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WILDLIFE HABITATS IN MANAGED RANGELANDS-- THE GREAT BASIN OF SOUTHEASTERN OREGON

EDGES

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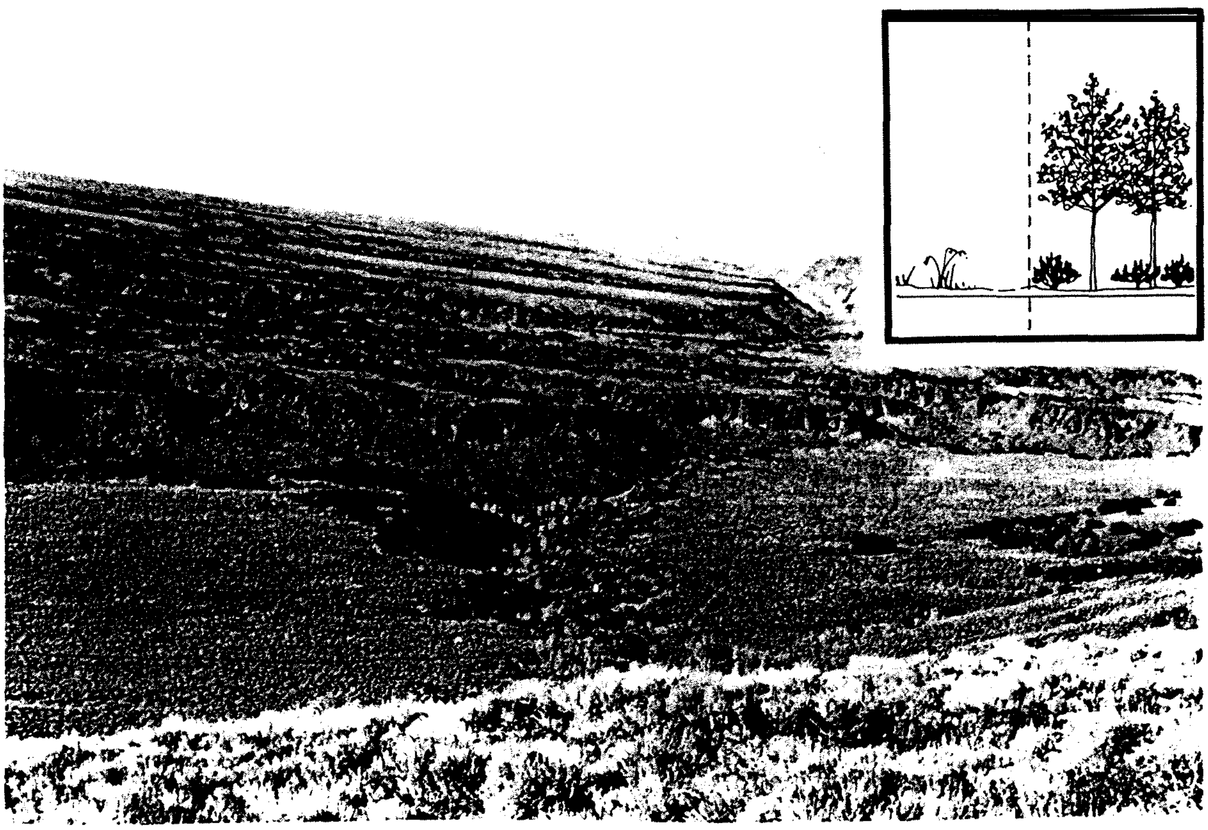

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
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ABSTRACT

Edge can be a measure of overall diversity of any area. Diversity is considered as inherent (community/community) edge, induced (successional stage/successional stage) edge and total edge. Size of stands are related to expected wildlife diversity.
KEYWORDS: Wildlife habitat, range management.

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This publication is part of the series **Wildlife Habitats in Managed Rangelands — The Great Basin of Southeastern Oregon.** The purpose of the series is to provide a range manager with the necessary information on wildlife and its relationship to habitat conditions in managed rangelands in order that the manager may make fully informed decisions.

The information in this series is specific to the Great Basin of Southeastern Oregon and is generally applicable to the shrub-steppe areas of the Western United States. The principles and processes described, however, are generally applicable to all managed rangelands. The purpose of the series is to provide specific information for a particular area but in doing so to develop a process for considering the welfare of wildlife when range management decisions are made.

The series is composed of **14** separate publications designed to form a comprehensive whole. Although each part will be an independent treatment of a specific subject, when combined in sequence, the individual parts will be as chapters in a book.

Individual parts will be printed as they become available. In this way the information will be more quickly available to potential users. This means, however, that the sequence of printing will not be in the same order as the final organization of the separates into a comprehensive whole.

A list of the publications in the series, their current availability, and their final organization is shown on the inside back cover of this publication.

Wildlife Habitats in Managed Rangelands — The Great Basin of Southeastern Oregon is a cooperative effort of the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, and United States Department of the interior, Bureau of Land Management.

Introduction

An edge (fig. **1)** is the place where plant communities meet or where structural conditions within plant communities come together. The area influenced by the transition between communities or conditions is called an ecotone (fig. 2). Edges and their ecotones are usually richer in wildlife than are the adjoining plant communities or structural conditions. As a result, they are an important consideration in wildlife management.

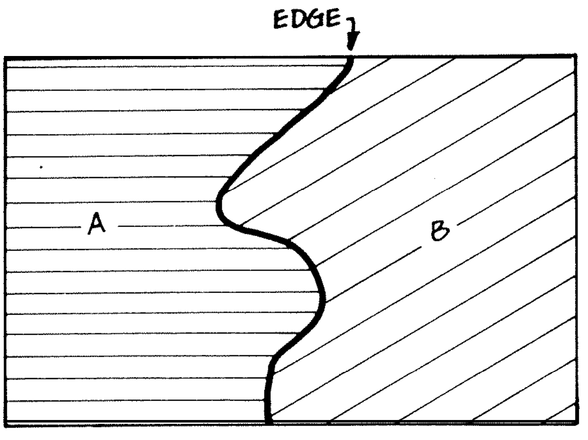
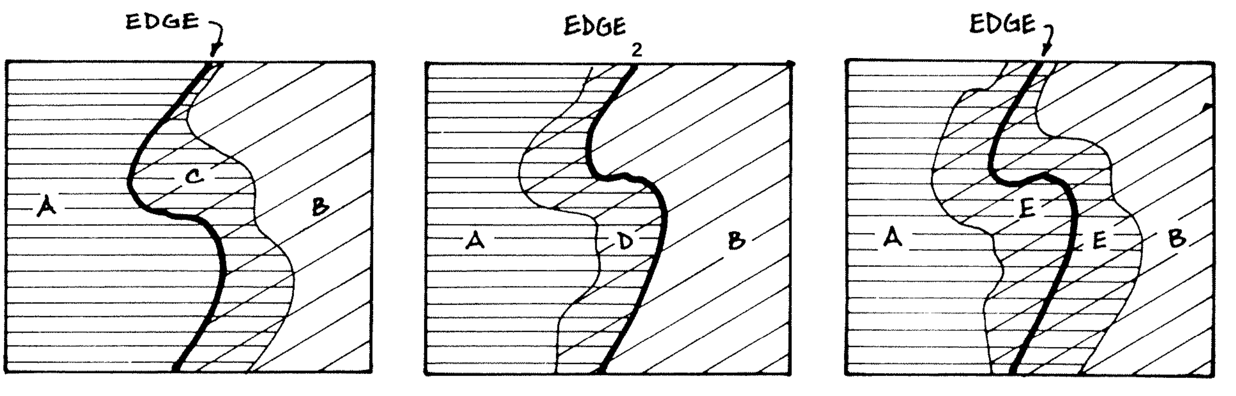


Figure 1.-An edge is the place where plant communities (A and B) or structural conditions within a plant community come together.

Aldo Leopold (1933, p. 132) stated that "game [wildlife] is a phenomenon of edges." Wildlife "occurs where the types of food and cover which it needs comes together, i.e., where these 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 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.

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). 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.



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 2.— Ecotones are formed along edges and may be created in several ways.

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 and 1966).

Interspersion is the intermixing of plant species and plant communities that provides habitat for animals within a defined area (Hanson 1962). 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 range 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.

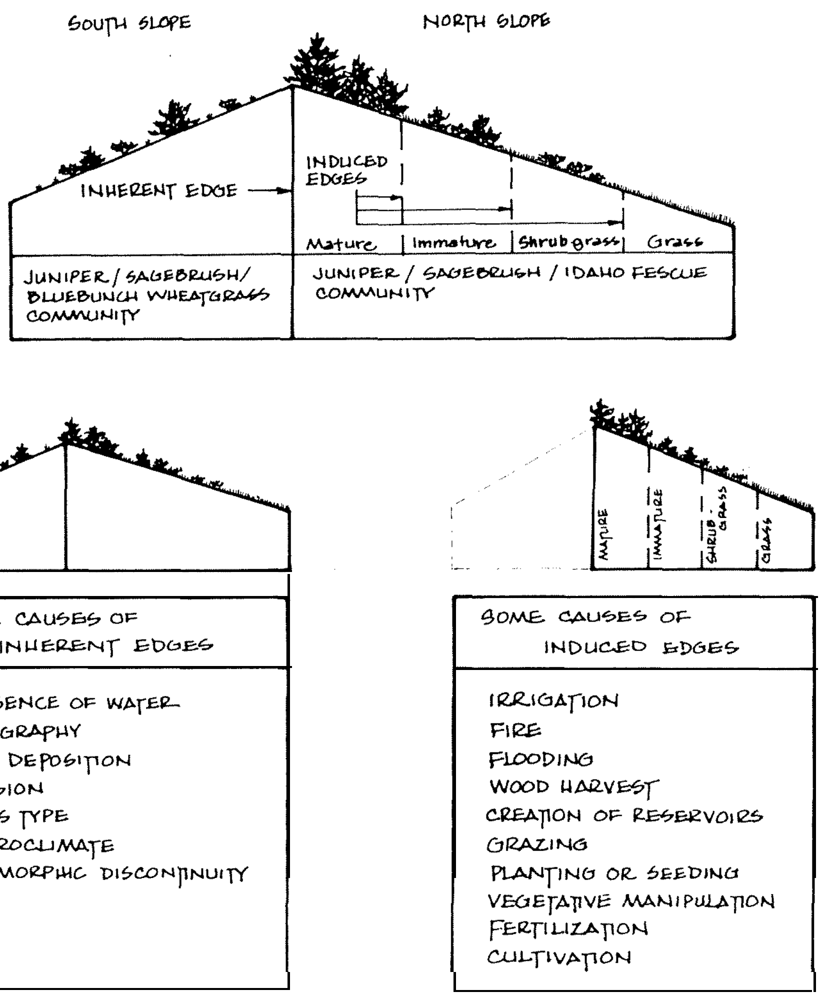


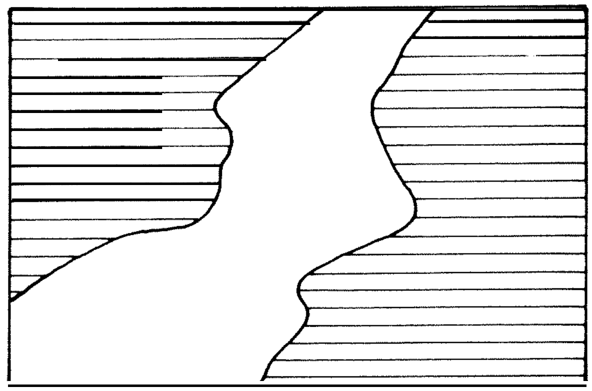
Figure B.-Inherent edges are created where plant communities meet. Induced edges are created where structural conditions within communities come together. Inherent and induced edges are created by many factors.

Inherent Edge

An edge that results from the meeting of two plant communities is called an inherent edge (fig. 3). The plant community is the tangible expression or integrator of the 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, however, change. 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. 4). In other situations, a broadened ecotone may result. An inherent edge can also be created suddenly, for example, by 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.



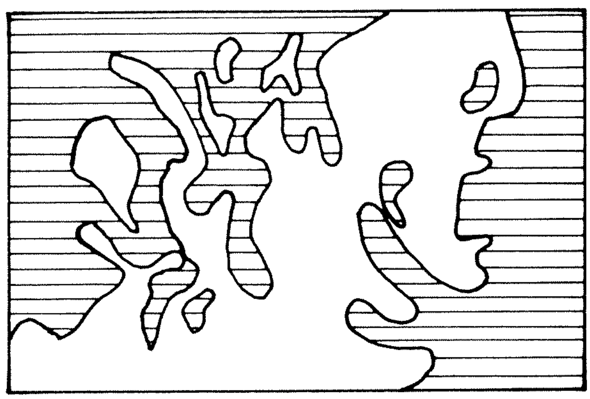


Figure 4.—Inherent edges may be abrupt or mosaic. inherent edges sometimes evolve into mosaic edges over prolonged periods.

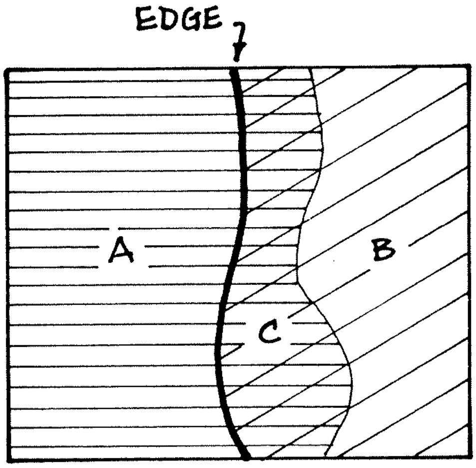
Induced Edges

An edge that results from the meeting of structural conditions within a plant community is called an induced edge (fig. 3). Such edges can be created by management practices or short-term natural phenomenon-that is, they can be induced.

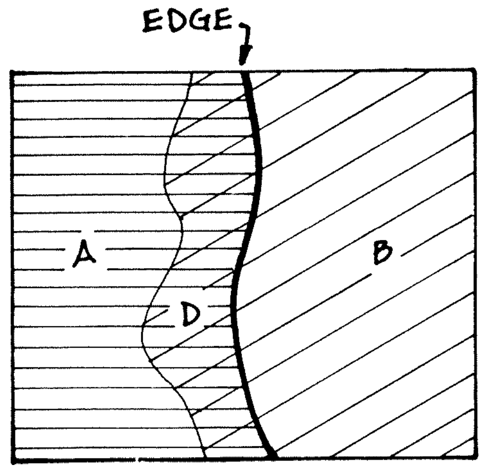
Under natural conditions, induced edges are created by drastic short-term environmental factors, such as fire, disease, insect outbreaks, floods, logging, and erosion (fig. 3). These factors tend to shift plant communities toward earlier, less mature, structural conditions. Compared with inherent edges, induced edges are relatively short lived. Although they may last for many years, they are constantly changing through such things as plant succession and are not permanent features of the landscape.

Importance to Wildlife Management

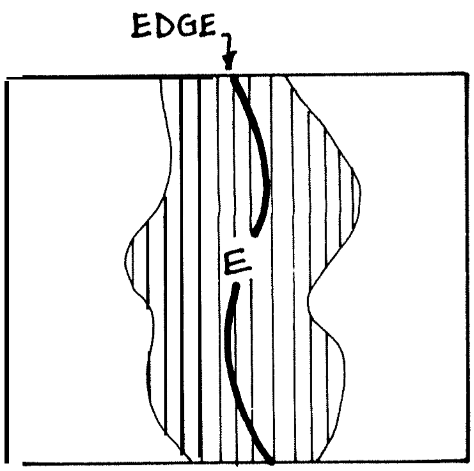
The biological importance of edges to wildlife managers is expressed by the term "richness." Edges and their ecotones are rich in wildlife, both in number of species and of individuals, because of the additive effect on the flora and fauna when two plant communities or structural conditions come together. 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 (Southwood 197'2) (fig. 5). In another sense, wildlife richness is related to the plant and habitat diversity expressed in the ecotone.



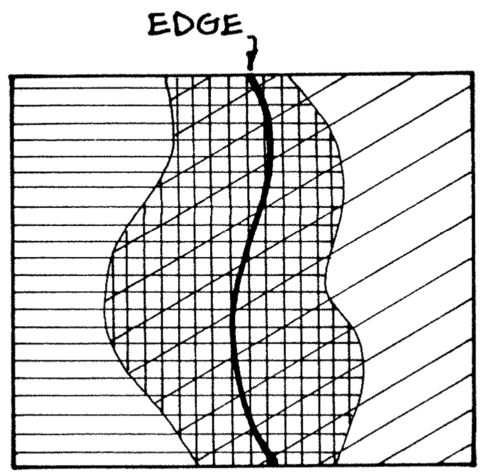
Some wildlife from plant community A overlaps into B within ecotone C.



Some wildlife from plant community B overlaps into A within ecotone D.



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 5.—Species richness associated with edges is an additive effect.

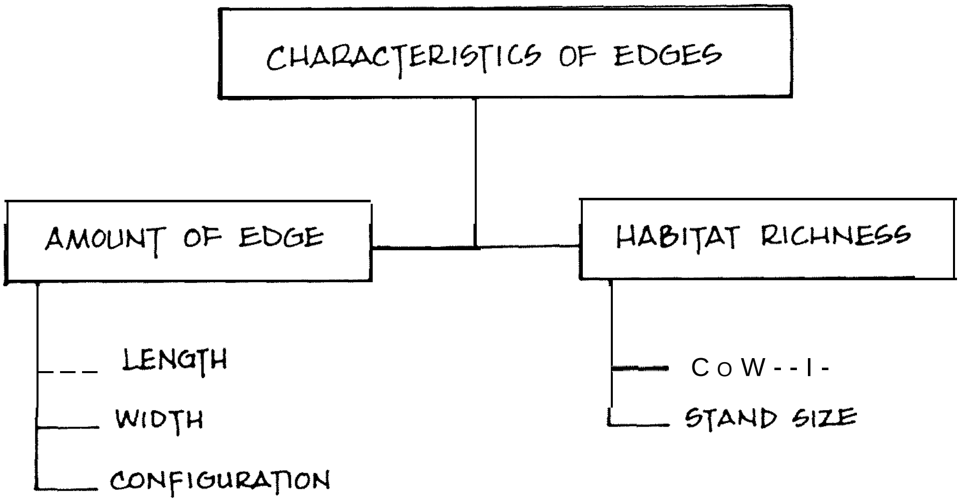


Figure 6.—Edges have characteristics that influence habitat and species richness.

Characteristics of Edges

Edges have characteristics (fig. 6) 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.

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. 4).

The degree of habitat richness associated with a particular edge is influenced by the size of the plant community and the type of habitat coming together in the edge (Halligan 1974, Johnsgard and Rickard 1957, Wiens 19'73). 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 structural conditions in figure 7. There are 5 structural conditions that can be formed into 10 combinations by the joining of 2 conditions. Each combination produces a different degree of contrast. Little contrast is produced by combining closely related conditions. Contrast can be dramatic, however, if an early structural condition is joined with a late condition. The degree of contrast may be determined by subtracting the smaller identifying numbers from the latter. The greater the difference, the greater the contrast.

Area Size and Diversity

At some point, increasing diversity tends toward homogeneity and tends to become decreasingly diverse. Galli et al. (1976, p. 356) said that "The number of species present in a particular habitat is strongly influenced by the size of that habitat." The number of species of

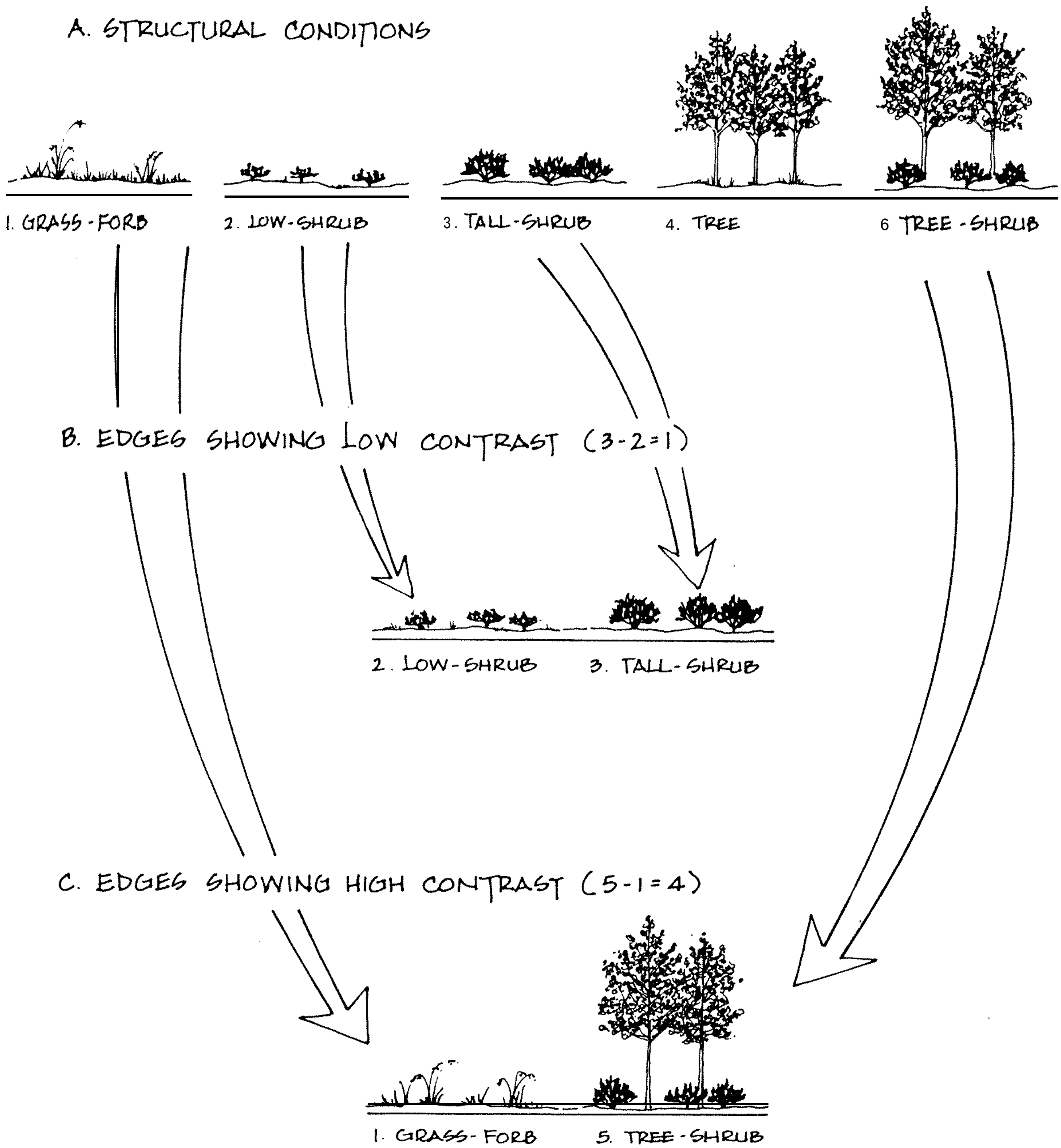


Figure 7.-Different combinations of edges yield different degrees of contrast in structure.

both animals and plants in an area is another indicator of diversity. Arrenhius (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 in a particular ecological condition. After review of this literature and experimental examination of the relationship of habitat size to species diversity of birds, 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 decreasingly diverse when the average size of the habitat blocks becomes smaller than that required to maximize the number of species present (fig. 8). Since no data could be found for rangeland ecosystems, the information of Galli et al. (1976) is used to illustrate the point. Galli et al. 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 hectares (59.30 acres) and is likely to continue increasing significantly at forest sizes beyond 24 hectares." Increase in bird species with 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 over the numbers predicted by the "best-prediction" equation:

$$y = 0.81 + 4.54\ x^{0.05}$$

where y is species richness and x is forest area in hectares. The correlation coefficient (R) was 0.92, accounting for 85 percent of the variation in species richness (R^2). 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.

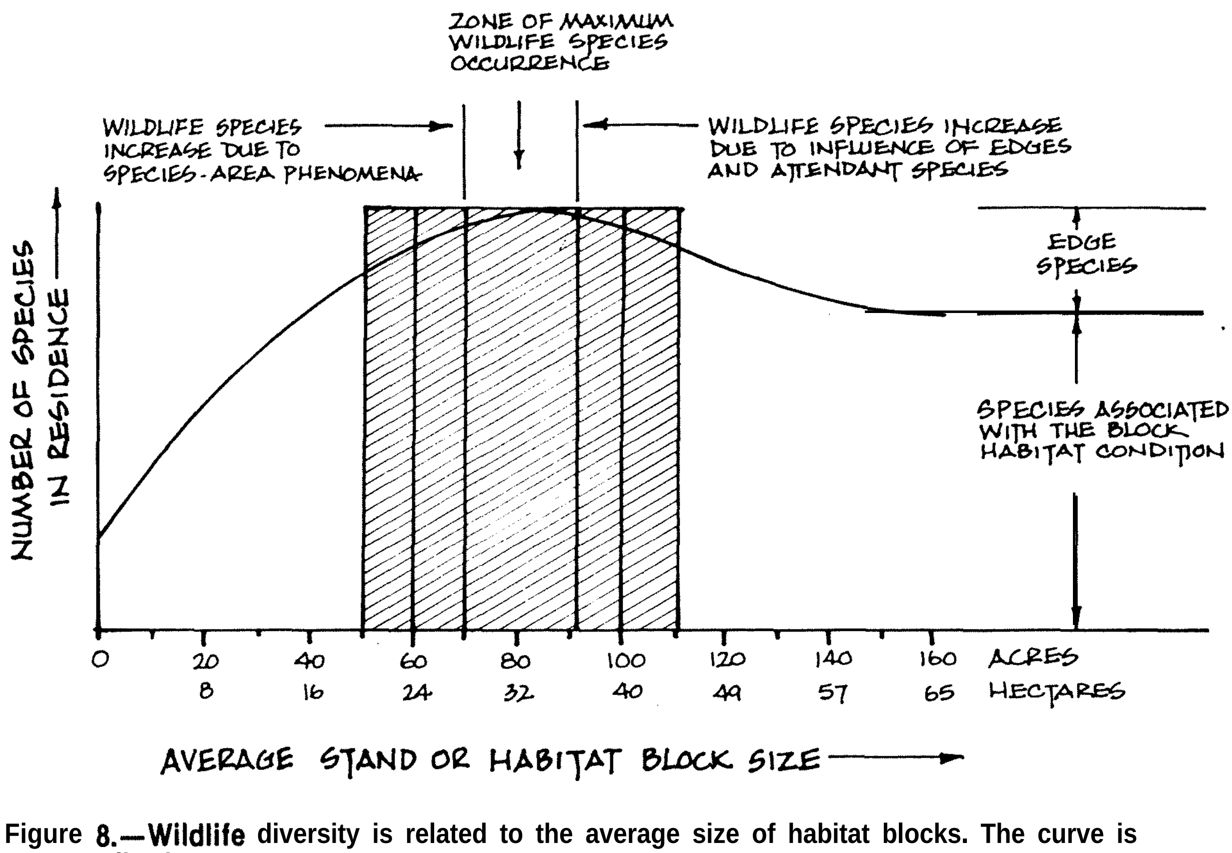


Figure 8.—Wildlife diversity is related to the average size of habitat blocks. The curve is generalized.

Data are lacking for these relationships in southeastern Oregon, but a best estimate is required. Due to the comparative lack of vertical habitat stratification in rangelands as compared to forests, it is obvious that rangeland habitats are not as diverse, and in turn not as rich, as the forest habitats explored by Galli et al. (1976). It seems likely that the increase in habitat size and species occurrence will peak at a higher figure than in forest habitats. Until research data is available, it is suggested that managers assume that wildlife species richness (at least that for birds) will increase significantly with habitat size to about 81 hectares (200 acres) and that bird species richness is a reasonable indicator of the relationship of all vertebrate wildlife to habitat size.

'So, wildlife species richness should be approaching the maximum where the average habitat size is approximately 81 hectares (200 acres). Pay special attention to the emphasis on "average." This indicates the existence of habitats both larger and smaller than 81 hectares (200 acres). The larger habitats will accommodate those relatively few species that require habitat blocks larger than the average while smaller habitats will increase edge effect.

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 animal's 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 rangeland ecosystems will help to insure the continued existence of the living components of that 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 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 rangeland ecosystems.

Some land management agencies are beginning to be concerned about diversity. For example, the United States Department of the Interior, Bureau of Land Management Manual 1603—Supplemental Guidance (19'73, p. 12D), under "Long-Term Objectives," directs that BLM will:

> a. Maintain a maximum diversity of wildlife species in sufficient numbers to meet public demands. This will be accomplished by means of habitat management.

And under "Major Principles and Standards" (1973, p. 12D), Manual 1603 further states that:

> c. The essential requirements of wildlife-food, cover, and water-will be maintained so as to provide optimum 'edge effect' and interspersion of habitat components in important wildlife areas.

The Chief of the USDA Forest Service has stated that the wildlife goal for the National Forest System is to insure wildlife diversity and to maintain or enhance wildlife populations (USDA Forest Service 1976). If diversity is a goal in rangeland management, it behooves managers and planners to be able to measure it and account for it in their activities.

Both inherent and induced edges are a direct reflection of the total diversity (fig. 9) in an area. Patton (1975) indicated that edge can be used as a measure of diversity. Traditional diversity indexes (Pielou 1975) require information about numbers of plant and animal

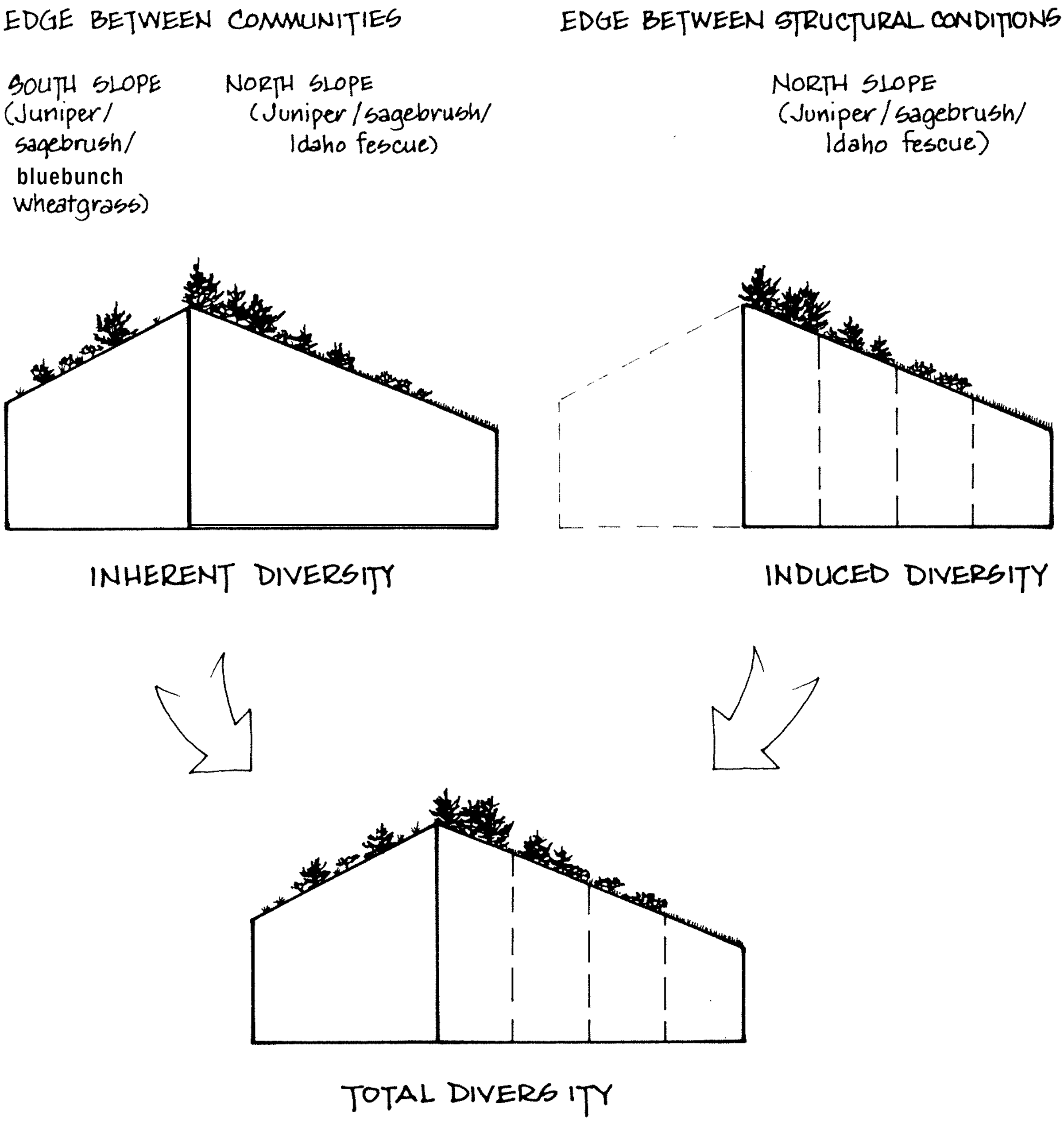


Figure O.-The type, amount, and arrangement of edges is an expression of habitat diversity.

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 rangeland 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 livestock grazing on diversity.

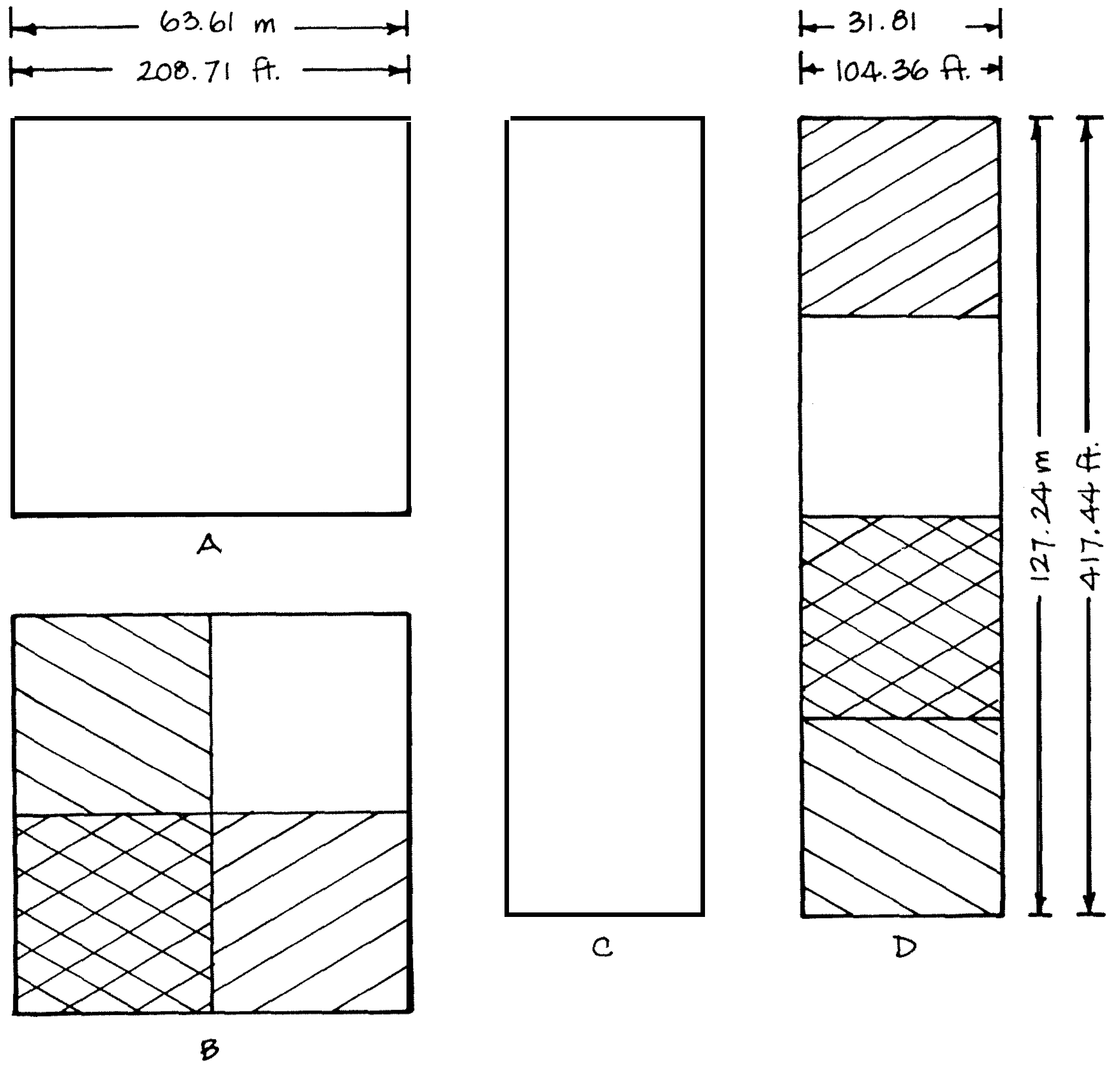
Derivation of Diversity Index

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 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 l-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. 10A], and the perimeter of the block is 834.84 linear feet. Substituting these values in the formula:
>
> $$DI = \frac{834.84}{2\sqrt{43,560 \times 3.1416}} = 1.13$$
>
> This indicates that a square of 1 acre has 0.13 times more edge than a circle of 1 acre. Dividing the l-acre block into 4 units of different vegetation types increases the DI to 1.69.. .[fig. 10B]. If the l-acre block is divided into 4 blocks in a long narrow unit. . .[fig. 10D], then the DI is increased to 1.83. In.. .[fig. 10D] the TP (1,356.68 feet) is computed by adding the outside perimeter (1,043.60 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 l-acre square with a DI of 1.3 the percent is:
>
> $$(1.13 - 1) \times 100 = 13\%$$
>
> This percent figure simply means that the l-acre square has 13 percent more perimeter than a l-acre circle. A square-mile block also will have 13 percent more perimeter than a circle of the same area.

Patton's diversity index assumes that the total perimeter of an area is actually edge. In that case, the index is valid. But usually all or part of the perimeter of an area under consideration is not an edge in the ecological sense. In such cases, the index will not be valid. Furthermore, if diversity is expressed as a product of edge, it seems best to consider it as derived from two sources: (1) inherent edge, and (2) induced edge (see fig. 9). 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.



CONFIGURATIONS OF 1-ACRE AREA	TOTAL EDGE		DIVERSITY INDEX
	METERS	FEET	
A	254.46 m	834.84 ft	1.13
B	381.69 m	1,252.26 ft	1.69
C	318.09 m	1,043.60 ft	1.41
D	419.52 m	1,356.68 ft	1.83

Figure lO.-Comparison of diversity indexes for four l-acre configurations. Feet converted to meters by multiplying by factor 0.3048 (adapted from Patton 1975).

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 structural conditions within plant communities come together. Induced edges can be produced when and where desired by the rangeland manager and are certain to result from any activity that alters vegetative structure.

Inherent Diversity Index

The inherent diversity index is computed as follows:

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

where TE_c is the total edge between plant communities in feet or meters found within or on the perimeter of the area under consideration, A is the area expressed in square feet or square meters, 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 11, a 60.9- X 60.9-meter square of 3 708.8 m^2 (200- X 200-foot square of 40,000 ft^2) is divided into four equal plant communities. In this case, the perimeter of the area is also inherent edge. The inherent DI in percent is computed as follows:

$$\text{Inherent DI (in feet)} = \frac{TE_c}{2\sqrt{A\pi}} = \frac{1{,}200 \text{ ft}}{2\sqrt{(40{,}000 \text{ ft}^2)(3.1416)}} = 1.69.$$

$$\text{Inherent DI (in meters)} = \frac{TE_c}{2\sqrt{A\pi}} = \frac{365.8 \text{ m}}{2\sqrt{(3\,708 \text{ m}^2)(3.1416)}} = 1.69.$$

Inherent DI in 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 in percent, an added descriptor showing the number of communities seems appropriate (Patton 1975). The descriptor may be added in parentheses after the inherent DI in percent. In this case:

Inherent DI in percent (number of communities) 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).

Induced Diversity Index

Induced diversity can be expressed in the same manner:

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

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

Then,

Induced DI in percent = induced DI(100).

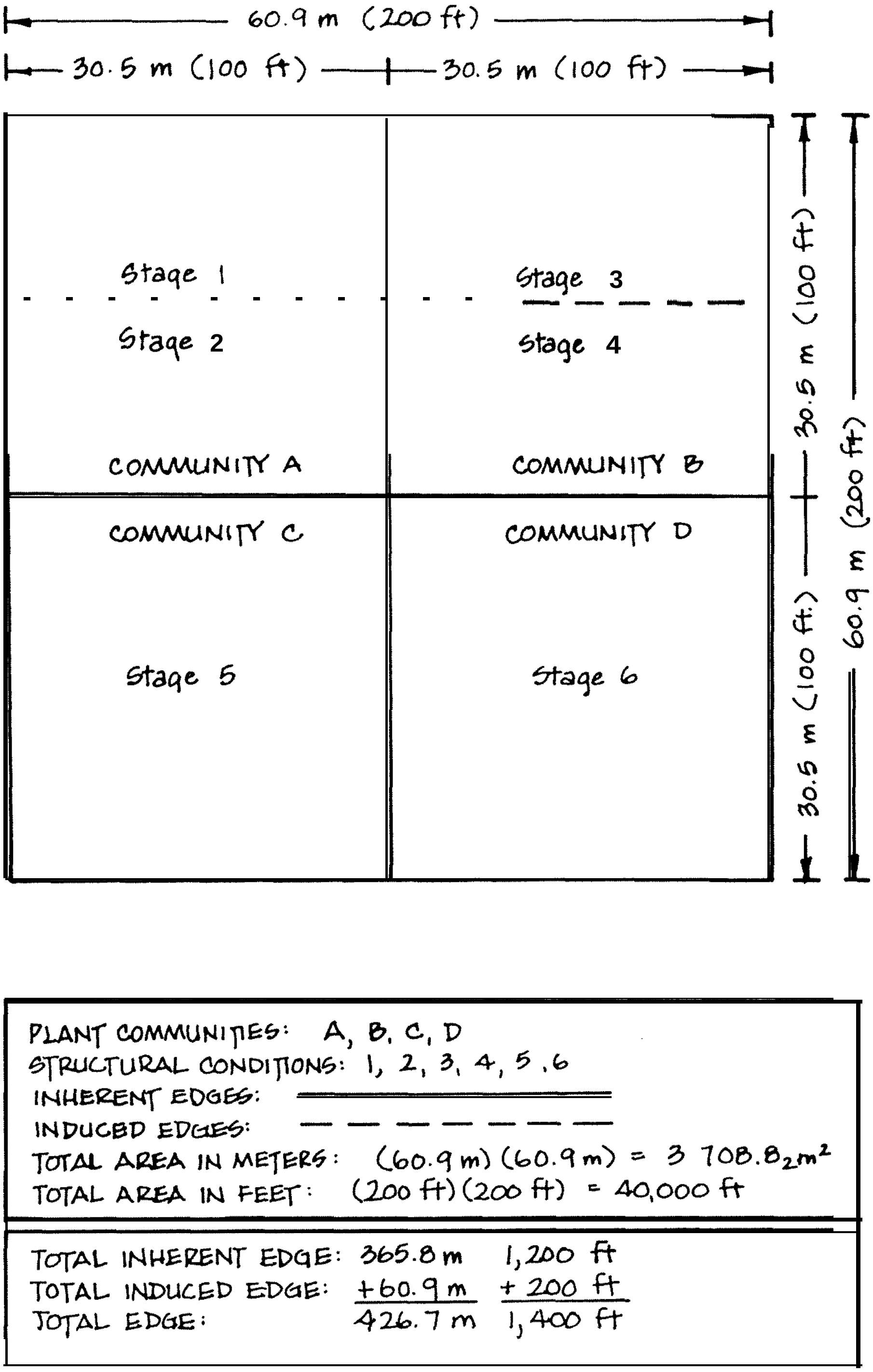


Figure 11.-An area showing plant communities, structural conditions, and edges.

Again consider figure 11. The dotted lines represent induced edge within plant communities A and B. The TE_s is 60.9 meters (200 feet) and the total area is 3 708.8 square meters (40,000 ft^2). The induced DI in percent is computed as follows:

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

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

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

$$\frac{60.9 \text{ m}}{2\sqrt{(3708.8 \text{ m}^2)(3.1416)}} = 0.28.$$

Induced DI in percent = induced DI(100) = 0.28(100) = 28%.

The number of structural conditions represented should be added in parentheses after the induced DI in percent as a further descriptor of induced diversity:

Induced DI in percent (number of structural conditions) 28%(6)

Total Diversity Index

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

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

and,

Total DI in percent = (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. 11):

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

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

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

$$\frac{426.7 \text{ m}}{2\sqrt{(3708.8 \text{ m}^2)(3.1416)}} = 1.97.$$

Total DI in percent = total DI(100) = 1.97(100) = 197%.

Total DI in percent can be enhanced by showing the contributions of the number of plant communities and the number of structural conditions as follows:

Total DI in percent (number of communities) (number of structural conditions) = 197%(4)(6).

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

	Inherent DI in percent	169
+	Induced DI in percent	+ 28
	Total DI in 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 edges and diversity in a planning area. The rangeland manager may find it desirable to account for the amount and characteristics of individual edges in an area. The following coding system 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.
Length:	In feet or meters
Average width of the ecotone:	In feet or meters
Contrast:	1 to4
Configuration:	A = abrupt; M = mosaic

Example: T - *AR TR* - 1,700 - 25 - 4 - A

The codes in this example mean that the area has an edge that is inherent; it is within the ***Artemisia tridentata*** community; it is 1,700 feet long and 25 feet wide; the contrast is 4; and it has an abrupt edge (A).

Management Tips

Each range 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. Conversely, an area may have only one or a few communities all in the same structural 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. 9). 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 range 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.

As a result, the use of diversity as a goal has a certain biopolitical appeal. Very broad diversity goals, loosely stated, can be used to justify management activities and make accountability unlikely. In this context, diversity goals are essentially nonconstraining. The range manager can give 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 range 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, range managers cannot be held accountable.

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