Ecology 25(2):233-245.

Stebbins, Robert C. 1966. A field guide to western reptiles and amphibians: Field marks of all species in western North America. 279 p. Houghton Mifflin Co. Boston.

Stebbins, Robert Cyril. 1951. Amphibians of western North America. 539 p. Univ. Calif. Press, Berkeley.

Stebbins, Robert Cyril. 1954. Amphibians and reptiles of western North America. 528 p. McGraw-Hill Book Co., Inc., New York.

Stefanski, Raymond A. 1967. Utilization of the breeding territory in the black-capped chickadee. Condor 69(3):259-267.

Steiner, A. L. 1971. Play activity of Columbian ground squirrels. Z. Tierpsychol. 28(3):247-261.

Steirly, C. C. 1957. Nesting ecology of the red-cockaded woodpecker in Virginia. Atl. Nat. 12(6):280-292.

Stelfox, John G. 1976. Range ecology of Rocky Mountain bighorn sheep in Canadian national parks. Can. Wildl. Serv. Rep. Ser. 39, 50 p. Ottawa.

Stepney, Philip H. R. 1975. Wintering distribution of Brewer's blackbird: Historical aspect, recent changes, and fluctuations. Bird-Banding 46(2):106-125.

Stewart, Paul A. 1952. Dispersal, breeding behavior, and longevity of banded barn owls in North America. Auk 69(3): 227-245.

Stickel, Paul W. 1940. The effect of basal-wounding by fire on trees in the Northeast. USDA For. Serv. Northeast. For. Exp. Stn. Tech. Note 30, 2 p.

Stoddard, Herbert L. 1931. The bobwhite quail: Its habits, preservation and increase. 559 p. Charles Scribner's Sons, New York.

Stoddard, Herbert L. 1961. The cooperative quail study association. Tall Timbers Res. Stn. Misc. Publ. 1, 500 p. Tallahassee, Fla.

Stoner, Dayton. 1936. Studies on the bank swallow *Riparia riparia riparia* (Linnaeus) in the Oneida Lake region. Roosevelt Wild Life Ann. 4(2):126-233. Roosevelt Wild Life For. Exp. Stn., N.Y. State Coll. For. Syracuse Univ., Syracuse.

Storer, T. I., F. P. Cronemiller, E. E. Horn, and Ben Glading. 1942. Studies on valley quail. Calif. Agric. Stn. Bull. 663: 130-135.

Storm, Gerald L., Ronald D. Andrews, Robert L. Phillips, Richard A. Bishop, Donald B. Siniff, and John R. Tester. 1976. Morphology, reproduction, dispersal, and mortality of midwestern red fox populations. Wildl. Monogr. 49, 82 p.

Storm, Robert M. 1966. Endangered plants and animals of Oregon: II. Amphibians and reptiles. Agric. Exp. Stn. Spec. Rep. 206, 12 p. Oreg. State Univ., Corvallis.

Stout, I. Jack, and Daniel E. Sonenshine. 1974. Ecology of an opossum population in Virginia, 1963-69. Acta Theriol. 19(15):235-245.

Streubel, Donald P. 1968. Food storing and related behavior of red squirrels (*Tamiasciurus hudsonicus*) in interior Alaska. M.S. thesis. 56 p. Univ. Alaska, Fairbanks.

Struthers, Parke H. 1928. Breeding habits of the Canadian porcupine (*Erethizon dorsatum*). J. Mammal. 9(4):300-308.

Stull, Olive Griffith. 1940. Variations and relationships in the snakes of the genus *Pituophis*. U.S. Nat. Mus. Bull. 175, 225 p. Washington, D.C.

Sturman, William A. 1968. Description and analysis of breeding habitats of the chickadees, *Parus atricapillus* and *P. rufescens*. Ecology 49(3):418-431.

Sullivan, Edward G. 1956. Gray fox reproduction, denning, range and weights in Alabama. J. Mammal. 37(3):346-351.

Summers-Smith, James Denis. 1963. The house sparrow. 269 p. Collins, London.

Summers-Smith, James Denis. 1967. An annotated bibliography of the genus *Passer*. Int. Stud. Sparrows 1(2):3-82.

Summers-Smith, James Denis, and J. Pinowski. 1968. An annotated bibliography of the genus *Passer*. II. Int. Stud. Sparrows 2(2):43-75.

Sumner, E. Lowell, Jr. 1935. A life history study of the California quail, with recommendations for its conservation and management. Calif. Fish and Game 21(3):167-256.

Sundstrom, Charles, William G. Hepworth, and Kenneth L. Diem. 1973. Abundance, distribution and food habits of the pronghorn: A partial characterization of the optimum pronghorn habitat. Wyo. Game and Fish Comm. Bull. 12, 61 p. Cheyenne.

Swanson, Donald Oscar. 1970. Roosevelt elk-forest relationships in the Douglas-fir region of the southern Oregon Coast Range. Ph. D. thesis. 186 p. Univ. Mich., Ann Arbor.

Swanson, Frederick J., George W. Lienkaemper, and James R. Sedell. 1976. History, physical effects, and management implications of large organic debris in western Oregon streams. USDA For. Serv. Gen. Tech. Rep. PNW-56, 15 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Swanson, George A., Mavis I. Meyer, and Jerome R. Serie. 1974. Feeding ecology of breeding blue-winged teals. J. Wildl. Manage. 38(3):396-407.

Swanson, John Roger. 1974. Prescribed underburning for wildfire hazard abatement in second-growth stands of westside Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). M.S. thesis. 130 p. Univ. Wash., Seattle.

Swarth, H. S. 1936. Savannah sparrow migration routes in the Northwest. Condor 38(1):30-32.

Swenson, Jon Eugene. 1975. Ecology of the bald eagle and osprey in Yellowstone National Park. M.S. thesis. 146 p. Mont. State Univ., Bozeman.

Swift, M. J., I. N. Healey, J. K. Hibberd, J. M. Sykes, V. Bampoe, and M. E. Nesbitt. 1976. The decomposition of branch-wood in the canopy and floor of a mixed deciduous woodland. Oecologia (Berl.) 26(2):139-149.

Tabor, James Eldon. 1974. Productivity, survival, and population status of river otter in western Oregon. M.S. thesis. 62 p. Oreg. State Univ., Corvallis.

Tanner, James Taylor. 1942. The ivory-billed woodpecker. Res. Pap. 1, p. 44, 81-82. N. Y. Natl. Audubon Soc., New York. [Reprinted 1966 by Dover Publ., New York.]

Taylor, Walter P. 1935. Ecology and life history of the porcupine (*Erethizon epixanthum*) as related to the forests of Arizona and the Southwestern United States. Univ. Ariz. Bull. Biol. Sci. Bull. 3, 6(5), 177 p. Tucson.

Taylor, Walter, P., Ed. 1956. Preface. *In* The deer of North America: The white-tailed, mule and black-tailed deer, genus *Odocoileus*, their history and management, p. ix-xi. Stackpole Co., Harrisburg, Pa., and Wildl. Manage. Inst., Washington, D.C.

Taylor, Walter Penn, and William T. Shaw. 1927. Mammals and birds of Mount Rainier National Park. 249 p. U.S. Gov. Print. Off., Washington, D.C.

Terrel, Ted Leon. 1973. Mule deer use patterns as related to pinyon-juniper conversion in Utah. Ph. D. diss. 187 p. Utah State Univ., Logan.

Tevis, Lloyd, Jr. 1952. Autumn foods of chipmunks and golden-mantled ground squirrels in the northern Sierra Nevada. J. Mammal. 33(2):198-205.

Tevis, Lloyd, Jr. 1953. Stomach contents of chipmunks and mantled squirrels in northeastern California. J. Mammal. 34(3):316-324.

Thiessen, J. L. 1976. Some relations of elk to logging, roading and hunting in Idaho's game management unit 39. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 3-5. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Thomas, Jack Ward. 1973. The determination of habitat requirements for birds in suburban areas: A pilot study. Ph. D. diss. 245 p. Univ. Mass., Amherst.

Thomas, Jack Ward, Glenn L. Crouch, Roger S. Bumstead, and Larry D. Bryant. 1975. Silvicultural options and habitat values in coniferous forests. *In* Proceedings of the symposium on management of forest and range habitats for nongame birds. D. R. Smith, ed. USDA For. Serv. Gen. Tech. Rep. WO-1, p. 272-287. Washington, D.C.

Thomas, Jack Ward, Richard M. DeGraaf, and Joseph C. Mawson. 1977. Determination of habitat requirements for birds in suburban areas. USDA For. Serv. Res. Pap. NE-357, 15 p. Northeast. For. Exp. Stn., Upper Darby, Pa.

Thomas, Jack Ward, Rodney J. Miller, Hugh Black, Jon E. Rodiek, and Chris Maser. 1976. Guidelines for maintaining and enhancing wildlife habitat in forest management in the Blue Mountains of Oregon and Washington. 41st North Am. Wildl. and Nat. Resour. Conf. Trans., p. 452-476. Wildl. Manage. Inst., Washington, D.C.

Thompson, Benjamin Hunter. 1932. History and present status of the breeding colonies of white pelican (*Pelecanus erythrorhynchos*) in the United States. M.A. thesis. 82 p. Univ. Calif., Berkeley.

Thompson, William L. 1976. Vocalizations of the lazuli bunting. Condor 78(2):195-207.

Thornton, W. A. 1960. Population dynamics in *Bufo woodhousei* and *Bufo valliceps*. Tex. J. Sci. 12(3-4):176-200.

Thut, Rudolph N. 1970. Feeding habits of the dipper in southwestern Washington. Condor 72(2):234-235.

Tinbergen, N. 1935. Field observations of east Greenland birds: I. The behavior of the red-necked phalarope (*Phalaropus lobatus* L.) in spring. Ardea 24:1-42.

Tinbergen, N. 1939. The behavior of the snow bunting in spring. Trans. Linn. Soc. N. Y. 5:1-94.

Tinbergen, L. 1960. The natural control of insects in pinewoods: I. Factors influencing the intensity of predation by songbirds. *In* The dynamics of insect and bird populations in pine woods. Arch. Neerl. Zool. 13(3):265-335.

Tinkle, Donald W. 1967. The life and demography of the side-blotched lizard, *Uta stansburiana*. Univ. Mich. Mus. Zool. Misc. Publ. 132, 182 p. Ann Arbor.

Tinkle, Donald W. 1973. A population analysis of the sagebrush lizard, *Sceloporus graciosus* in southern Utah. Copeia 1973(2):284-296.

Tompa, Frank S. 1962. Territorial behavior: The main controlling factor of a local song sparrow population. Auk 79(4):687-697.

Toole, E. Richard. 1960. Butt rot of southern hardwoods. U.S. Dep. Agric. For. Pest Leafl. 43, 4 p. Washington, D.C.

Toweill, Dale E. 1974. Winter food habits of river otters in western Oregon. J. Wildl. Manage. 38(1):107-111.

Trappe, James M., and Robert D. Fogel. 1977. Ecosystematic functions of mycorrhizae. *In* The belowground symposium: A synthesis of plant-associated processes. Range Sci. Dep. Sci. Ser. 26, p. 205-214. Colo. State Univ., Fort Collins.

Trappe, James M., and Chris Maser. 1976. Germination of spores of *Glomus macrocarpus* (Endogonaceae) after passage through a rodent digestive tract. Mycologia 68(2):433-436.

Trimble, Stephen A. 1975a. Habitat management series for unique or endangered species: Merlin *Falco columbarius*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 271, Rep. 15, 41 p. Denver, Colo.

Trimble, Steve. 1975b. Non-game birds of the West: An annotated bibliography; the ecology and life histories of seven orders. U.S. Dep. Inter., Bur. Land Manage. Tech. Note T-N-269, 320 p. Denver, Colo.

Trippensee, Reuben Edwin. 1948. Wildlife management: Upland game and general principles. Vol. 1, 479 p. McGraw-Hill Book Co., Inc., New York.

Tuck, Leslie M. 1972. The snipes: A study of the genus Capella. Can. Wildl. Serv. Monogr. Ser. 5, 429 p. Ottawa.

Tueller, Paul T., and Leslie A. Monroe. [1975.] Management guidelines for selected deer habitats in Nevada. Agric. Exp. Stn. Publ. R104, 185 p. Univ. Nev., Reno.

Turcek, Frank J. 1948. Birds in an oak forest during a gypsy moth outbreak in South-Slovakia. Am. Midl. Nat. 40(2): 391-394.

Turner, Bruce C., and William Threlfall. 1975. The Metazoan parasites of green-winged teal (*Anas crecca* L.) and blue-winged teal (*Anas discors* L.) from eastern Canada. Proc. Helminthol. Soc. Wash. 42(2):157-169.

Turner, Frederick, B. 1960. Population structure and dynamics of the western spotted frog, *Rana p. pretiosa* Baird and Girard, in Yellowstone Park, Wyoming. Ecol. Monogr. 30(3):251-278.

Turner, Larry W. 1972. Habitat differences between *Spermophilus beldingi* and *Spermophilus columbianus* in Oregon. J. Mammal. 53(4):914-917.

Tuttle, Merlin D., and Lawrence R. Heaney. 1974. Maternity habits of *Myotis leibii* in South Dakota. South. Calif. Acad. Sci. Bull. 73(2):80-83. Los Angeles.

Twombly, Asa D. 1977. Even-aged silviculture. *In* Integration of forest resource management in the Blue Mountains, p. 47-49. John Herbst, ed. Oreg. State Univ. Ext. Serv., and Blue Mt. Chapter Soc. Am. For., Corvallis.

Tyler, Winsor M. 1916. A study of a white-breasted nuthatch. Wilson Bull. 28(1):18-25.

U.S. Department of Agriculture, Forest Service. 1956. Glossary of terms used in forest fire control. U.S. Dep. Agric. Agric. Handb. 104, 24 p. Washington, D.C.

U.S. Department of Agriculture, Forest Service. 1968. Guide for fuel type identification. USDA For. Serv. Reg. 6, 48 p. Portland, Oreg.

U.S. Department of Agriculture, Forest Service. 1971a. Endangered-rare-unique species in Region 6 as of March 1971. Unpublished report on file at Reg. 6, Portland, Oreg.

U.S. Department of Agriculture, Forest Service. 1971b. Wildlife habitat management handbook, Southern Region, FSH 2609.23R. 189 p. U.S. Dep. Agric. For. Serv. Reg. 8, Atlanta, Ga.

U.S. Department of Agriculture, Forest Service. 1973a. Wildlife habitat management guide for the National Forests in Missouri. 42 p. Mark Twain Natl. For., Rolla, Mo. [In cooperation with the Mo. Dep. Conserv.]

U.S. Department of Agriculture, Forest Service. 1973b. Silvicultural systems for the major forest types of the United States. U.S. Dep. Agric. Agric. Handb. 445, 114 p. Washington, D.C.

U.S. Department of Agriculture, Forest Service. 1973c. The outlook for timber in the United States. For. Resour. Rep. 20, 367 p. Washington, D.C.

U.S. Department of Agriculture, Forest Service. 1974. Silvicultural examination and prescription handbook. USDA For. Serv. FSH 2409.26d, Reg. 6, 106 p. Portland, Oreg.

U.S. Department of Agriculture, Forest Service. 1975. Fisheries and wildlife habitat management handbook, Ottawa, Hiawatha, and Huron-Manistee National Forests, Michigan, FSH 2609.23-R9. U.S. Dep. Agric. For. Serv. Reg. 9, Milwaukee, Wis.

U.S. Department of Agriculture, Forest Service. 1976a. Final environmental statement & renewable resource program—1977 to 2020. (RPA: A recommended renewable resource program.) 658 p. Washington, D.C.

U.S. Department of Agriculture, Forest Service. 1976b. The National Forest Management Act of 1976. Curr. Inf. Rep. 16, 43 p. Washington, D.C.

U.S. Department of Agriculture, Forest Service. 1978a. Draft environmental statement: Roadless area review and evaluation. 112 p. [Plus RARE II maps A and B.] Washington, D.C.

U.S. Department of Agriculture, Forest Service. 1978b. An overview of the TRI System. 12 p. [Plus append., map, and microfiche.] Unpublished report on file at Pac. Northwest Reg., TRI Service Center, P.O. Box 3623, Portland, Oreg. 97208.

U.S. Department of Agriculture, Forest Service. [n.d.] Snag management: Coordination guidelines for wildlife, No. 1. 11 p. Calif. Reg.

U.S. Department of Agriculture, Press Service. 1921. Mice and chipmunks help restock forests. J. Mammal. 2(2): 113.

U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife. 1973. Threatened wildlife of the United States. ["Red Book."] Resour. Publ. 114, 289 p. Off. Endangered Species and Int. Act., Washingtion, D.C.

U.S. Department of the Interior, Fish and Wildlife Service. 1962. Abstracts of mourning dove literature. U.S. Fish and Wildl. Serv. Circ. 136, 153 p. Washington, D.C.

U.S. Fish and Wildlife Service. 1976. Endangered and threatened wildlife and plants: Republication of the list of species. Fed. Regist. 41 (Oct. 27):47179-47198.

U.S. Laws, Statutes, etc. Public Law 85-624. [H.R. 13138], August 12, 1958. To amend the Act of March 10, 1934, to provide for more effective integration of a fish and wildlife conservation program with Federal water-resource developments, and for other purposes. *In its* United States statutes at large. 1958. Vol. 72, p. 563. Washington, D.C., U.S. Gov. Print. Off., 1959. [16 U.S.C. sec. 661-664 (1959).]

U.S. Laws, Statutes, etc. Public Law 86-517. [H.R. 10572], June 12, 1960. An act to authorize and direct that the National Forests be managed under principles of multiple use and to produce a sustained yield of products and services, and for other purposes. *In its* United States statutes at large. 1960. Vol. 74, p. 215. U.S. Gov. Print. Off., Washington, D.C. 1961. [16 U.S.C. sec. 528-531 (1976).]

U.S. Laws, Statutes, etc. Public Law 91-135. [H.R. 11363], December 5, 1969. Endangered Species Conservation Act of 1969. *In its* United States statutes at large. 1969. Vol. 83, p. 275. Washington, D.C., U.S. Gov. Print. Off., 1970. [16 U.S.C. sec. 668 (1970).]

U.S. Laws, Statutes, etc. Public Law 91-190. [S. 1075], Jan. 1, 1970. National Environmental Policy Act of 1969. An act to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality, and for other purposes. *In its* United States statutes at large. 1969. Vol. 83, p. 852-856. U.S. Gov. Print. Off., Washington, D.C. 1970. [42 U.S.C. sec. 4321, et seq. (1970).]

U.S. Laws, Statutes, etc. Public Law 93-205. [S. 1983], December 28, 1973. Endangered Species Act of 1973. *In its* United States statutes at large. 1973. Vol. 87, p. 884. [16 U.S.C. sec. 668 (1976).]

U.S. Laws, Statutes, etc. Public Law 93-378. [S. 2296], Aug. 17, 1974. Forest and Rangeland Renewable Resources Planning Act of 1974. An act to provide for the Forest Service, Department of Agriculture, to protect, develop, and enhance the productivity and other values of certain of the Nation's lands and resources, and for other purposes. *In its* United States statutes at large. 1974. Vol. 88, Part 1, p. 476-480. U.S. Gov. Print. Off., Washington, D.C. 1976. [16 U.S.C. sec. 1601(1976).]

U.S. Laws, Statutes, etc. Public Law 93-452. [H.R. 11537], October 18, 1974. An act to extend and expand the authority for carrying out conservation and rehabilitation programs on military reservations and to authorize the implementation of such programs on certain public lands. *In its* United States statutes at large. 1974. Vol. 88, p. 1369. Washington, D.C., U.S. Govt. Print. Off., 1976. [16 U.S.C. sec. 670 (1976).]

U.S. Laws, Statutes, etc. Public Law 94-588 [S. 3091], Oct. 22, 1976. National Forest Management Act of 1976. *In* United States code congressional and administrative news. 94th Congr. 2d Sess., 1976. Vol. 2, p. 2949-2963. West Publ. Co., St. Paul, Minn. [1976.] [16 U.S.C. sec. 1600(1976).]

Urban, David. 1970. Raccoon populations, movement patterns, and predation on a managed waterfowl marsh. J. Wildl. Manage. 34(2):372-382.

Urhahn, Helmuth J. M. 1968. Feeding requirements, feeding ecology, and feeding behavior of the great blue heron. Term pap. 40 p. Univ. B. C., Dep. Zool., Vancouver.

Urner, Chas. A. 1925. Notes on two ground-nesting birds of prey. Auk 42(1): 31-41.

Van Ballenberghe, Victor, Albert W. Erickson, and David Byman. 1975. Ecology of the timber wolf in northeastern Minnesota. Wildl. Monogr. 43, 43 p.

VanCamp, Laurel F., and Charles J. Henny. 1975. The screech owl: Its life history and population ecology in northern Ohio. U.S. Dep. Inter. Fish and Wildl. Serv., North Am. Fauna 71, 65 p. Washington, D.C.

Van de Velde, Robert L., Jan Martan, and Paul L. Risley. 1962. Eggs and hatchlings of the snake *Coluber constrictor mormon* from Oregon. Copeia 1962(1): 212-213.

Van Meter, Wayne P., and Charles E. Hardy. 1975. Predicting effects on fish of fire retardants in streams. USDA For. Serv. Res. Pap. INT-166, 16 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Van Tets, Gerrard Frederick. 1959. A comparative study of the reproductive behavior and natural history of three sympatric species of cormorants, *Phalacrocorax auritus, P. penicillatus,* and *P. pelagicus.* M.A. zoology thesis. 86 p. Univ. B. C., Vancouver.

Vaughan, Michael R. 1975. Aspects of mountain goat ecology, Wallowa Mountains, Oreg. M.S. thesis. 113 p. Oreg. State Univ., Corvallis.

Verbeek, Nicolaas A. M. 1967. Breeding biology and ecology of the horned lark in alpine tundra. Wilson Bull. 79(2):208-218.

Verbeek, Nicolaas A. M. 1970. Breeding ecology of the water pipit. Auk 87(3): 425-451.

Vermeer, Kees. 1967. A study of two species of gulls, *Larus californicus* and *Larus delawarensis,* breeding in an inland habitat. Ph. D. diss. 157 p. Univ. Alberta, Edmonton.

Verner, Jared. 1975a. Complex song repertoire of male long-billed marsh wrens in eastern Washington. Living Bird, 14th Annu. 1975, p. 263-300. Cornell Lab. Ornithol., New York.

Verner, Jared. 1975b. Interspecific aggression between yellow-headed blackbirds and long-billed marsh wrens. Condor 77(3):328-331.

Verner, Jared, and Gay H. Engelsen. 1970. Territories, multiple nest building, and polygyny in the long-billed marsh wren. Auk 87(3):557-567.

Verts, B. J. 1967. The biology of the striped skunk. 218 p. Univ. Ill. Press, Urbana.

Vos, Anton de. 1952. The ecology and management of fisher and marten in Ontario. Ont. Dep. Lands and For. Tech. Bull., 90 p. Toronto.

Vuilleumier, Francois. 1973. Insular biogeography in continental regions: II. Cave faunas from Tessin, southern Switzerland. Syst. Zool. 22(1):64-76.

W. B. Saunders Company. 1968. Dorland's pocket medical dictionary, 21st edition. 699 p. Philadelphia, Pa.

Wagener, Willis W., and Harold R. Offord. 1972. Logging slash: Its breakdown and decay at two forests in northern California. USDA For. Serv. Res. Pap. PSW-83, 11 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

Waian, Lee B., and Rey C. Stendall. 1970. The white-tailed kite in California with observations of the Santa Barbara population. Calif. Fish and Game 56(3):188-198.

Wakeley, James S. 1974. Activity periods, hunting methods and efficiency of the ferruginous hawk. Raptor Res. 8(3-4):67-72.

Walker, Alex. 1935. The snowy egret in Oregon. Condor 37(2):80.

Walkinshaw, Lawrence H. 1949. The sandhill cranes. Cranbrook Inst. Sci. Bull. 29, 202 p. Bloomfield Hills, Mich.

Wall, Brian R. 1965. 1964 Oregon log production. USDA For. Serv. Resour. Bull. PNW-13, 2 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Wall, Brian R. 1965-72. Washington timber harvest. USDA For. Serv. Resour. Bull. PNW-14, PNW-18, PNW-21, PNW-25, PNW-30, PNW-34, PNW-37, and PNW-41. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Wall, Brian R. 1966-72. Oregon timber harvest. USDA For. Serv. Resour. Bull. PNW-16, PNW-22, PNW-27, PNW-29, PNW-33, PNW-38, and PNW-43. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Wallestad, Richard. 1975. Life history and habitat requirements of sage grouse in central Montana. Mont. Dep. Fish and Game, Game Manage. Div., 66 p. Helena.

Wallmo, O. C. 1969. Response of deer to alternate-strip clearcutting of lodgepole pine and spruce-fir timber in Colorado. USDA For. Serv. Res. Note RM-141, 3 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Ward, A. Lorin. 1976. Elk behavior in relation to timber harvest operations and traffic on Medicine Bow Range in south-central Wyoming. *In* Proceedings of the elk-logging-roads symposium, Moscow, Idaho, Dec. 16-17, 1975. p. 32-43. Susan R. Hieb, ed. Univ. Idaho, Moscow.

Warren, Edward R. 1926. A study of the beaver in the Yancey region of Yellowstone National Park. Roosevelt Wild Life Ann. 1(1-2):13-191.

Weaver, Richard Lee. 1939. Winter observations and a study of the nesting of English sparrows. Bird-Banding 10:73-79.

Weber, Wayne C. 1975. Occurrence and possible breeding of the white-throated swift at Spences Bridge, British Columbia. Murrelet 56(2):10-11.

Weeden, J. Stenger. 1965. Territorial behavior of the tree sparrow. Condor 67(3): 193-209.

Weeden, Robert Barton. 1960. The ecology and distribution of ptarmigan in western North America. Ph. D. diss. 247 p. Univ. B. C., Vancouver.

Welsh, Daniel A. 1975. Savannah sparrow breeding and territoriality on a Nova Scotia dune beach. Auk 92(2):235-251.

Westerskov, Kaj E. 1949. A comparative study of the ecology and management of the European partridge, *Perdix p. perdix,* in Ohio and Denmark. M.S. thesis. 339 p. Ohio State Univ., Columbus.

Weston, John Bradford. 1969. Nesting ecology of the ferruginous hawk *Buteo regalis.* Brigham Young Univ. Sci. Bull. Biol. Ser. 10(4):25-36.

Wetmore, Alexander. 1964. Song and garden birds of North America. 400 p. Natl. Geogr. Soc., Washington, D.C.

Wheeler, Richard J. 1965. Pioneering of blue-winged teal in California, Oregon, Washington, and British Columbia. Murrelet 46(3):40-42.

Whitaker, Gene A. 1974. Phoebe and barn swallow nesting structures. 31st Northeast. Fish and Wildl. Conf. Trans., p. 57-62. Northeast Sect. Wildl. Soc. [USDA Conserv. Serv., College Park, Md.]

Whitaker, John O., Jr., and Chris Maser. 1976. Food habits of five western Oregon shrews. Northwest Sci. 50(2):102-107.

Whitaker, John O., Jr., Chris Maser, and Laurel E. Keller. 1977. Food habits of bats of western Oregon. Northwest Sci. 51(1):46-55.

Whitaker, John O., Jr., and Russell E. Mumford. 1972. Ecological studies on *Reithrodontomys megalotis* in Indiana. J. Mammal. 53(4):850-860.

Whitford, Walter G. 1976. Temporal fluctuations in density and diversity of desert rodent populations. J. Mammal. 57(2):351-369.

Wiens, John Anthony. 1966. An approach to the study of ecological relationships among grassland birds. Ph. D. thesis. 277 p. Univ. Wis., Madison.

Wiewandt, Thomas A. 1969. Vocalization, aggressive behavior, and territoriality in the bullfrog, *Rana catesbeiana.* Copeia 1969(2):276-285.

Wight, Howard M. 1974. Nongame wildlife and forest management. *In* Wildlife and forest management in the Pacific Northwest, p. 27-38, Hugh C. Black, ed. Sch. For., Oreg. State Univ., Corvallis.

Wight, Howard M., Robert U. Mace, and Wesley M. Batterson. 1967. Mortality estimates of an adult band-tailed pigeon population in Oregon. J. Wildl. Manage. 31(3):519-525.

Willey, Charles Harvey. 1968. The ecology, distribution and abundance of the mute swan (*Cygnus olor*) in Rhode Island. M.S. thesis. 93 p. Univ. R. I., Kingston.

Williams, Laidlaw. 1941. Roosting habits of the chestnut-backed chickadee and the Bewick wren. Condor 43(6):274-285.

Williamson, Penelope. 1971. Feeding ecology of the red-eyed vireo (*Vireo olivaceus*) and associated foliage-gleaning birds. Ecol. Monogr. 41(2):129-152.

Willner, Gale R., Joseph A. Chapman, and James R. Goldsberry. 1975. A study and review of muskrat food habits with special reference to Maryland. Md. Wildl. Adm. Publ. Wildl. Ecol. 1, 25 p. [Md. Dep. Nat. Resour., LaVale.]

Willson, Mary F. 1966. Breeding ecology of the yellow-headed blackbird. Ecol. Monogr. 36(1):51-77.

Willson, Mary F., and Gordon H. Orians. 1963. Comparative ecology of red-winged and yellow-headed blackbirds during the breeding season. 16th Int. Congr. Zool. Proc. 3:342-346.

Winn, David S. 1976. Terrestrial vertebrate fauna and selected coniferous forest habitat types on the north slope of the Unita Mountains. USDA For. Serv. Reg. 4, Wasatch Natl. For., 145 p. Salt Lake City, Utah.

Winter, Jon. 1974. The distribution of the flammulated owl in California. West. Birds 5(2):25-44.

Wirtz, William O., II., and Paul G. Pearson. 1960. A preliminary analysis of habitat orientation in *Microtus* and *Peromyscus*. Am. Midl. Nat. 63(1):131-142.

Wiseman, Arthur J. 1975. Changes in body weight of American goldfinches. Wilson Bull. 87(3):390-411.

Wolfe, Michael L., and Durward L. Allen. 1973. Continued studies of the status, socialization, and relationships of Isle Royale wolves, 1967 to 1970. J. Mammal. 54(3):611-635.

Wolff, Jerry O., and John C. Zasada. 1975. Red squirrel response to clearcut and shelterwood systems in interior Alaska. USDA For. Serv. Res. Note PNW-255, 7 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Wood, John E. 1958. Age structure and productivity of a gray fox population. J. Mammal. 39(1):74-86.

Wood, Thomas J., and Stanley A. Munroe. 1977. Dynamics of snowshoe hare populations in the Maritime Provinces. Can. Wildl. Serv. Occas. Pap. 30, 21 p. Ottawa.

Woodbury, Marian, and Angus M. Woodbury. 1945. Life-history studies of the sagebrush lizard *Sceloporus g. graciosus* with special reference to cycles in reproduction. Herpetologica 2(7-8):175-196.

Wooding, Jerry. 1973. Census of the breeding birds of the Roaring Fork watershed. Colo. Field Ornithol. 18:23-37.

Woods, John G. 1972. An introduction to the literature on the saw-whet owl. Ont. Bird-Banding 8(1):8-23.

Work, Lewis M. 1977. Uneven-aged management. *In* Integration of forest resource management in the Blue Mountains, p. 50-54. John Herbst, ed. Oreg. State Univ. Ext. Serv. and Blue Mt. Chapter Soc. Am. For., Corvallis.

Wright, Ernest. 1971. *Mycorrhizae* on Douglas-fir and ponderosa pine seedlings. Oreg. State Univ. Sch. For. Res. Bull. 13, 36 p. Corvallis.

Wright, Ernest, and Leo A. Isaac. 1956. Decay following logging injury to western hemlock, Sitka spruce, and true firs. U.S. Dep. Agric. Tech. Bull. 1148, 34 p. Washington, D.C.

Wright, Albert Hazen, and Anna (Allen) Wright. 1949. Handbook of frogs and toads, of the United States and Canada. 640 p. Comstock Publ. Co., Inc., Ithaca, N.Y.

Wright, Albert Hazen, and Anna (Allen) Wright. 1957. Handbook of snakes of the United States and Canada. 2 vols. 1,105 p. Comstock Publ. Assoc., Cornell Univ. Press, Ithaca, N.Y.

Wythe, Margaret W. 1938. The white-throated sparrow in western North America. Condor 40(3):110-117.

Yoakum, Jim. 1967. Literature of the American pronghorn antelope: An annotated bibliography with abstracts emphasizing food habits and range relationships. U.S. Dep. Inter., Bur. Land Manage., 82 p. Reno, Nev.

Yocom, Charles F. 1943. The Hungarian partridge, *Perdix perdix* L. in the Palouse region, Washington. Ecol. Monogr. 13(2):167-201.

Yocom, Charles F. 1974a. Recent wolverine records in Washington and Oregon. Murrelet 55(2):15-18.

Yocom, Charles F. 1974b. Status of marten in northern California, Oregon and Washington. Calif. Fish and Game 60(1):54-57.

Young, Howard. 1955. Breeding behavior and nesting of the eastern robin. Am. Midl. Nat. 53(2):329-352.

Young, J. A., D. W. Hedrick, and R. F. Keniston. 1967. Forest cover and logging-herbage and browse production in the mixed coniferous forest of northeastern Oregon. J. For. 65(11):807-813.

Young, Vernon A., and W. Leslie Robinette. 1939. A study of the range habits of elk on the Selway Game Preserve. Univ. Idaho Bull. 34(16), 48 p.

Yousef, M. K., and W. G. Bradley. 1971. Physiological and ecological studies on *Citellus lateralis*. Comp. Biochem. and Physiol. 39(4A):671-682.

Zak, Bratislav. 1964. Role of mycorrhizae in root disease. Annu. Rev. Phytopathol. 2:377-392.

Zarn, Mark. 1974a. Habitat management series for unique or endangered species: Osprey *Pandion haliaetus carolinensis*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 254, Rep. 12, 41 p. Denver, Colo.

Zarn, Mark. 1974b. Habitat management series for unique or endangered species: Burrowing owl *Speotyto cunicularia hypugaea*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 250, Rep. 11, 25 p. Denver, Colo.

Zarn, Mark. 1974c. Habitat management series for unique or endangered species: Spotted owl *Strix occidentalis*. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 242, Rep. 10, 22 p. Denver, Colo.

Zarn, Mark, Thomas Heller, and Kay Collins. 1977a. Wild, free-roaming horses: Status of present knowledge. Tech. Note 294, 72 p. U.S. Dep. Inter., Bur. Land Manage., and USDA For. Serv.

Zarn, Mark., Thomas Heller, and Kay Collins. 1977b. Wild, free-roaming horses: An annotated bibliography. Tech. Note 295, 54 p. U.S. Dep. Inter., Bur. Land Manage., and USDA For. Serv.

Zeedyk, William D., and Robert B. Hazel. 1974. The southeastern featured species plan. *In* Timber-wildlife management symposium. J. P. Slusher and T. M. Hinckley, eds. Mo. Acad. Sci. Occas. Pap. 3, p. 58-62. Columbia.

Zirul, D. L., and W. A. Fuller. 1970. Winter fluctuations in size of home range of the red squirrel (*Tamiasciurus hudsonicus*). 35th North Am. Wildl. and Nat. Res. Conf. Trans., p. 115-127. Wildl. Manage. Inst., Washington, D.C.

Glossary

abiotic the nonliving components of the environment, such as air, rocks, soil, water, coal, peat, plant litter, etc. (Schwarz et al. 1976).

abrupt edge an edge between stands or communities that is regular (i.e., straight lines or gently sweeping curves) leading to relatively low amounts of edge per unit area.

adapted the suitability of an organism for a particular condition, usually habitat, which comes from the process by which an organism becomes better suited to its environment or particular functions.

adjunct a stand attached to or joining another stand.

adventitious root a root arising from a plant part other than preexisting roots, such as from a stem or leaf (Ford-Robertson 1971).

aerate to mix air and water so that the oxygen content of the water is enhanced.

aerial oblique photograph a photograph of a landscape taken from an aircraft or elevated position with the camera at an angle of less than 90° to the earth's surface.

age classes intervals (commonly 10 years) into which the age range of a tree crop is divided; also the trees falling into such an interval (Ford-Robertson 1971).

ambient surrounding, encircling (Morris 1976).

angiosperm any of a class of plants that is identified by having their seeds enclosed in an ovary (Mason 1975).

animal community (also see "habitat niche") the species of animals supported by a combination of habitat niches.

animal complex the variety of species that together form the fauna of a particular area.

animal habitat the arrangement of food, cover, and water required to meet the biological needs of an animal.

apical growth growth from the terminal shoot meristem.

aquatic habitat habitat that occurs in free water.

aquatic zone an area covered by water.

area control an indirect method of controlling (and roughly determining) the amount of forest produce to be harvested, annually or periodically, on the basis of stocked area (Ford-Robertson 1971); synonymous with "area regulation."

area regulation see "area control."

arithmetical mean see "mean."

arthropod any invertebrate organism of the phylum Arthropoda, which includes the insects, crustaceans, arachnids, and myriapods, having a horny, segmented, external covering and jointed limbs (Morris 1976).

ascomycetes fungi with hyphae divided into cells by cross septa; with asexual reproduction by conidia and sexual reproduction by the formation of ascospores in the ascus (Abercrombie et al. 1964).

asexual having no evident sex or sex organs; sexless; pertaining to or characterizing reproduction involving a single individual, and without male or female gametes, such as binary fission or budding (Morris 1976).

aspect the direction toward which a slope faces (Ford-Robertson 1971).

average snag life the average time a class of snags (based on species and d.b.h.) may be expected to stand after death.

basal area (also see "crop basal area" and "stand basal area") the area of the cross section of a tree stem near its base, generally at breast height—1.37 meters (4.5 ft)—above the ground and inclusive of bark (Ford-Robertson 1971).

basal metabolism the measure of metabolism of the body in the resting state, determined by the amount of oxygen utilized or of heat produced (W. B. Saunders Company 1968).

basalt (also see "igneous") of or pertaining to basalt, an extrusive igneous rock.

base use potential the amount of use expected by deer and elk on a land-type when all forest sites meet the definition of hiding or thermal cover or both.

bedding the process of an animal lying down for rest.

best estimate the best possible approximation given a combination of available information and understanding of a situation.

best-prediction equation the equation which best predicts, on the basis of existing information, the relationship between two or more variables.

Betulaceae a family of plants; specifically, the birch family.

big game large animals hunted, or potentially hunted, for sport; in the Blue Mountains area—elk, mule deer, big-horned sheep, pronghorn, black bear, and puma.

binomial the latinized name of an organism consisting of two words, the first of which is the genus and the second the species (Hanson 1962); synonymous with scientific name.

biological control the use of organisms or viruses to control parasites, weeds, or other pests (Hanson 1962).

biological potential the maximum production of a selected organism that can be attained under optimum management.

biomass the total quantity of living organisms of one or more species per unit of space which is called species biomass, or of all the species in a community which is called community biomass (Hanson 1962).

biotic life or the act of living (Hanson 1962).

biotrophic levels the feeding levels in a food chain.

bird box a box with an entrance hole into a hollow interior; these boxes, when mounted in the forest, provide nesting and roosting sites primarily for secondary cavity-using species.

blowdown (also see "windthrow") trees felled by high winds.

blue stain the most common form of fungal stain of the sap stain type, producing a bluish discoloration of, usually, the sapwood. Most commonly caused by species of *Ceratocystis, Aureobasidium,* and *Lasiodiplodia* (Ford-Robertson 1971).

blue stain fungi (also see "blue stain") any fungi that cause blue stain in wood.

board foot the amount of timber equivalent to a piece 1 by 1 foot and 1 inch thick ($= 1/12$ ft^3) (Ford-Robertson 1971).

bole a tree stem once it has grown to substantial thickness—roughly capable of yielding sawtimber, veneer logs, or large poles (Ford-Robertson 1971).

broadcast burning intentional burning in which fire is intended to spread over all a specific area (USDA Forest Service 1956).

brushblade a vertically mounted blade, commonly attached to tracked logging equipment, having fingerlike projections along its lower edge which facilitates the moving of logging debris without excessive scraping of the soil.

brush form woody vegetation that gives the visual impression of shrubs.

buffer strip a strip of vegetation that is left or managed to reduce the impact of a treatment or action of one area on another.

burrow a hole or tunnel dug in the ground by an animal (Morris 1976).

cable assisted felling a technique for felling trees in which a cable is attached to the tree and pulled taut to help guide the tree in the desired direction.

calving area (also see "elk calving habitat") the areas, usually on spring-fall range, where cows give birth to calves and maintain them during their first few days or weeks.

cambium in woody vegetation, the layer of cells that lies between the secondary xylem and secondary phloem cell layers; through a process of cell division, the cambium produces the secondary xylem and the secondary phloem which are also known, respectively, as the wood and the innermost living bark (Ford-Robertson 1971).

canopy the more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth. Layers of canopy may be called stories (Ford-Robertson 1971).

canopy closure the progressive reduction of space between tree crowns as they spread laterally (Ford-Robertson 1971); a measure of the percent of potential open space occupied by the collective tree crowns in a stand.

carrying capacity the maximum rate of animal stocking possible without inducing damage to vegetation or related resources; may vary from year to year because of fluctuating forage production (Kothmann 1974).

case-harden in wood, characterized by compression in the outer layers and tension in the core, the result of too severe drying conditions (Ford-Robertson 1971); trees or logs charred on the outside are often case hardened.

catastrophic events events resulting from a great and sudden calamity or disaster. In the case of forest stands such events include windstorms, wildfire, floods, snowslides, and insect outbreaks.

catchment the total area draining into a given waterway or reservoir (Ford-Robertson 1971).

cave a natural underground chamber that is open to the surface.

cavity the hollow excavated in snags by birds; used for roosting and reproduction by many birds and mammals.

cavity excavation the process of digging or chipping a cavity in dead wood.

cavity excavator an animal that excavates a cavity in wood for nesting or roosting.

cavity nesters wildlife species that nest in cavities.

char to burn the surface of; scorch; to reduce to charcoal by incomplete combustion (Morris 1976).

charcoal a black, porous carbonaceous material produced by the destructive distillation of wood (Morris 1976).

chill factor the increased chilling effect on an animal, attributable to air movement.

chipping the process of reducing large pieces of wood into small pieces of more or less uniform size by running the material through a chipper.

chipper a machine for cutting wood into chips of more or less uniform dimension (Ford-Robertson 1971).

chlorophyll a complex of mainly green pigments in the chloroplasts, characteristic of plants whose light-energy-transforming properties permit photosynthesis (Ford-Robertson 1971).

chloroplast the protoplasm body or plastid in plant cells that contains chlorophyll (Hanson 1962).

clearcut an area from which all trees have been removed by cutting.

clearcutting removal of the entire standing crop of trees; in practice much unsalable material may be left standing (Ford-Robertson 1971).

cliff a steep, vertical, or overhanging rock face.

climax the culminating stage in plant succession for a given site where the vegetation has reached a highly stable condition (Ford-Robertson 1971).

climax forest (also see "climax") a community that represents the culminating stage of a natural forest succession for a particular site (Ford-Robertson 1971).

climax vegetation (also see "climax") plants occurring in the climax successional stage.

closed canopy the condition that exists when the canopy created by trees or shrubs or both is dense enough to exclude most of the direct sunlight from the forest floor.

clumping of snags the occurrence of snags in patches or groups.

colonization (also see "colony") the act or process of establishing a colony or colonies (Morris 1976).

colony a group of the same kind of animals or plants living together (Morris 1976).

commercial forest base see "commercial forest land."

commercial forest land in the Blue Mountains, a working definition is forest land capable of producing 1.4 cubic meters of wood per hectare (20 ft^3/acre) per year of merchantable timber, currently or prospectively accessible to timber harvest and not withdrawn from such use.

commercial harvest the cutting and marketing of trees for use.

commercial thinning any type of thinning that produces merchantable material at least equal to the value of the direct costs of harvesting (Ford-Robertson 1971).

commercial timber production the process of growing wood products for sale or use.

community a group of one or more populations of plants and animals in a common spatial arrangement; an ecological term used in a broad sense to include groups of various sizes and degrees of integration (Hanson 1962).

community type a generalized category comprising a number of similar units or stands of vegetation and including animal life (Hanson 1962).

computer code see "species code."

configuration the shape or outline of forest stands or plant communities; the degree of irregularity in the edge between stands or communities; varying from simple to mosaic.

conifer the most important order of the Gymnospermae, comprising a wide range of trees, mostly evergreens that bear cones and have needle-shaped or scalelike leaves; timber commercially identified as softwood (Ford-Robertson 1971).

coniferous forest (also see "conifer") a forest dominated by cone-bearing trees.

connectors strips or patches of vegetation used by wildlife to move between habitats.

constraint the state, quality, or sense of being restricted to a given course of action or inaction; something that restricts, limits, or regulates (Morris 1976).

contour line an imaginary line, or its representation on a contour map, joining points of equal elevation (Morris 1976).

contrast in wildlife management, the degree of difference in vegetative structure along edges where plant communities meet or where successional stages or vegetative conditions within plant communities meet.

control in wildlife management, the process of managing populations of a species to accomplish an objective; usually used in the sense of depressing population numbers of a pest species to prevent or decrease the impact of that species.

control line (also see "fireline") an inclusive term for constructed or natural fire barriers; a fire edge treated to control a fire (USDA Forest Service 1956).

coordinated timber-wildlife management the melding of timber and wildlife management planning and action into one plan so that goals of both timber and wildlife are met.

coring a small piece of wood removed from a tree by means of an increment borer; the number of growth rings in a tree can be determined from such corings.

correlation coefficient an index number indicating the degree of influence of two or more variables on each other; a coefficient of 1.0 or −1.0 indicates perfect correlation—i.e., the change in one variable can be totally explained by a change in the other.

cortex the primary tissue of a stem or root that lies between the epidermis or the phellem and the vascular system (Ford-Robertson 1971).

cover vegetation used by wildlife for protection from predators, or to ameliorate conditions of weather, or in which to reproduce; also a shortened version of "crown cover."

cover patch a discrete area covered by vegetation that meets either the definition of hiding or thermal cover.

cover-forage area ratio the ratio, in percent, of the amount of area in forage condition to that area in cover condition; the criteria by which potential deer and elk use of an area is judged.

critical habitat component one of the three general habitat requirements of all wildlife—food, cover, and water.

crop the vegetation growing on a forest area, more particularly the major woody growth forming the forest crop—anything harvestable (Ford-Robertson 1971).

crop basal area (also see "basal area" and "stand basal area") the total basal area per unit area (Ford-Robertson 1971).

crop tree any tree forming, or selected to form, part of the final crop; generally a tree selected in a young stand for that purpose (Ford-Robertson 1971).

crown the upper part of a tree or other woody plant, carrying the main branch system and foliage, and surmounting at the crown base a more or less clean stem (Ford-Robertson 1971).

crown class any grouping into which trees forming a crop or stand may be identified on the basis of crown development and crown position relative to crowns of adjacent trees and the general canopy; also trees falling into such groupings (Ford-Robertson 1971).

crown closure see "canopy closure."

crown cover the amount of canopy provided by branches and foliage of trees, shrubs, and herbs in a plant community. May be specified by species, kind of plant, or collectively.

cubic volume a measure of wood in which the expression is the cube of a linear measure—usually feet cubed (1 ft by 1 ft by 1 ft) or meters cubed (1 m by 1 m by 1 m).

culls any item of production (e.g., trees, logs, lumber) relegated or rejected because it did not meet certain specifications (Ford-Robertson 1971).

culmination of mean annual increment the stand age at which mean annual increment culminates; mean annual increment is total increment up to a given age divided by that age (Ford-Robertson 1971).

cut material removed during road construction to reach the formation level or the excavation so formed (Ford-Robertson 1971); the removal of timber from a stand.

cutting the act of cutting or felling a standing tree (Ford-Robertson 1971).

cutting series an area of forest identified as a sustained-yield unit and forming all or part of a working circle; the purpose is to distribute felling and regeneration operations to suit local administrative or market conditions and to maintain or create a suitable distribution of age classes (Ford-Robertson 1971).

cutting unit an area on which the trees have been, are being, or are to be cut, commonly forming one of an annual succession (Ford-Robertson 1971).

cycling to occur in or pass through a cycle; to move in, or as if in, a circle (Morris 1976).

d.b.h. see "diameter breast high."

dead and down woody material all woody material, from whatever source, that is dead and lying on the forest floor.

debris the scattered remains of something broken or destroyed; ruins; rubble; fragments (Morris 1976).

decadent deteriorating; when used in reference to stand condition there are inferences of the loss of trees from the overstory and of the presence of disease, or indications of loss of vigor in dominant trees so that the mean annual increment is negative.

decay in wood, the decomposition by fungi and other micro-organisms resulting in softening, progressive loss of strength and weight, and changes in texture and color (Ford-Robertson 1971).

decay model a model representing the decline in wood density with residence time.

deciduous pertaining to any plant organ or group of organs that is shed naturally; perennial plants that are leafless for some time during the year (Ford-Robertson 1971).

decked logs logs stacked in a manner to facilitate handling for hauling or milling.

decompose to separate into component parts or elements; to decay or putrefy (Morris 1976).

decomposition class any of five stages of decomposition of logs left in the forest; stages range from essentially sound to almost total decomposition.

decomposition model (also see "model") a model of the rate of decomposition of dead and down material as related to a number of variables, such as tree species, microclimate, temperature, age, etc.

deer fawning habitat (also see "fawning area") areas used regularly by female deer for fawning; optimum fawning habitat includes low shrubs or small trees under a tree overstory of about 50-percent closure, usually located on slopes of less than 15 percent where vegetation is succulent and plentiful in June and potable water is available within 183 meters (600 ft).

Delphi Technique the process of combining expert opinions into a consensus (Gordon and Helmer-Hirschberg 1964); a method of making predictions.

denning site a place of shelter for an animal; also where an animal gives birth and raises young.

dense canopy (also see "closed canopy") a condition where the forest canopy is essentially closed and the foliage is particularly thick or luxuriant.

dependent variable the variable in a relationship that is influenced by the independent variable.

deteriorated stand see "decadent."

deviation the difference between any particular observation in a set of observations and the arithmetical mean of the set (Ford-Robertson 1971).

DI see "diversity index."

diameter breast high (d.b.h.) the standard diameter measurement for standing trees, including bark, taken at 1.37 meters (4.5 ft) above the ground (Ford-Robertson 1971).

diplopod any species of millipede; an order or class of Arthropoda (Abercrombie et al. 1964).

direct habitat improvement habitat manipulations primarily for the benefit of wildlife.

directional felling the felling of trees in a prescribed direction to accomplish a management objective.

dispersion (also see "law of dispersion") the pattern of distribution of individuals in an animal population; in the mathematical sense, dispersion describes the probability of occurrence of such individuals in particular places.

diversity the relative degree of abundance of wildlife species, plant species, communities, habitats, or habitat features per unit of area.

diversity index a number that indicates the relative degree of diversity in habitat per unit area. It is expressed mathematically:

$$DI = \frac{TP}{2\sqrt{A \cdot \pi}};$$

where TP is the total perimeter of an area plus any edge within the area in meters or feet, A is the area in square meters or square feet, and π is 3.1416.

dominant plant species or species groups which, by means of their numbers, coverage, or size, influence or control the existence of associated species. Also, individual animals which determine the behavior of one or more other animals, resulting in the establishment of a social hierarchy (Kothmann 1974).

dominant tree see "dominant."

drainage see "catchment."

drum to make a reverberating sound by beating the wings rapidly as grouse do or by tapping on a suitable surface as woodpeckers do.

duff (also see "litter") the combination of litter and the less decomposed humus on the forest floor.

dusting the process of rolling or exercising vigorously in dust or duff; in birds, has the function of alining barbules and maintaining feathers.

dynamic characterized by or tending to produce continuous change or advance (Morris 1976).

ecological niche the role a particular organism plays in the environment (Hanson 1962).

ecological role the part or influence of an organism in an ecoystem.

ecology the study of the interrelationships of organisms with one another and with the environment (Hanson 1962).

ecosystem an interacting natural system including all the component organisms together with the abiotic environment (Hanson 1962).

ecotone the area influenced by the transition between plant communities or between successional stages or vegetative conditions within a plant community.

ectomycorrhiza fungi which form a symbiotic relationship with the roots of plants where the fungus mantles the host rootlet surface with mycelial tissue and grows between the cells of the rootlet cortex.

edaphic pertaining to the soil, particularly the influence of soil on organisms (American Geological Institute 1962).

edge the place where plant communities meet or where successional stages or vegetative conditions within plant communities come together.

edge effect the increased richness of flora and fauna resulting from the mixing of two communities where they join.

elk calving habitat (also see "calving area") a habitat used by elk for calving; usually located on spring-fall range in areas of gentle slope; contains forage areas and hiding and thermal cover close to water.

endangered species a wildlife species officially designated by the U.S. Fish and Wildlife Service as having its continued existence threatened over its entire range because its habitat is threatened with destruction, drastic modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors.

endemic native or confined to a certain region; having a comparatively restricted distribution (Morris 1976).

environment the sum total of all the external conditions that may influence organisms (Hanson 1962).

Environmental Analysis Report a report on environmental effects of proposed Federal actions which require an Environmental Impact Statement under section 102 of the National Environmental Policy Act (U.S. Laws, Statutes, etc. Public Law 91-190, 1970); an "in-house" document which becomes the final document on projects whose effects are so minor as not to require a formal Environmental Impact Statement; though not formally required by the Act, this document is commonly used to determine if section 102 applies to the contemplated action (Schwarz et al. 1976).

environmental factor any influence on the combined plant and animal community.

Environmental Impact Statement the final version of the statement required under section 102 of the National Environmental Policy Act (U.S. Laws, Statutes, etc. Public Law 91-190, 1970) for major Federal actions affecting the environment; a revision of the draft statement which includes public and governmental agency comments; a formal document meeting legal requirements and used as the basis for judicial decisions concerning compliance with the Act; also refers to similar statements required by State and local laws patterned after the Act (Schwarz et al. 1976).

enzyme a catalyst, generally a specific protein joined to some simple substance produced by cellular action that is essential to biological processes (Ford-Robertson 1971).

ephemeral streams streams that contain running water only for brief periods.

epidermis the outermost layer(s) of cells of a plant; often with strongly thickened and cuticularized outer walls (Ford-Robertson 1971).

escape cover (also see "hiding cover for deer" and "hiding cover for elk") usually vegetation dense enough to hide an animal; used by animals to escape from potential enemies.

even-aged management a system of forest management in which stands are produced or maintained with relatively minor differences in age (Ford-Robertson 1971).

exponential expressed in terms of a designated power of *E*, the base of natural logarithms (Morris 1976).

extended rotation carrying a timber stand beyond the time when economic return is greatest or the wood production objectives are best met; a longer rotation than is normal for the majority of stands in the forest.

extended rotation age any rotation age for a stand or stands that is longer than the optimum age for maximized wood production or optimum age for a particular desired class or form of wood product.

external succession the changes in the plant community over time that surround a snag or dead and down log.

Fagaceae a family of plants; specifically, the beech family.

fawning area (also see "deer fawning habitat") an area, usually on spring-fall range, where does give birth to fawns and maintain them in their first few days or weeks.

featured species management (also see "indicator species management") a wildlife management strategy to produce relatively high numbers of selected wildlife species in particular places for particular purposes.

fecal material material discharged from the bowels (W. B. Saunders Company 1968); more generally, any discharge from the digestive tract of an organism.

feeding substrate the surface on which an animal finds its food.

felling see "cutting."

fill material placed during road construction to complete the formation up to its required level (Ford-Robertson 1971).

final crop the portion of the growing stock (crop trees) kept to maturity; i.e., in regular crops roughly until the end of the rotation, forming the final yield (Ford-Robertson 1971).

final cut generally, removal of the last trees left in a stand; more particularly, removal of the last seed bearers or shelter trees after regeneration is considered to be established under a shelterwood system.

final harvest cut see "final cut" and "harvest cutting."

financial maturity the age of a tree, crop, or stand, beyond which increase in value is insufficient to earn a specified rate of interest obtainable from other sources; synonymous with financial rotation (Ford-Robertson 1971).

fine fuels grass, leaves, tree needles, fern, tree moss, and some kinds of slash which ignite readily and are consumed rapidly when dry (USDA Forest Service 1956).

fire hazard any condition in the forest stand that appreciably increases the danger of fire.

fireline (also see "control line") part of a control line that is scraped or dug to mineral soil; sometimes called a fire trail (USDA Forest Service 1956).

fire retardant a substance that by chemical or physical action reduces flammability of combustibles (USDA Forest Service 1956).

fire succession a particular plant succession that occurs on a site following burning of the previous vegetation.

firing technique the manner in which a prescribed burn is ignited.

flashy fuel combustible material that has a low kindling temperature and burns with high intensity for a comparatively short time.

flora the plant population of a particular area; a list of plant species (with descriptions) of a particular area arranged in families and genera, together with a key to aid identification (Abercrombie et al. 1964).

forage vegetation used for food by wildlife, particularly ungulate wildlife and domestic livestock.

forage areas forest stands that do not qualify as either hiding or thermal cover and all natural and man-made openings.

forage medium the environment in which feeding by a wildlife species occurs.

foraging substrate see "feeding substrate."

forb any herbaceous plant species other than those in the Gramineae, Cyperaceae, and Juncaceae families (Kothmann 1974); fleshy leaved plants.

forced trailing trails that compel animals, particularly big game and domestic livestock, to take a particular route of travel.

forest generally, an ecosystem characterized by tree cover; more particularly, a plant community predominantly of trees and other woody vegetation, growing closely together; an area managed for the production of timber and other forest produce; or maintained in forest cover for such indirect benefits as protection of catchment areas or recreation; an area of land proclaimed to be a forest under a forest act or ordinance (Ford-Robertson 1971).

forest estate an area, whatever its ownership, used for forestry purposes (Ford-Robertson 1971).

forest floor the surface layer of a soil supporting forest vegetation (Ford-Robertson 1971).

forest inventory (also see "inventory") a list or estimate of the species and sizes of trees within an area.

forest management the application of scientific, economic, and social principles to the management of a forest estate for specified objectives; the branch of forestry concerned with its overall administrative, economic, legal, social, scientific, and technical aspects—especially silviculture, protection, and forest regulation (Ford-Robertson 1971).

forest manager a person who makes decisions concerning management of forest land.

forest-opening edge an edge and associated ecotone that exists where an opening and a stand of trees join.

form class any of the intervals into which a numerical expression of the taper of a tree stem or log may be classified—commonly a range of form factors, form quotients, or form point heights; the actual trees or logs falling into such classes (Ford-Robertson 1971).

formation geologically, something naturally formed, commonly differing conspicuously from adjacent objects or material, or being noteworthy for some other reason (American Geological Institute 1962)—for example, a cliff; in road works, the surface of the ground on which the road base is laid after excavation, filling, and shaping are completed (Ford-Robertson 1971).

fragile soils soils that are especially subject to damage by human activities, particularly roadbuilding and impacts by machinery used in standard logging operations.

free water water that is not bound to any surface, particularly soil particles, and is available for transpiration by plants.

fructification the production of fruit; a seed- or spore-bearing structure (Morris 1976).

fuel any substance that will, when burned, produce energy or heat in useful amounts; more precisely, anything susceptible to ignition and combustion (Ford-Robertson 1971); in forestry, usually used to describe dead and down woody material on the forest floor.

fuel break a lane through the forest or range land from which most combustible material, including trees and shrubs, has been removed or markedly reduced to prevent spread of fire.

fuel class an identifiable association of fuel elements of distinctive species, form, size, arrangement, or other characteristics that will result in a predictable rate of fire spread or difficulty of control under specified weather conditions; also called fuel type (USDA Forest Service 1956).

fuel loading the amount of combustible material present per unit of area.

fuel management the manipulation of fuels to accomplish objectives of management, usually to reduce the risk of damage from wildfire.

fuel management standard a condition of size, arrangement, and density of fuel created to meet management requirements in terms of fire hazard and susceptibility of potential fire to control.

fuel moisture content the quantity of moisture in fuel expressed as a percentage of the weight when thoroughly dried at 100°C (212°F) (USDA Forest Service 1956).

fuel type see "fuel class."

full stocking that stocking level of a forest stand that yields maximum biologically possible growth rates; synonymous with optimum stocking.

function the natural or proper action for which an organism or habitat or behavioral action is fitted or employed.

fungal (also see "fungi") caused by or associated with fungi.

fungal conk a fructification of a wood-destroying fungus which projects beyond the substrate (Ford-Robertson 1971).

fungal hyphae see "fungi" and "hyphae."

fungi mushrooms, molds, yeast, rusts, etc.; subdivision of Thallophyta; simply organized plants, unicellular or made of cellular filaments called hyphae, lacking chlorophyll; reproduce sexually and asexually with the formation of spores; many are microscopic, though some fruiting bodies reach a larger size; saprophytes or parasites of other plants and animals; take part with other soil organisms in decomposition of plant and animal residues; important as agents of many plant and some animal diseases (Abercrombie et al. 1964).

game species of vertebrate wildlife hunted by man for sport.

gametophyte a phase of the plant life cycle, characterized by the presence of haploid nuclei, during which sex cells are produced (Abercrombie et al. 1964).

gene pool narrowly, the genic material of a localized interbreeding population; broadly, the genic resources or materials of a species throughout its entire range (Hanson 1962).

genus one or a group of related species used in the classification of organisms (Hanson 1962); the first word in a binomial or scientific name.

geomorphic of or like the earth or the configuration or shape of the earth's surface (Morris 1976).

girdling making more or less continuous incisions around a living stem which cut through at least the bark and cambium; a method of killing woody vegetation (Ford-Robertson 1971).

gleaning a process of feeding, particularly by birds, in which food items are gathered from the surface of the foraging substrate—usually plant parts.

gradient the rise or fall of a ground surface expressed in degrees of slope (Ford-Robertson 1971).

grass any plant species that is a member of the family Gramineae (Kothmann 1974).

grass-forb stage (also see "successional stage") one of six successional stages in the coniferous forests of the Blue Mountains; a successional stage dominated by grasses and forbs.

greater than 1,000-hour fuel timelag class (>1,000-hour) all dead fuels larger than 20.3 centimeters (8 in) in diameter or more than 30.5 centimeters (12 in) below surface of the forest floor (no fuel classes are defined beyond the 1,000-hour fuel timelag class) (Deeming et al. 1978).

group selection (also see "selection system") a modification of the selection system in which trees are removed in small groups rather than individually (Ford-Robertson 1971).

growing layer (also see "increment") a layer of wood or bark apparently produced during one growing period (Ford-Robertson 1971); in cross section the rings may be readily discerned.

growing stock all the trees growing in a forest or a specified part of it; generally expressed in numbers or volume (Ford-Robertson 1971).

growth increment (also see "volume increment") a measurable increase in growth of a stand; usually expressed as an increase in wood volume.

growth ring see "growing layer."

Gymnospermae a group of woody plants having naked seed; i.e., seeds not enclosed in an ovary (Mason 1975).

habitat the sum total of environmental conditions of a specific place occupied by a wildlife species or a population of such species.

habitat block an area of land covered by a relatively homogeneous plant community in essentially a single successional stage or condition.

habitat component a simple part, or a relatively complex entity regarded as a part, of an area or type of environment in which an organism or biological population normally lives or occurs.

habitat niche the peculiar arrangement of food, cover, and water that meets the requirements of a particular species (Hanson 1962).

habitat richness the relative degree of ability of a habitat to produce numbers of species of either plants or animals; the more species produced the richer the habitat.

habitat type (also see "site type" and "plant community type") the aggregate of all areas that support, or can support, the same primary vegetative climax; a classification of environmental settings characterized by a single plant association; the expression through the plants present of the sum of the environmental factors that influence the nature of the climax (Daubenmire 1976).

hand-piling (also see "machine-piling") the piling of slash by hand labor; causes less impact on the site and is more selective than machine piling but usually costs more.

hang up the act of bats attaching themselves to the ceiling of a cave or other structure and resting in an upside down position.

hard snag a snag composed primarily of sound wood, particularly sound sapwood; generally merchantable.

hardwood the wood of broad-leaved trees, and the trees themselves, belonging to the botanical group Angiospermae; distinguished from softwoods by the presence of vessels (Ford-Robertson 1971).

harvest cutting the felling of the final crop of trees; either a single cutting or a series of regeneration cuttings; also a general term for the removal of financially or physically mature trees as contrasted to cuttings that remove immature trees (Ford-Robertson 1971).

harvesting in forestry, a loose term for the removal of wood from the forest for utilization; comprised of cutting and, sometimes, initial processing and extraction of trees from the forest (Ford-Robertson 1971); in wildlife management, the removal, usually by sport hunting or trapping, of all or part of the surplus of a wildlife species.

harvesting techniques a means of removing all or part of a stand for commercial purposes.

hawking the feeding behavior of birds wherein they catch insects in flight.

hazard reduction a management action designed to reduce risk from a recognized combination of factors that may lead to injury or economic loss.

heart rot any rot in a tree confined to the heartwood, associated with fungi such as *Fomes* and *Polyporus* species; generally originating in a living tree (Ford-Robertson 1971).

heartwood the inner layers of wood which, in a growing tree, have ceased to contain living cells and in which the reserve materials (e.g., starch) have been removed or converted into more durable substances (Ford-Robertson 1971).

heavy fuels see "larger diameter fuels."

herbicide a chemical substance used for killing plants (Hanson 1962).

herd behavior the collective behavior exhibited by social groups of ungulates.

hibernacula habitat niches where certain animals overwinter (Hanson 1962).

hiding cover see "hiding cover for deer" and "hiding cover for elk."

hiding cover for deer (also see "cover") vegetation capable of hiding 90 percent of a standing adult deer from the view of a human at a distance equal to or less than 61 meters (200 ft); generally, any vegetation used by deer for security or to escape from danger.

hiding cover for elk (also see "cover") vegetation capable of hiding 90 percent of a standing adult elk from the view of a human at a distance equal to or less than 61 meters (200 ft); generally, any vegetation used by elk for security or escape from danger.

high density fuel a large or heavy accumulation of fuel per unit of area.

holding crew personnel active in fire management whose job it is to contain a fire within prescribed boundaries.

hole nesters wildlife species that nest in cavities.

holistic emphasizing the importance of the whole and the interdependence of its parts (Morris 1976).

home range the area which an animal traverses in the scope of normal activities; not to be confused with territory.

homoiotherm an animal which is able to maintain the temperature of the body at an approximately constant level independent of the surrounding medium; "warm-blooded" (Hanson 1962).

homoiothermic animals see "homoiotherm."

horizontal diversity the diversity in an area that results from the number of plant communities or successional stages or both; the greater their number the greater the horizontal diversity; also, the greater the amount of edge the higher the degree of horizontal diversity.

humidity see "relative humidity."

humus a general term for the more or less decomposed plant and animal residues in the soil, litter therefore being excluded (Ford-Robertson 1971).

humus layer the surface soil layer composed of or dominated by organic material, whether or not incorporated with mineral soil (Ford-Robertson 1971).

hyphae filament of a fungus thallus that is composed of one or more cylindrical cells; increases by growth at its tip; gives rise to new hyphae by lateral branching (Abercrombie et al. 1964).

igneous rocks evolving from molten material and of two types: (1) those cooled from molten masses beneath the earth's surface (*intrusive rocks*) and (2) those cooled from molten masses flowing or forcibly extruded upon the earth's surface (*extrusive rocks*) (Baldwin 1964).

imperfect fungi a fungi group that lacks a sexual reproduction stage; mostly asexual Ascomycetes in which the sexual stage has been lost during evolution or has not yet been identified (Abercrombie et al. 1964).

incidental association the accidental, unpredictable, or noncompelling association of a wildlife species with a habitat as opposed to an association that is strong, predictable, and mandatory.

increment (also see "growing layer") the increase in girth, diameter, basal area, height, volume, quality, or value of individual trees or crops over a specified time, usually annually (Ford-Robertson 1971).

increment borer (also see "increment core") an augerlike instrument with a hollow bit and an extractor, used to extract radial cylinders of wood or corings from trees with annual growth rings; the growth rings are used to determine increment and age (Ford-Robertson 1971).

increment core (also see "increment borer") the wood section removed by an increment borer; this section is examined for annual growth rings to determine increment and age (Ford-Robertson 1971).

independent variable the variable in a relationship that is judged for its effect on the dependent variable.

indicator species management (also see "featured species management") a wildlife management scheme in which the welfare of a selected species is presumed to indicate the welfare of other species.

indicator species system in wildlife, analogous to "featured species management"; in plant ecology, plant species used to indicate special environmental factors or plant community types (Daubenmire 1976).

indirect habitat improvement habitat manipulation done for purposes other than wildlife habitat improvement but exploited to accomplish wildlife management objectives.

induced diversity index a number that indicates the relative degree of induced diversity in habitat per unit area produced by edges formed by the junction of successional stages or vegetative conditions within plant communities; expressed mathematically:

$$\text{Induced DI} = \frac{TE_s}{2\sqrt{A \cdot \pi}};$$

where TE_s is the total length of edges between successional stages or conditions within plant communities, in meters or feet; A is the area expressed in square meters or square feet and π is 3.1416.

induced edge an edge that results from the meeting of two successional stages or vegetative conditions within a plant community; can be controlled by management action.

inherent edge (also see "edge") an edge that results from the meeting of two plant community types.

inherent diversity index a number that indicates the relative degree of inherent diversity in habitat per unit area produced by plant community to plant community edges; expressed mathematically:

$$\text{Inherent DI} = \frac{TE_c}{2\sqrt{A \cdot \pi}};$$

where TE_c is the total edge between plant communities within or on the perimeter of the area; A is the area and π is 3.1416.

in-house inside or internal to an organization, agency, or bureau.

inoculation introduction of an organism into a new environment.

inorganic involving neither organic life nor the products of organic life; not composed of organic matter; mineral (Morris 1976).

insectivorous an animal that eats insects (Hanson 1962); in common usage, includes animals that eat insects and, sometimes, other selected invertebrates.

integrator an attribute that expresses the combined influence of a number of interacting variables.

integrity the state of being unimpaired; soundness; completeness; unity (Morris 1976).

intensive forestry the practice of forestry to obtain a high level of volume and quality of wood products per unit of area; accomplished through the application of the best techniques of silviculture and management (Ford-Robertson 1971).

intensive timber management see "intensive forestry."

interface a surface forming a common boundary between two regions (Morris 1976) or between two things.

intermittent stream a stream that ordinarily goes dry at one or more times during the year but sustains flows for some period.

internal succession the process of change stimulated primarily by decay and deterioration in a snag or dead and down log.

interspersion (also see "law of interspersion") the intermixing of plant species and plant communities that provide habitat for animals in a defined area.

intersuccessional link (also see "relic") something that persists from one successional stage to one or more later successional stages.

inventory (also see "forest inventory") a detailed list of things in possession; especially, a periodic survey of goods and materials in stock; the process of survey; the items and the quantity of goods and materials listed (Morris 1976).

invertebrate an animal lacking a spinal column (Hanson 1962).

juxtapose to situate side by side; to place together (Morris 1976).

juxtaposition (also see "juxtapose") the act of arranging stands in space.

kerf the slot cut by a saw moving through wood (Ford-Robertson 1971).

key-species management in wildlife, analogous to "featured species management;" in range management, the most palatable and common plant species used by livestock; the plants on whose status livestock management decisions are based (Kothmann 1974).

land base the amount of land with which the land manager has to work.

landscape the aspect of the land that is characteristic of a particular region (Morris 1976).

landscape foreground areas managed particularly for their impact on the visual attributes of an area as viewed from a specified point.

land-type particular combinations of land features and plant community types used by USDA Forest Service land-use planners in the Blue Mountains to predict responses to timber management practices.

land-use planning the process of categorizing land units for various kinds and intensities of use and management; theoretically based on public demands, land use capability, cost/benefit analyses, public welfare, sociological considerations, and specifications or constraints of applicable law.

large diameter fuels fuels of large diameter—such as snags, logs, and large limbwood—which ignite and are consumed more slowly than small diameter fuels.

law of dispersion (also see "dispersion") an ecological theory; the potential density of wildlife species with small home ranges that require two or more types of habitat is roughly proportional to the sum of the peripheries of those types (Kelker 1964).

law of interspersion (also see "interspersion") the number of resident wildlife species that require two or more types of habitat depends on the degree of interspersion of numerous blocks of such types (Leopold 1933, Dice 1931).

lek a site where birds (primarily grouse) traditionally gather for sexual display and courtship.

letter code see "species code."

life form a group of wildlife species whose requirements for habitat are satisfied by similar successional stages within given plant communities.

lighting pattern the arrangement of ignition points and the timing of the ignition of those points in a prescribed burn.

limiting factor the environmental influence through which the toleration limit of an organism is first reached, which acts, therefore, as the immediate restriction in one or more of its functions or activities or in its geographic distribution (Hanson 1962).

litter the uppermost layer of organic debris on a forest floor; essentially the freshly fallen or slightly decomposed vegetable material, mainly foliate or leaf litter, but also bark fragments, flowers, and fruits (Ford-Robertson 1971).

litter fall see "litter."

live burning progressive burning of green slash as it is cut (USDA Forest Service 1956).

livestock domestic animals, usually ungulates, raised for use, profit, or pleasure (Ford-Robertson 1971).

locally distributed the occurrence of wildlife species in discrete localized areas as opposed to a general distribution throughout an area of seemingly similar habitat.

log (also see "dead and down woody material") any section of the bole or thicker branches of a felled tree after trimming and cross-cutting (Ford-Robertson 1971); also, any section of the bole or of the thicker branches of a dead and down tree.

log accumulation the total of logs on the forest floor at any given time.

log class the identification of logs by groups based on their state of decomposition.

log decomposition class see "log class."

log value the economic or market value of a dead and down log on the forest floor.

logging debris (also see "debris") woody material left on the forest floor as a result of logging.

long-range planning planning for a future more than 5 years distant (Schwarz et al. 1976).

lookout site a structure used by wildlife for a better vantage point.

lopping after felling, the chopping of small trees and branches and tops of large trees so that the resultant slash will lie close to the ground and decay more rapidly (Ford-Robertson 1971).

lopping and scattering lopping the slash created by logging and spreading it more or less evenly over the ground without burning (Ford-Robertson 1971); a method of slash disposal.

machine-piling (also see "hand-piling") the piling of slash by machine; creates more soil impacts than hand-piling but is cheaper.

main crop in regular crops or stands, the portion of the growing stock retained after an intermediate cutting (Ford-Robertson 1971).

main road a forest road, 1½ or more lanes wide, in good condition; main route of travel, having constant maintenance (Perry and Overly 1977).

managed forest a forest that has been brought under management to accomplish specified objectives.

managed stand a stand subject to silvicultural manipulation planned to give a desired result—usually increased wood production.

managed yield table a table that shows the growth pattern for one or more tree species in a managed, even-aged stand; derived from measurements at regular intervals covering the stand's useful life; includes mean d.b.h. and tree height, number of stems, and standing wood volume per unit area; may include volume of thinnings or main crop or total volume (Ford-Robertson 1971).

management constraint see "constraint."

management for species richness a wildlife management strategy to produce a relatively high number of species per unit area.

mast the fruit of trees suitable as food for livestock and wildlife (Ford-Robertson 1971).

mature stage (also see "successional stage" and "maturity") one of six recognized successional stages in the coniferous forests of the Blue Mountains in which the stand is primarily composed of or dominated by mature trees in vigorous condition.

mature tree see "maturity."

maturity in physiology, the stage at which a tree or other plant has attained full development and is in full seed production; in forest management, the stage at which a tree or stand best fulfills the purpose for which it was managed (Ford-Robertson 1971).

maximum population level the greatest number of a wildlife species that can occur if the constraints of food, cover, and water are removed; the greatest number that can exist without losses caused by social strife.

mean average; the total of a series of measurements divided by the number of measurements.

mean annual increment (also see "increment" and "culmination of mean annual increment") the total increment up to a certain age divided by that age (Ford-Robertson 1971).

Mendelian population a group of individuals that share in a common gene pool through reproduction; a species (Hanson 1962).

merchantable snag a snag containing enough sound wood that its value at the mill exceeds the cost of cutting and transporting it to that location.

merchantable trees trees that can be marketed.

meristem a plant tissue that divides to form new cells; located in such places as root tips, stem tips, and buds (Hanson 1962).

metabolic rate (also see "basal metabolism") the rate of expenditure of energy compared to basal metabolism.

metamorphic a rock formed from any existing rock which has been altered by additional heat and pressure (Baldwin 1964); for example, slate.

microarthropod (also see "arthropod" and "microscopic") an arthropod that is microscopic.

microbe microscopic organism (Hanson 1962).

microbial community (also see "microbe" and "community") a community of microbes of one or more species.

microclimate the climatic conditions within a small or local habitat that is well defined (Hanson 1962).

microenvironment (also see "environment") a small environment.

micro-organism see "microbe."

microscopic too small to be seen by the unaided eye; large enough to be seen with the aid of a microscope; exceedingly small; minute (Morris 1976).

migration corridor (also see "travel corridor") a belt, band, or stringer of vegetation that provides a completely or partially suitable habitat and which animals follow during migrations.

migration route a travel route used routinely by wildlife in their seasonal movement from one habitat to another.

mineral cycling (also see "cycling" and "ecosystem") the cycling of minerals throughout an ecosystem.

mineral soil soil composed mainly of inorganic materials and with a relatively low amount of organic material (Hanson 1962).

minimally stocked (also see "stocking") the smallest number of trees in an area that will allow accomplishment of the timber management goal.

minimum size snag the smallest d.b.h. snag that can be excavated by a particular species of primary excavator for a nest or roost cavity.

mixed age stand a stand composed of trees of two or more ages.

mixed conifer community a forest community of the Blue Mountains dominated by two or more coniferous species—ponderosa pine, Douglas-fir, white fir, lodgepole pine, and larch.

mixed-species stand a stand composed of two or more species.

MM standard the type and amount of fuel that would allow a medium rate of fire spread and be of medium resistance to control based on tree cover and type, understory type and density, and the amount of fuel on the ground (USDA Forest Service 1956).

model a formalized expression of a theory or of the causal situation that generated observed data (Ford-Robertson 1971).

moisture regime the amount of moisture available at specific times in a particular area.

mopup the act of making a fire safe after it has been controlled; extinguishing or removing burning material along or near the control line, felling snags, or trenching logs to prevent rolling (USDA Forest Service 1956).

mortality in wildlife management, the loss in a population from any cause, including hunter kill, poaching, predation, accident, and disease (Ford-Robertson 1971); in forestry, the trees in a stand that die of natural causes.

mosaic the intermingling of plant communities and their successional stages in such a manner as to give the impression of an interwoven design.

mosaic edge an edge between stands or communities that is highly irregular, leading to a relatively large amount of edge per unit area.

mulch any loose covering on the surface of the soil, such as litter or deliberately applied organic material; residues or artificial cover may be used in this manner (Ford-Robertson 1971).

multiple use a concept of land management in which a number of products are deliberately produced from the same land base; in National Forests, the simultaneous provision of water, wood, recreation, wildlife, and recreation is required by the Multiple-Use Sustained Yield Act (U. S. Laws, Statutes, etc. Public Law 86-517, 1960).

multiple use constraint a restriction placed on the forest manager because of requirements of the Multiple-Use Sustained Yield Act (U. S. Laws, Statutes, etc. Public Law 86-517, 1960).

multiple use planning (also see "multiple use") the planning of management activities for a defined area to simultaneously accomplish goals for several distinct purposes, such as production of wood, water, wildlife, recreation, and grazing (U. S. Laws, Statutes, etc. Public Law 86-517, 1960).

Multiple-Use Sustained Yield Act (U. S. Laws, Statutes, etc. Public Law 86-517, 1960) authorizes and directs that the National Forests be managed for outdoor recreation, range, timber, watershed, and wildlife and fish purposes, and to produce a sustained yield of products and services, and for other purposes (Schwarz et al. 1976).

multistoried stands see "multitiered stands."

multitiered stands stands with two or more distinct tree layers in the canopy; synonymous with multistoried stands.

mycelial tissue see "mycelium."

mycelium the vegetative part of a fungus, composed of hyphae, as distinct from fructification (Ford-Robertson 1971).

mycorrhiza the symbiotic relationship of a fungus with the roots of certain plants (Hanson 1962).

National Environmental Policy Act (U.S. Laws, Statutes, etc. Public Law 91-190, 1970) declares a national policy encouraging productive and enjoyable harmony between man and environment, to promote prevention or elimination of damage to the environment and biosphere and stimulate health and welfare of people, to enrich understanding of ecological systems and natural resources of the United States and to establish a Council of Environmental Quality (Schwarz et al. 1976).

National Forest in the United States, a Federal reservation, of forest, range, or other wild land administered by the Forest Service of the U.S. Department of Agriculture under a program of multiple use and sustained yield (Ford-Robertson 1971).

natural regulation (also see "regulate") the regulation of a stand through naturally occurring biological processes as opposed to regulation through silvicultural practices.

nematode an animal in the class Nematoda and the phylum Nemathelminthes (Hanson 1962); like a thread; roundworms (W. B. Saunders Company 1968).

nest box see "bird box."

nesting population level the number of individuals or pairs of a species in an area during the breeding season.

new soil profile the soil profile that exists after a management action or a rapidly occurring natural process.

niche see "habitat niche."

nitrogen fixation the conversion of elemental nitrogen (N_2) from the atmosphere to organic combinations or to forms readily utilizable in biological processes (Ford-Robertson 1971).

node a point on the stem from which a leaf arises (Mason 1975).

nongame wildlife (also see "game" and "wildlife") all wild terrestrial vertebrates not subject to sport hunting.

normal distribution a continuous frequency distribution symmetrical about the random variable having the greatest frequency and conforming to a particular mathematical formula; this distribution appears to be a good approximation of many naturally occurring distributions; the basis of many methods of statistical analysis (Ford-Robertson 1971).

nurse log a dead and down log that fosters tree seedlings by protecting them from such environmental factors as wind, insolation, or frost, or by providing appropriate soil and microclimate.

nursery colonies a congregating of bats for the purpose of giving birth and nurturing their young.

nutrient cycling the circulation of elements, such as nitrogen and carbon, via specific pathways from abiotic to biotic portions of the environment and back again; all mineral and nutrient cycles involving man, animals, and plants—such as the carbon cycle, phosphorous cycle, and nitrogen cycle (Schwarz et al. 1976).

nutrient immobilization the tying up of nutrients in some form so that they are temporarily restrained from cycling in the ecosystem.

obligate a plant or animal that occurs in a narrowly defined habitat.

old-growth stand a stand that is past full maturity and showing decadence; the last stage in forest succession; the USDA Forest Service's working definition for old-growth stands in the Blue Mountains is 37 live trees or more per hectare (15/acre) over 53-centimeter (21-in) d.b.h., 1.2 or more snags per hectare (0.5 snag/acre) over 53-centimeter (21-in) d.b.h., two or more canopy levels, heart rot and other signs of stand decadence present and obvious, overstory canopy closure of 10-40 percent, usually with a definite shrub-sapling layer with a canopy closure of over 40 percent, with understory and overstory canopy combined exceeding 70 percent, and logs obvious on the ground.

1-hour fuel timelag class dead herbaceous and woody fuels less than 0.6 centimeter (0.25 in) in diameter and the uppermost 0.6 centimeter (0.25 in) of needles and leaves on the forest floor (Deeming et al. 1978, Furman 1975).

100-hour fuel timelag class dead fuels from 2.5 to 7.6 centimeters (1 to 3 in) in diameter and litter from 2.5 to 10.2 centimeters (1 to 4 in) below surface of the forest floor (Deeming et al. 1978, Furman 1975).

1,000-hour fuel timelag class dead fuels from 7.6 to 20.3 centimeters (3 to 8 in) in diameter and litter 10.2 to 30.5 centimeters (4 to 12 in) below surface of forest floor (Deeming et al. 1978).

on-grade strictly, timber free from defect; more generally, timber free from any defect not acceptable in the grade or for the particular use intended (Ford-Robertson 1971).

open canopy a canopy condition which allows large amounts of direct sunlight to reach the ground.

opening a break in the forest canopy; the existence of an area of essentially bare soil, grasses, forbs, or shrubs in an area dominated by trees.

open-stocked stand a stand of trees in which the trees are located relatively far apart.

opportunity curve a curve on a graph that displays the expected yield of a product under the possible combinations of two or more factors bearing on the production of that product.

optimum habitat amounts and arrangement of cover and forage areas that result in the greatest possible proper use of the greatest possible area by deer and elk.

optimum stocking see "full stocking."

organ a distinct part of a plant or animal that has one or more particular functions (Hanson 1962).

organic matter in soil materials derived from plants or animals, much of it in an advanced state of decomposition (Hanson 1962).

organism any living individual of any plant or animal species (Morris 1976).

overgrazing a continued overuse, usually by ungulates, that creates a deteriorated range condition (Kothmann 1974).

overmature (also see "old-growth stand") the condition that exists after an even-aged stand reaches maturity and decline in vigor, health and soundness (Ford-Robertson 1971).

overstocked (also see "stocking") a situation in which so many trees exist in a stand that it is impossible to achieve maximum wood production.

overstory the portion of the trees that form the uppermost canopy layer in a forest of more than one story (Ford-Robertson 1971).

overstory removal the removal, usually for silvicultural purposes, of overstory trees from a stand.

overuse use by ungulates of an excessive amount of the current year's growth of forage plants which, if continued, will result in overgrazing and range deterioration (Kothmann 1974).

parameter any variable or arbitrary constant appearing in a mathematical expression, the values of which restrict or determine the specific form of the expression (Morris 1976).

partial cuts any timber harvest that leaves live trees standing for some management purpose.

pathogen any agent that causes disease, especially micro-organisms, such as bacteria or fungi (Morris 1976).

pathological pertaining to or caused by disease (Morris 1976).

pathology the anatomic or functional manifestations of disease (Morris 1976).

perennial stream a stream that ordinarily has running water on a year-round basis.

perfect simplicity (also see "diversity index") an area in which no edges occur either on or within the perimeter; i.e., where the diversity index is equal to zero.

permanent stream see "perennial stream."

pest an organism causing or capable of causing damage to the forest (Ford-Robertson 1971).

pesticide a substance that destroys pests; e.g., a fungicide or an insecticide (Hanson 1962).

pH a notation designating acidity and alkalinity, and standing for the negative logarithm to base 10 of the H-ion concentration in a solution; a pH of 7 indicates neutrality; higher values indicate alkalinity and lower values indicate acidity (Ford-Robertson 1971).

phellem a tissue produced externally; i.e., on the bark side, by the phellogen in a stem or root (Ford-Robertson 1971).

photosynthesis the buildup of organic compounds, particularly carbohydrates, in green cells (Ford-Robertson 1971).

phylogenetic order species listed in sequence as to evolutionary development.

phylogenetic sequence see "phylogenetic order."

piling and burning the stacking of slash from logging and the subsequent burning of the individual stacks (USDA Forest Service 1956).

Pinaceae a family of plants; specifically, the pine family.

planning area the area encompassed by a particular forest management plan.

plant community a vegetative complex unique in its combination of plants; occurs in particular locations under particular influences; a reflection or integration of the environmental influences on the site —such as soils, temperature, elevation, solar radiation, slope, aspect, and rainfall; denotes a general kind of climax vegetation, such as ponderosa pine or bunchgrass, from which several plant community types may be derived on the basis of characteristic lesser vegetation.

plant community structure see "vegetative structure."

plant community type (also see "habitat type" and "plant community") a classification unit for vegetation using plant associations which characterize a type of plant community in a manner particularly useful to forest managers; classification is based on (1) floristic similarity in climax or other stable state, (2) similarity in biomass production, and (3) differences from other plant community types in terms of management actions acceptable or required; must be identifiable in any state of disturbance.

pole a young tree, from the time its lower branches begin to die until the time the rate of crown growth begins to slow and crown expansion is noticeable (Ford-Robertson 1971).

pole-sapling stage (also see "successional stage," "pole," and "sapling") one of six recognized successional stages in the coniferous forests of the Blue Mountains in which the dominant vegetation is trees that qualify as poles or saplings or both.

population in statistics, the aggregate of all units forming the subject of study; otherwise, a community of individuals that share a common gene pool (Ford-Robertson 1971).

population dynamics the totality of changes in number, sex, and age that take place during the life of a population (Hanson 1962).

potential maximum population see "maximum population level."

precommercial thinning (also see "thinning") any type of thinning that takes place in a stand before the size or condition of the material cut or killed makes it of sufficient value to meet the costs of the activity (Ford-Robertson 1971).

predator any animal that kills and feeds on other animals (Ford-Robertson 1971).

prescribed burning skillful application of fire to natural fuels under conditions of weather, fuel moisture, soil moisture, etc., that allows confinement of the fire to a predetermined area and produces the intensity of heat and rate of spread to accomplish planned benefits to one or more objectives of silviculture, wildlife management, grazing, or hazard reduction (USDA Forest Service 1956).

prescribed fire fire used as a management tool under specified conditions for burning a defined area (Kothmann 1974).

prescription in silvicultural terms, the formal written plan of action to carry out a silvicultural treatment of a forest stand to achieve specific objectives.

primary association the relationship between a wildlife species and a habitat condition that reflects a dependence on such habitat; a relationship that is strong and predictable.

primary cavity nesters wildlife species that excavate cavities in snags.

primary climax the climax vegetative stage toward and to which the vegetation evolves without interference of fire or other catastrophic event (Daubenmire 1968).

primary conversion the first stage in converting trees to products; the cutting and removal of trees from the forest.

primary excavator a species that digs or chips out cavities in wood to provide itself or its mate with a site for nesting or roosting.

primitive road a one-lane unimproved forest road in fair to poor condition that is seldom or never maintained (Perry and Overly 1977).

probability the frequency, expressed as a proportion or percent of the total occurrences, which will, over a long series of trials, produce a specified value for the variable in question (Ford-Robertson 1971).

program a planned sequence of logical instructions and routines performed by a computer to solve a problem (Ford-Robertson 1971); any organized list of procedures or schedule (Morris 1976).

programed (also see "program") to include or schedule in a program (Morris 1976).

proper use a degree and time of use by ungulates of the current year's forage production which, if continued, will either maintain or improve the range condition (Kothmann 1974).

prosenchyma cells elongated cells with tapering ends (Ford-Robertson 1971).

public forest any forest in public ownership; in the Blue Mountains such forests are primarily in National Forests managed by the USDA Forest Service.

public involvement the inclusion of the general public in the process of planning the goals and activities to occur on public forest land over a specified time period.

public land (also see "public forest") any land, including public forest land, held in Government ownership in trust for the citizens of the State or Nation; in the Blue Mountains, lands under the control of the USDA Forest Service and the U.S. Department of the Interior, Bureau of Land Management.

quantify (also see "quantity") to determine or express the number of some item (Morris 1976).

quantity a number or amount of anything, either specific or indefinite (Morris 1976).

radiation the emission and transmission of energy from any source (Hanson 1962).

radiation loss the heat loss from an animal by radiation to the surrounding environment.

radio-collar a collar containing a radio transmitter that is fastened on an animal; signals from the transmitter are received and used by wildlife biologists to gain information, usually about the position of the animal.

range in statistics, an elementary measure of the dispersion of a set of random variables, equal to the largest minus the smallest; in land classification, all land, including forest land, that produces native forage in contrast to land cultivated for agricultural crops or carrying dense forest (Ford-Robertson 1971); in wildlife management, the general area occupied by a particular animal, often on a seasonal basis, such as elk winter range.

raptor any predatory bird—such as a falcon, hawk, eagle, or owl—that has feet with sharp talons or claws adapted for seizing prey and a hooked beak for tearing flesh.

recoverable wood volume the wood produced in a growing stand that can be commercially harvested over a specified period.

recruitment of logs (also see "dead and down woody material") new logs accumulating on the forest floor.

reforestation reestablishment of a tree crop on forest sites (Ford-Robertson 1971).

regenerate to renew a tree crop through artificial or natural means or both (Ford-Robertson 1971).

regeneration the renewal of the tree crop by natural or artificial means; also, the young crop (Ford-Robertson 1971).

regeneration area (also see "regenerate") the area selected for regeneration; generally, with a stated specified period for accomplishment (Ford-Robertson 1971).

regeneration cut any removal of trees intended to assist regeneration already present or to make regeneration possible (Ford-Robertson 1971).

regeneration unit see "regeneration area."

regulate to control or direct by rule, principle, or method; to adjust to some standard or requirement; to put in desired order.

relative humidity the ratio of the amount of water vapor in the air at a specific temperature to the maximum capacity of the air to contain water vapor at that temperature (Morris 1976).

relic a surviving memorial of something past; an object having interest by reason of its age or association with the past; a surviving trace of something; remaining parts or fragments.

residence time the amount of time something has been in place; the amount of time a log has lain on the forest floor.

resident species the wildlife species commonly found in a specific area.

response curve a curve describing the response in potential use by elk or deer on a land-type to changes in the cover-forage area ratio.

rhizoid a filamentous organ, one cell thick, found in mosses, ferns, Gametophytes, and other plants; used for attachment and probably for absorption of water and nutrient salts (Hanson 1962).

rhizome a stem, generally modified for storing food materials, that grows along and below the ground surface and produces adventitious roots, scale leaves, and suckers irregularly along its length, not just at nodes (Ford-Robertson 1971).

rhizomorph a compact strand of fungus hyphae, capable of increase in length by apical growth, that transports food materials from one thallus part to another and assists in spreading fungi through or over substratum (Abercrombie et al. 1964).

richness (also see "species richness management") a measure of the relative degree or number of plant or wildlife species or both associated with particular habitat conditions.

ring see "growing layer."

riparian zone an area identified by the presence of vegetation that requires free or unbound water or conditions more moist than normally found in the area (Franklin and Dyrness 1973, Minore and Smith 1971).

road hunter a hunter who seeks game by cruising roads in vehicles which is illegal as a means of taking game in the Blue Mountains.

roadless area in the Blue Mountains, the USDA Forest Service's working definition is any area of 2 023 contiguous hectares (5,000 acres) that contains no developed roads; areas temporarily withdrawn from management until their suitability for wilderness classification is determined; also, any area to be managed without construction of roads.

root wad the mass of roots, soil, and rocks that remains intact when a tree, shrub, or stump is uprooted.

rotation the planned number of years between the regeneration of a stand and its final cutting at a specified stage (Ford-Robertson 1971).

rotation age the age of the forest stand when the final harvest cut is made (Ford-Robertson 1971).

rotation cycle see "rotation."

roundwood any wood products prepared in the round state—from felled trees to material trimmed, barked, and cross-cut; examples of such products are unsplit fuelwood, poles, and posts (Ford-Robertson 1971).

runoff precipitation that is not retained on the site where it fell; natural drainage away from an area (Ford-Robertson 1971).

runway a path so frequently followed by wildlife that a definite trail is formed, characterized by denuding of the land or creation of a depression on the ground.

sale area the area in which a timber sale has been made or is planned; often refers to the area in which timber will be, is being, or has been harvested.

salvage (also see "salvage cutting") the dead, dying, or deteriorating woody material removed from the stand and sold.

salvage cutting the removal and sale of trees that are dead, dying, or deteriorating (Ford-Robertson 1971).

salvage logging see "salvage cutting."

sanitation cutting the removal of dead or damaged trees or trees susceptible to death or damage—usually to prevent the spread of pests or pathogens and so promote forest hygiene (Ford-Robertson 1971).

sanitation harvest see "sanitation cutting."

sapling a young tree that is no longer a seedling but not yet a pole; a tree more than a few feet high and an inch or so in d.b.h., growing vigorously and without dead bark or more than an occasional dead branch (Ford-Robertson 1971).

saprophytes a plant incapable of synthesizing its nutrient requirements from inorganic sources that feeds on dead organic material, commonly assisting decay (Ford-Robertson 1971).

sap stain (also see "stain") any stain that predominantly affects sapwood; stain resulting from the growth of fungi that derive their nourishment from the cell contents but do not cause decomposition of the timber (Ford-Robertson 1971).

sapwood the outer layer of wood in the growing tree which contains living cells and reserve materials; e.g., starch (Ford-Robertson 1971).

saw log a log suitable in size and quality to produce sawn timber (Ford-Robertson 1971).

sawtimber trees fit to yield saw logs or logs that will yield sawn timber (Ford-Robertson 1971).

scheduling the selection of times to institute silvicultural treatments to accomplish management objectives.

scientific name (also see "genus," "species," and "binomial") the binomial or two-word latinized name of an organism; the first word describes the genus, the second the species.

Scribner rule one of the oldest diagram log rules in existence; the rule assumes 1-inch boards and a ¼-inch kerf; makes a liberal allowance for slabs and disregards taper (Ford-Robertson 1971).

secondary cavity nester wildlife that occupies a cavity in a snag that was excavated by another species.

secondary cavity user see "secondary cavity nester."

secondary occupier see "secondary cavity nester."

secondary road a forest road of 1½ lanes or less, somewhat improved, in good to fair condition, irregularly maintained (Perry and Overly 1977).

secondary wind maxima the air movement at ground level under dense canopied stands.

sediment material suspended in liquid or air; the deposition of that material onto the surface underlying this liquid or air (Morris 1976); usually the deposition of organic and inorganic soil materials by water.

sedimentary rocks rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits) (American Geological Institute 1962).

seed bearer any tree retained to provide seed for natural regeneration (Ford-Robertson 1971).

seedling a young tree grown from seed from the time of germination until it becomes a sapling; the division between seedlings and saplings is indefinite and may be arbitrarily fixed (Ford-Robertson 1971).

seed tree see "seed bearer."

seed-tree cutting removal in one cut of the mature timber crop from an area, except for a small number of seed bearers left singly or in small groups (Ford-Robertson 1971).

seed-tree regeneration regeneration of the stand by the intentional leaving of selected seed trees during the final harvest cut; once the new stand has sprouted, these trees are commonly removed or killed.

selection cutting the annual or periodic removal of trees, individually or in small groups, from an uneven-aged forest in order to realize the yield and establish a new tree crop (Ford-Robertson 1971).

selection system an uneven-aged silvicultural system; trees are removed individually or in small groups, here and there, from a large area each year; regeneration is mainly natural and the stand is ideally composed of many ages (Ford-Robertson 1971).

self-sustaining population a wildlife population of sufficiently large size to assure its continued existence within the area of concern without introduction of other individuals from outside the area.

semiaquatic species wildlife species that spend part of their lives on land and part in water.

sere the stages that follow one another in an ecologic succession (Hanson 1962).

shaded fuel break a lane through forest or rangeland from which most combustible material has been removed; some shade-forming vegetation is left to provide shade to retard growth of understory vegetation and to maintain a cooler, more moist environment.

shade-intolerant plants plant species that do not germinate or grow well in shade.

shade-tolerant plants plants that grow well in shade.

sheet erosion loss or movement of soil in thin layers.

shelterwood see "shelterwood cutting."

shelterwood cutting any regeneration cutting designed to establish a new tree crop under the protection of remnants of the old stand (Ford-Robertson 1971).

Shigometer an instrument used to detect the presence of wood decay.

short-range planning planning for a future less than 5 years distant (Schwarz et al. 1976).

shrub a plant with persistent woody stems and relatively low growth form; usually produces several basal shoots as opposed to a single bole; differs from a tree by its low stature and nonarborescent form (Kothmann 1974).

shrub-seedling stage (also see "successional stage," "shrub," and "seedling") one of six recognized successional stages in the coniferous forests of the Blue Mountains; the vegetation of the stand is dominated by shrubs or tree seedlings or both.

sight barrier any object that serves to block the vision of an observer.

sight distance the distance at which 90 percent or more of an adult elk or deer is hidden from the view of a human.

silvics the study of the life history and general characteristics of forest trees and stands, with particular reference to site factors, in order to provide a basis for the practice of silviculture (Ford-Robertson 1971).

silvicultural prescription the decision to use one or more of a series of silvicultural treatments to produce a desired result in terms of stand composition and condition.

silvicultural system a process which follows accepted silvicultural principles, whereby the tree crops are tended to produce crops of a desired form, harvested, and replaced (Ford-Robertson 1971).

silviculture generally, the science and art of cultivating forest crops, based on a knowledge of silvics; more particularly, the theory and practice of controlling establishment, composition, constitution, and growth of forests (Ford-Robertson 1971).

single-species stand a stand composed essentially of a single species.

single-storied stand a stand of trees in which the canopy is contained in one layer.

single-tiered stand see "single-storied stand."

single tree selection a method of harvesting under an uneven-aged forest management system in which trees are individually selected for harvest.

single-tree selection cutting single trees are removed from an uneven-aged forest in order to realize the yield and establish a new crop of irregular constitution.

single use a concept of management in which a single management objective is paramount.

site an area considered in terms of its environment, particularly as this determines the type, quality, and growth rate of the potential vegetation.

site class a measure of the relative productive capacity of a forest site based on volume or height of the trees or the maximum mean annual increment that is attained or attainable at a given age (Ford-Robertson 1971).

site index a measure of forest site class based on the height of the dominant trees in a stand at an arbitrarily chosen age (Ford-Robertson 1971); in the Blue Mountains the age is 100 years.

site potential see "site index."

site type (also see "plant community type" and "habitat type") classification of an area considered quantitatively in terms of how its environment determines the type, quality, and growth rate of the potential vegetation (Ford-Robertson 1971).

slabs any exterior portion of a log that is removed by the saw in the process of ripping; one side of this off-cut is the natural curve of the log and the other is the sawn surface (Ford-Robertson 1971).

slash the residue left on the ground after trees are felled or accumulated there as a result of storm, fire, or silvicultural treatment (Ford-Robertson 1971).

slash disposal (also see "lopping and scattering") the treatment or handling of slash to reduce fire or insect hazard; main treatments are broadcast burning, live burning, piling and burning, progressive burning, spot burning, chipping, and strip burning; the main methods of handling are lopping and scattering and pulling tops (Ford-Robertson 1971).

slash treatment see "slash disposal."

slope the incline of the land surface measured in degrees from the horizontal or in percent as determined by the number of units change in elevation per 100 of the same measurement units; also, characterized by the compass direction in which it faces (Kothmann 1974).

small diameter fuel woody fuels of small diameter that ignite and are consumed much more rapidly than large diameter fuels; usually composed of small diameter limbs, twigs, and stems.

snag (also see "stub") a standing dead tree from which the leaves and most of the limbs have fallen; such a tree broken off but still more than 6.1 meters (20 ft) tall is a snag; less than 6.1 meters (20 ft) tall, it is called a stub (Ford-Robertson 1971); in the Blue Mountains, a snag is defined for management purposes as any dead or partly dead tree at least 10.2-centimeter (4-in) d.b.h. and at least 1.8 meters (6 ft) tall.

snag-dependent wildlife wildlife species that are dependent on snags for nesting or roosting habitat or for food.

snag life the length of time a tree stands after it dies.

snag management level the number of snags per unit of area by d.b.h. class selected as a management goal; the level is predicated on the theoretical number of snags per unit of area by d.b.h. class needed to support nesting populations of woodpeckers at a selected density.

snag substitutability in snag management, larger snags can be substituted for smaller snags.

snag volume (also see "snags") the cubic volume of wood contained in snags.

snag year one snag standing for 1 year is equal to 1 snag year.

soaker hose a hose with holes or perforations along its length; stretched out and filled with water under pressure, the hose delivers water along its length; usually used to soak a strip of soil with water.

social strife conflict between animals of the same species; usually associated with overcrowding.

soft snag a snag composed primarily of wood in advanced stages of decay and deterioration, particularly in the sapwood portions; generally not merchantable.

softwood excavators cavity excavating birds that can excavate only in soft snags.

soil earth material so modified by physical, chemical, and biological agents that it will support rooted plants (American Geological Institute 1962).

soil erosion the displacement of soil from one place to another by any means, including water, wind, logging, and roadbuilding.

soil profile (also see "soil") a vertical section of the soil through all its horizons and extending into the parent material (Soil Science Society of America 1973).

soil structure (also see "soil") the form which individual soil particles assume when they cling together or aggregate as natural units of the soil mass; structures vary in shape, size, and degree of aggregation.

solid wastes any material regarded as worthless or useless that is in a solid state as opposed to gaseous or liquid; often a byproduct of a process.

sound wood wood free from decay or marked deterioration.

special habitat a habitat which has a special function not provided by plant communities and successional stages; includes riparian zones, snags, dead and down woody material, and edges; biological in nature; can be created or altered by management.

species a unit of classification of plants and animals consisting of the largest and most inclusive array of sexually reproducing and cross-fertilizing individuals which share a common gene pool; the most inclusive Mendelian population (Hanson 1962).

species-area curve a relationship describing the increasing number of plant or animal species per unit increase in area or vice versa.

species-area phenomenon a relationship revealing that the number of plant or wildlife species increases with the size of the area.

species code a code of four to six letters for the binomial (see "binomial") of each vertebrate; the first two letters of the code are the first two letters of its genus and the next two to four letters of the code are the first letters of its species (e.g., *Cervus elaphus* or CEEL).

species composition the species that occur on a site or in a successional or vegetative stage of a plant community.

species richness a measurement or expression of the number of species of plants or animals present in an area; the more species present, the higher the degree of species richness.

species richness management a wildlife management strategy whose goal is to produce a relatively high number of species per unit area.

spore a single- or several-celled reproductive body that becomes detached from the parent and gives rise to a new individual; occurs in all groups of plants but particularly in fungi, bacteria, and protozoa (Abercrombie et al. 1964).

sporocarp a multicellular structure in which spores are formed (Morris 1976).

spot burning a modified form of broadcast slash burning in which only the greater accumulations are fired and the fire is confined to these spots (USDA Forest Service 1956).

spring-fall range an area between summer range at high elevation and winter range at low elevation that is used by deer and elk during spring and fall as they move between summer and winter range.

stability the ability of an ecosystem, when changed from a steady state, to develop forces that tend to restore it to its original condition (Margalef 1969).

stagnated stand a stand in which the growth of individual trees is much below potential because of crowding or high density of the trees.

stagnation the process of the lessening of the growth rate of individual trees in a stand because of overcrowding.

stain (also see "blue stain" and "sap stain") in wood, any alteration in natural color caused by fungus attack.

stand plant communities, particularly of trees, sufficiently uniform in composition, constitution, age, spatial arrangement, or condition to be distinguishable from adjacent communities; also, may delineate a silvicultural or management entity (Ford-Robertson 1971).

stand age the age of a stand under even-aged management at any particular time; stand age 1 occurs when trees sprout and the final age occurs when the stand is subjected to final harvest or regeneration cutting.

stand basal area (also see "basal area" and "crop basal area") the total basal area in a stand (Ford-Robertson 1971).

stand condition the descriptive measurement of a stand by the criteria of composition, health, age, size, volume, or spatial arrangement.

stand mortality trees in a stand that die from natural causes, usually low vigor, inferior crown position, or crowding, or a combination of these factors; also, loss from insects, disease, or blowdown.

stand regulation (also see "regulate") to bring stand conditions into a desired state.

stand structure (also see "stand") the configuration of elements, parts, or constituents of a stand.

stand type a classification for silvicultural or management purposes made on the basis of composition, size, density, and age (Ford-Robertson 1971).

standard aerial photograph a photograph of the landscape taken from an aircraft with the camera at about a 90° angle to the earth's surface.

standard deviation a statistical term; a measure of the dispersion about the mean of a population; i.e., the positive square root of the variance (Ford-Robertson 1971).

standard error a statistical term; the standard deviation of a distribution of means or of any other statistic determined from samples; determined by dividing the standard deviation by the square root of the number of observations (Ford-Robertson 1971).

stem the principal axis of a plant, from which buds and shoots develop; with woody species, the term applies to all ages and thicknesses (Ford-Robertson 1971); in forestry, synonymous with a standing tree.

stocking a loose term for the amount of anything in a given area, particularly in relation to the optimum; more precisely, a measure of the proportion of an area actually occupied by trees, in terms of stocked quadrats or percent canopy closure (Ford-Robertson 1971).

stocking density (also see "stocking") a measure of the proportion of the area actually occupied by trees (Ford-Robertson 1971); synonymous with stocking rate.

stocking rate see "stocking density."

story a horizontal stratum or layer of vegetation formed by a plant community; in forests they are formed essentially by canopy layers (Ford-Robertson 1971).

strata see "vegetative strata."

stream management unit a management zone alongside a stream where the management objective is the protection of the riparian zone or of water quality or quantity or both.

stream protection zone a zone in which management activity is excluded or modified to protect the riparian zone or quality and quantity of water or both.

stringer vegetation arranged in a long, thin, linear fashion.

strip burning setting fire to a narrow strip of fuel adjacent to a central line and then burning successively wider adjacent strips inside as the preceding strip burns out; or, burning only a relatively narrow strip or strips of slash through a cutting unit and leaving the remainder (USDA Forest Service 1956).

structural diversity diversity in a forest stand that results from layering or tiering of the canopy; an increase in layering or tiering leads to an increase in structural diversity.

structure see "stand structure."

stub (also see "snag") a standing dead tree broken off at a height of 6.1 meters (20 ft) or less from which the leaves and most of the limbs have fallen (Ford-Robertson 1971).

stump the woody base of a tree left in the ground after felling (Ford-Robertson 1971).

substitutable area an area that may serve in the place of another area for a particular purpose selected by the forest manager.

succession the changes in vegetation and in animal life that take place as the plant community evolves from bare ground to climax.

successional stage a stage or recognizable condition of a plant community which occurs during its development from bare ground to climax; coniferous forests in the Blue Mountains progress through six recognized stages: grass-forb → shrub-seedling → pole-sapling → young → mature → old growth.

sucker a shoot arising from below ground level, either from a rhizome or from a root (Ford-Robertson 1971).

summer range a range, usually at higher elevation, used by deer and elk during the summer; a summer range is usually much more extensive than a winter range.

sunning the process of an animal methodically exposing itself to direct sunlight; also called sunbathing.

surface sediment (also see "sediment") sediment originating on the soil surface.

surface-water runoff runoff from precipitation that does not soak into the soil but moves over the soil surface.

suspended sediment soil and other material suspended in water, usually disturbed or moving water; this material drops out of suspension when water movement slows or ceases.

sustained yield the yield that a forest can produce continuously from a given intensity of management; implies continuous production; a prime goal is to achieve, at the earliest practical time, a balance between increment and cutting (Ford-Robertson 1971).

symbiosis a relationship between two or more kinds of living organisms wherein all benefit; sometimes obligatory to one or more of the organisms in the relationship (Ford-Robertson 1971).

talus the accumulation of broken rocks that occurs at the base of cliffs or other steep slopes.

taper the decrease in diameter of a tree stem or log from the base upward (Ford-Robertson 1971).

temperate forest (also see "temperate zone") a forest occurring in the temperate zone.

temperate zone the portions of the earth in the northern and southern hemispheres that lie between the tropics and the polar circles 23°27′ from the poles (Hanson 1962).

10-hour fuel timelag class dead fuels from 0.6 to 2.5 centimeters (0.25 to 1 in) in diameter and litter from 0.6 to 2.5 centimeters (0.25 to 1 in) below the surface of the forest floor (fuel moisture sticks 1.25 centimeters (0.5 in) in diameter are used to estimate moisture content of this fuel timelag class) (Deeming et al. 1978, Furman 1975).

terrestrial vertebrates animals with backbones that dwell primarily on land.

terrestrial wildlife wildlife species that dwell primarily on land.

territorial requirement (also see "territory") the area necessary to satisfy an animal's need for space.

territory the area which an animal defends, usually during breeding season, against intruders of its own species (Hanson 1962).

thallophyte a plant in any one of the phyla of algae and fungi (Hanson 1962).

thallus a plant body that is not differentiated into leaves, stems, and roots; one- to many-celled, e.g. thallophytes (Hanson 1962).

thermal cover (also see "cover" and "cover patch") cover used by animals to ameliorate effects of weather; for elk, a stand of coniferous trees 12 meters (40 ft) or more tall with an average crown closure of 70 percent or more; for deer, cover may include saplings, shrubs, or trees at least 1.5 meters (5 ft) tall with 75-percent crown closure.

thermal-neutral zone an area where the ambient conditions do not trigger a metabolic response on the part of the occupying animal.

thinning felling of part of an immature crop or stand to accelerate growth in the remaining trees; by suitable selection, to improve the form of the trees that remain (Ford-Robertson 1971).

thinning regime (also see "thinning") the silviculturally prescribed schedule and intensities of thinnings throughout the life of a stand.

threatened species a wildlife species officially designated by the U.S. Fish and Wildlife Service as having its existence threatened in a localized area, such as State or province or lesser area, because its habitat is threatened with destruction, drastic modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors.

timber a general term for forest crops and stands containing timber; also, for any lesser aggregation of such trees (Ford-Robertson 1971).

timber management the management of the forest to enhance production of wood products for commercial use.

timber management system the overall process followed in the management of a forest to produce timber; the two primary types are even-aged and uneven-aged management.

Timber Resource Allocation Model (Timber RAM) a computer model developed by the USDA Forest Service (Navon 1971) that projects data on timber stands and is used in calculating timber harvest levels over the rotation period; accepts constraints imposed by yield tables, area by timber class or type, and law or management decision.

timber sale the process of selling timber to a buyer.

timber type a classification of a plant community based on the naturally occurring dominant tree species in the climax.

timelag (TL) the time required for a fuel particle to lose 63 percent of the moisture it can potentially lose under a particular set of environmental conditions.

total diversity (also see "total diversity index") the sum total of diversity within an area; the sum of induced and inherent diversity.

total diversity index a number that indicates the relative degrees of total diversity (induced diversity + inherent diversity) in habitat per unit area produced by all edges within or on the periphery of the area. Expressed mathematically:

$$\text{Total DI} = \frac{TE_{c+s}}{2\sqrt{A \cdot \pi}};$$

where TE_{c+s} is the total length, in meters or feet, of all inherent and induced edges, A is the area in square meters or square feet, and π is 3.1416; or

$$\text{Total DI} = \text{Inherent DI} + \text{Induced DI}.$$

trade-off an exchange of one thing in return for another; especially a giving up of something desirable, as a benefit or advantage, for something regarded as more desirable (Morris 1976).

transition zone (also see "ecotone") an area on which two or more plant communities or successional stages within plant communities merge and which shows characteristics of all involved communities or stages.

travel corridor (also see "migration corridor") a route followed by animals along a belt or band of suitable cover or habitat.

travel lanes (also see "travel corridor") areas of cover commonly used by animals moving from one location to another.

treat to subject to some process, action, or change (Morris 1976).

treatment in experimentation, a stimulus applied in order to observe its effect on an experimental situation or to compare its effect with the effects of other treatments; in practice, may refer to anything capable of controlled application according to experimental requirements (Ford-Robertson 1971); the act or manner of treating something (Morris 1976).

treatment scheduling the times chosen to institute various silvicultural practices.

tree form woody vegetation that presents the shape and structure of trees.

tropical forest a forest occurring in the tropics.

tropics the region between the Tropic of Cancer at 23°27′ north latitude and the Tropic of Capricorn at 23°27′ south latitude (Hanson 1962).

two-storied stand a stand of trees whose crown structure is divided into two distinct canopy layers.

type (also see "site type," "habitat type," and "plant community type") a site classified qualitatively by its climate, soil, or vegetation (Ford-Robertson 1971); in forestry, usually based on the dominant tree species.

unbound water see "free water."

underburning (also see "prescribed fire") the prescribed use of fire to burn vegetation under a forest canopy but without burning the canopy.

understory in silviculture, trees growing under the canopy formed by taller trees; in range management, herbaceous and shrub vegetation under a brushwood or tree canopy (Ford-Robertson 1971).

uneven-aged stand a forest stand managed to maintain an intermingling of trees that differ markedly in age (Ford-Robertson 1971); stands continuously or periodically regenerated, tended, and harvested with no real beginning or end (Alexander and Edminster 1977).

ungulate a mammal with hooves (Hanson 1962).

unique habitats (also see "special habitat") wildlife habitats (i.e., cliffs, caves, and talus) of special function not included within plant communities and successional stages or special habitats; geomorphic in nature.

unit area control see "area control."

unmanaged forest (also see "managed forest") a forest in which no management is presently occurring; an unmanaged forest may have been managed in the past or may be managed in the future.

unsalvaged mortality (also see "salvage" and "mortality") any dead or dying trees in the stand that have not been or will not be salvaged.

unstocked a forest site on which there are no trees.

upper slope a location on the upper one-third of a slope.

use potential the amount of use by deer and elk that may be expected on a land-type as cover-forage area ratios are changed when judged against base use potential.

variable generally, any quantity that varies; more precisely, a quantity that may take any one of a set of values (Ford-Robertson 1971); a single influence or one of several measurable influences acting on a particular process.

variance a statistical term; a measure of variability within a finite population or sample; the total of the squared deviations of each observation from the arithmetical mean divided by one less than the total number of observations (Ford-Robertson 1971).

vascular containing or concerning vessels which contain fluid; in animals, the fluid is usually blood; in plants, water with mineral salts and synthesized food materials (Abercrombie et al. 1964).

vascular plants plants containing vessels.

vector a carrier.

vegetation complex the admixture of plant species that occupy a site.

vegetation condition the results of a silvicultural treatment imposed on a successional stage of a forest plant community.

vegetation strata the layers of vegetation that may be discerned in a plant community.

vegetation structure the form or appearance of a stand; the arrangement of the canopy; the volume of vegetation in tiers or layers.

versatile capable of or adapted for survival in several plant communities or successional stages or both.

versatility index a figure indicating relative degrees of versatility between species in terms of the number of plant communities and successional stages used by the individual species for feeding and reproduction; the more communities and successional stages used, the more versatile the species.

versatility rating (also see "versatility index") the position, in rank order, assigned to a wildlife species on the basis of its versatility index number.

vertical diversity the diversity in an area that results from the complexity of the aboveground structure of the vegetation; the more tiers of vegetation or the more diverse the species makeup or both, the higher the degree of vertical diversity.

viable population a wildlife population of sufficient size to maintain its existence over time in spite of normal fluctuations in population levels.

visual management zone an area in which the overriding management concern is for an esthetically pleasing appearance; in most forested areas, such zones are managed to give the impression of mature and relatively unbroken forest.

visual resource management area see "visual management zone."

volume control see "volume regulation."

volume increment (also see "growth increment") a measurable increase in wood volume in a tree or stand of trees.

volume regulation a direct method of determining and controlling the amount of timber to be cut, annually or periodically, through calculations based on growing stock volume and increment and disregarding area (Ford-Robertson 1971).

V score see "versatility index."

vulnerability the relative probability of timber management activities having an adverse effect on the numbers of a wildlife species; vulnerability can be measured by the inverse of the versatility index.

water-holding capacity a measure of the ability of soil to soak up and hold water.

water quality determined by a series of standard parameters: turbidity, temperature, bacterial content, pH, and dissolved oxygen.

water quantity the amount of water coming from a watershed or drainage.

watershed see "catchment."

wilderness lands designated by law as wilderness; no roadbuilding or timber management is allowed on such lands; they are intentionally managed to maintain their primitive character.

wildfire an unplanned fire requiring suppression action, as contrasted with a prescribed fire burning within prepared lines enclosing a designated area under prescribed conditions; a free-burning fire unaffected by fire suppression measures (USDA Forest Service 1956).

wildlife all nondomesticated vertebrates.

wildlife habitat management the manipulation or maintenance of vegetation to yield desired results in terms of habitat suitable for designated wildlife species or groups of species.

wildlife logs logs left in place on the forest floor for wildlife habitat.

wildlife management the scientifically based art of manipulating habitats to produce some level of a desired species or manipulating animal populations to achieve a desired end.

windrow slash, brushwood, etc., concentrated along a line, so as to clear the intervening ground between such lines (Ford-Robertson 1971).

windthrow (also see "blowdown") a tree or trees uprooted or felled by the wind (Ford-Robertson 1971).

winter range a range, usually at lower elevation, used by migratory deer and elk during the winter months; usually better defined and smaller than summer ranges.

woody debris (also see "dead and down woody material") the woody remains of something scattered or destroyed—ruins, rubble, fragments; the accumulation of dead woody material on the forest floor.

working circle (see also "working plan" and "working plan area") a forest area that forms all or part of a working plan area, organized to accomplish a particular objective and operated under one set of working plan prescriptions that embodies one silvicultural system or a designed combination of such systems (Ford-Robertson 1971).

working definition a definition used in management even though the definition is recognized as interim and subject to revision.

working plan a plan for forest management; more particularly a written plan aimed at achieving a continuity of policy and action; prescribes and controls basic operations in a forest over an extended period (Ford-Robertson 1971).

working plan area the area covered by a single working plan; the largest forest management unit (Ford-Robertson 1971).

yarding transporting timber from the point of felling to a yard or landing (Ford-Robertson 1971).

yield in forestry, the wood products that are harvested.

yield table see "managed yield table."

young stage (also see "successional stage") one of six successional stages in the coniferous forests of the Blue Mountains in which a stand of trees is dominated by trees that are no longer poles but have not yet reached maturity.

Index

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