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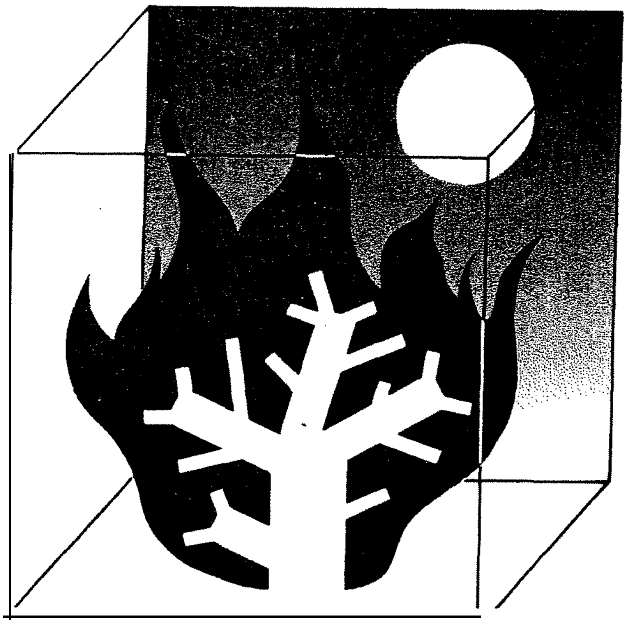
Fire and the Environment: Ecological and Cultural Perspectives



Proceedings of an International Symposium

Knoxville, Tennessee
March 20-24, 1990

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Forty-one papers based on oral presentations are included under four categories: Fire Ecology; Fire Management; Cultural; and Fire History. In addition, three papers are presented from a special session on the 1988 tires in the Greater Yellowstone Area and fourteen papers are presented from a poster session.

Fire and the Environment: Ecological and Cultural Perspectives

Proceedings of an International Symposium

Editors
Stephen C. Nodvin and Thomas A. Waldrop

Knoxyille, Tennessee
March 20-24, 1990

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PREFACE

Fire and the Environment: Ecological and Cultural Perspectives was an international symposium held on March 20-24, 1990, in Knoxville, TN. The meeting was attended by over 150 researchers, land managers, and wildlife managers. Forty-one papers based on oral presentations are included under four categories: Fire Ecology; Fire Management; Cultural; and Fire History. In addition, three papers are presented from a special session on the 1988 tires in the Greater Yellowstone Area and fourteen papers are presented from a poster session.

Papers and posters were selected by the program committee based on title summaries submitted prior to the meeting. The major objective of the editorial committee was to compile a proceedings covering a broad range of topics with papers representing new results, ongoing research, overviews of past research, and new ideas or hypotheses. Preference was given to papers covering cultural aspects of fire; such as public perception of tire, fire policy, wildland/urban interface, historical and prehistoric roles, fire and climate, use of fire toward management objectives, and effects of fue exclusion; and ecological effects of fire on climate, air quality, water quality, nutrient cycling, wildlife, fisheries, vegetation, and soils. After the meeting, papers were submitted to the editorial board for review. Each paper was given a blind review by two peers and one grammatical editor. Reviewer comments were incorporated by authors and submitted to the editorial board for approval. Some papers required additional revision but all papers were accepted. These proceedings have been prepared electronically from copy supplied by the authors. Authors are responsible for the content and accuracy of their papers as well as any stated opinions or conclusions.

The steering committee gratefully appreciates the efforts of authors and reviewers who contributed to a successful and informative program. Our appreciation is given to Brian Ostby and John Mullins, who arranged the poster session, and to Janet Paces, Ellen Williams, and Julie Smith, who served as assistants to the Program Chairman and proceedings editors. A special note of thanks is given to the moderators who provided additional insight to each topic and kept each Session on schedule. Moderators included William Boyer, Southern Forest Experiment Station; Bob James, USDA Forest Service, Region 8; Gary Schneider, The University of Tennessee; Eugene McGee, The University of Tennessee; Joe Abrell, USDI Park Service; Frank Woods, The University of Tennessee; Joe Clayton III, Tennessee Division of Forestry; Dale Wade, Southeastern Forest Experiment Station; David Van Lear, Clemson University; Larry Landers, Tall Timbers Research Station; Thomas Waldrop, Southeastern Forest Experiment Station; and Stephen Nodvin, USDI Park Service.

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VARIABLE FIRE REGIMES ON COMPLEX LANDSCAPES: ECOLOGICAL CONSEQUENCES, POLICY IMPLICATIONS, AND MANAGEMENT STRATEGIES

Norman L. Christensen, Jr.'

INTRODUCTION

Half a century ago, fire policy in most public and private agencies charged with the management of wilderness was neatly summarized in the so-called 10 A.M. Rule: If a fire starts, it should be extinguished by 10 the next morning. Our attitudes toward fire and other natural disturbances in wilderness landscapes have changed during recent decades. We now recognize that disturbances caused by fire, wind, insects, and pathogens play key roles in a variety of ecosystems processes. The folly of excluding or trying to exclude agents of disturbance from landscapes is now obvious to most wilderness managers.

Despite this knowledge, articulation of operational policies and management strategies for wilderness preserves has proven to be a daunting task. What arc the proper fire regimes for our diverse wilderness ecosystems? How and why have the frequency and behavior of tire changed through time? How have human activities such as a century of tire exclusion, landscape fragmentation, and alteration of ignition patterns affected fire regimes? How can we reintroduce fire into landscapes so altered? How can wilderness fire managers accommodate nonwilderness values such as recreation, timber and watershed resources, and air quality? Finally, how do we know when we are managing fire correctly?

In this paper, I shall argue that questions such as these can only be answered in the context of a clear understanding of wilderness processes and overall wilderness management objectives. I shall assert that wilderness management should be based on the answers to three questions, and since we have generally answered two of these questions incorrectly presents us with our most difficult management challenges.

NATURAL DISTURBANCE AND MANAGEMENT POLICY

Wilderness management can be reduced to answering correctly three questions: 1. What should be preserved? 2. How should preserves bc configured? 3. How should management be executed (Christensen 1988)?

'Professor and Dean, School of the Environment, Duke University, Durham, NC 27706.

What should we preserve?

The actual foci of preservation in particular wilderness ecosystems are often identified in nebulous, nonoperational terms or are not stated at all. The question must be answered in both philosophical and practical terms. We must first agree on the categories of items that will be the objects of preservation (i.e., genotypes, species, ecosystems, landscapes, etc.). Having made this decision, we must then determine which items within a category are worthy of preservation; that is, we must produce "shopping lists"--lists of rare and endangered species, or inventories of various ecosystem types, for example. The formulation of such lists is often the occasion for battles over the dedication of land to wilderness or nonwildemess management. In many regions, our ignorance of ecosystem variability prevents us from making such lists.

How should preserves be configured?

Patterns of natural disturbance have rarely, if ever, been a major consideration in the spatial configuration of wilderness preserves. However, if a wilderness preserve is to include the full range of patterns generated by natural disturbance, the frequency, area1 extent, and behavior of such disturbances must be considered. Ideally, a preserve should be sufficiently large to include not only the variety of post-disturbance age classes typical of a pristine wilderness landscape, but also the range of variation in disturbance severity. When disturbances occur on small spatial scales and at high frequency, small preserves will suffice. However, in environments in which large-scale tires are the norm (e.g., western coniferous forests and shrublands), few existing preserves are large enough. In addition, those who determine preserve boundaries should understand the effects of landscape features on the behavior of disturbances.

How should management be executed?

The details of procedures for managing natural disturbances depend on a variety of considerations. For unpredictable and uncontrollable disturbances such as the Mt. St. Helens eruption, management will focus on post disturbance intervention and will likely involve compromises between the wish to allow the affected area to recover as it would have in our absence and the potential consequences of the lack of intervention for areas outside the preserve (e.g., flooding, siltation, etc.). In the case of fire, where management intervention may alter the course of the disturbance, additional issues must be addressed. The manager must decide the extent of disturbance that is acceptable within the constraints of the design of the preserve. For example, assuming suppression is a real option, should a naturally ignited fire be allowed to become so large that containment is impossible or allowed to consume a major portion of the preserve? We know very little about the ecological consequences of artificially limiting the size of such disturbances. Are there wilderness processes that depend on the occurrence of fires of large spatial extent?

FIRE REGIMES AND ECOSYSTEM RESPONSE

Many of our views about the role of natural disturbance in general, and of wilderness fire in particular, reflect the evolution of ecological theories pertaining to succession, the recovery of ecosystems from disturbance. Clements' (1916) theory of succession portrayed wilderness as the touchstone of stability and order. Natural disturbances such as tire not only alter the structure of ecosystems, but render the landscape less habitable. Pioneer species that colonize such disturbed areas are usually organisms with high dispersal ability and considerable tolerance of harsh conditions; such organisms are rarely effective competitors under favorable growing conditions. Clements posited that these vagrant species become established and alter the environment of a disturbed site by stabilizing and enriching soil and by creating a microclimate that favors establishment of other species. Similarly, these new invaders alter their environment so as to favor yet another wave of immigrants. This succession of species continues until a community of organisms is established that maintains its environment in such a way as to perpetuate itself. This so-called climax ecosystem was considered to be the most stable assemblage of organisms that could exist on a given site within the constraints of regional climate.

Thus, ecosystems develop much like individual organisms from simple beginnings toward increasing complexity and stability. Ecologists of Clements' era recognized that individual organisms would necessarily die, but asserted that the regeneration of climax community species was associated with small-scale disturbances such as the deaths of individual trees.

Over spatial scales of interest to wilderness managers, the composition and structure of climax ecosystems was thought to remain constant over long periods of time. In Clements' (1935) words, "Under primitive conditions, the great climaxes of the globe must have remained essentially intact, since fires from natural causes were undoubtedly infrequent and localized." The quantity of data supporting this theory was quite small However, we generally require little data to support theories that portray the world as we wish it to be. It was indeed appealing to view wilderness as inevitably converging on stability. The vision of a climax ecosystem as a "super organism" composed of species performing specific functions as if they were roles much like the organs and tissues of an individual organism was proof of the "balance of nature."

This model of ecosystem change provided clear guidelines for management of wilderness. The object of management (*what* should be climax ecosystems. The supposed structure of attributed to climax communities was often based on romantic accounts by early explorers and naturalists. The view that species comprising natural communities were regenerated by small disturbances implied that questions about preserve configuration could be answered by reference to economic and political factors. If the dominant species can reproduce in openings created by the demise of individual trees, then relatively small areas should be sufficient to perpetuate the entire community. Consequently, the boundaries of our major wilderness parks have very little in common with natural ecological barriers or divides. Finally, it was clear that the key to preserving wilderness areas (*management execution.?*) thus defined was the prevention of catastrophic disturbances. Only in this way could we nurture wilderness to its climax state.

Research over the past three decades has taught us that Clements' theory was at best too simple and at worst flat wrong. Long-term studies demonstrate that the process of ecosystem change is not nearly so predictable or simple as Clements imagined (See Christensen 1991 for a review).

Perhaps the most startling discovery was that many ecosystems become increasingly ***unstable*** during succession, particularly in areas where fire is an important factor. Early in the development of most forests there is an abundance of green, moist, and relatively non-flammable plant tissue. However, as communities develop, dead woody debris accumulates increasing the ability of such communities to carry a fire. Exclusion of tire from such systems may result in additional fuel accumulation, increased flammability, and higher fire intensity when fires eventually occur. We have learned that fire is an essential and inevitable agent of biomass decomposition in many forest ecosystems.

If succession following disturbance is not a linear, predictable process that terminates with the establishment of a stable climax community, perhaps we can view it as a deterministic and stable cycle, driven by internal feedbacks such as fuel accumulation and inevitable fires. In this view, ecosystems are dynamically stable, like a pendulum with a period determined by return times between disturbances.

Alas, wilderness landscapes are not so easily modeled. Disturbances are indeed regulated in part by internal feedbacks, but actual periods or return times are quite variable and heavily dependent on extrinsic factors such as variations in regional climate. Furthermore, variations in disturbance intensity result in highly variable trajectories of postdisturbance change. Thus, the pendulum may swing in a highly chaotic random fashion. Wilderness landscapes are best viewed as an ever-changing "patch mosaics," and the frequency distribution of patch types may vary as a consequence of short- and long-term changes in climate and other chance factors (See Pickett and White 1985).

The pattern of successional change from less to more habitable conditions proposed by Clements is often reversed in the case of postfire ecosystem succession. As forests develop following fire, mineral nutrients such as nitrogen and phosphorus become less available in the soil as they are taken up and stored in plant tissues. Thus, low fertility, organic debris in the forest floor, and shade cast by mature trees may severely limit opportunities for seedling establishment and growth of the young plants in late succession ecosystems. The ash raining onto burned soils is an effective fertilizer, and postfire microclimate often favors successful plant reproduction.

This pattern of environmental change in relation to tire has resulted in evolution of plant adaptations that concentrate reproductive effort in the period immediately following the tire. Such adaptations include underground buds that are protected from heat, production of seeds that germinate only when heated, cones or fruits that open only when heated, and production of flowers only following fire. The evolution of such adaptations has not simply made some ecosystems tolerant of fire; it has made them dependent on it. Burned areas quickly lose their bleak aspect and, by the end of a single growing season, are carpeted with new growth.

Describing the evolution of knowledge in another area, Samuel Clements quipped that "the researches of many commentators have shed considerable darkness on this subject, and should they continue we shall soon know nothing about it." What once appeared to be a tidy linear process leading inevitably to stability on relatively small spatial scales is now seen as a dynamic, chaotic, and complex pattern of change in which the word "stable" may have little if any meaning.

POLICY, MANAGEMENT, AND RESEA RCH IMPLICATIONS

Policy Considerations

Given the variability in tire history, tire behavior, fire effects, and fire responses, it is clear that fire policies must vary from preserve to preserve. Nevertheless, I suggest that successful policies will have three common characteristics: (1) clearly stated operational goals, (2) identification of potential constraints, and (3) recognition of the variability and complexity of the successional process.

It is not enough to acknowledge that tire is an important natural process in an ecosystem and then simply reintroduce tire to the ecosystem. We must formulate specific operational goals for fire management programs. We do not set aside wilderness preserves in order to bum them. Rather we should withhold, apply, regulate, and respond to tire in order to accomplish specific management goals. The specification of these goals is made more difficult by the complexity of change on many landscapes.

The difficulty of setting operational goals is illustrated by the problems that the National Fire Management Policy Review Team (Philpot 1988) encountered when it attempted to define the specific goals of the Fire Manager Programs in federal wilderness areas. The overall goal was relatively simple--i.e., "to restore fire to a more natural role." But this formula begs the question "What is natural?" The Review Team defined natural as "those dynamic processes in components which would likely exist today and go on functioning, if technological humankind had not altered them." Putting aside the implication that Native Americans lacked technology, this statement seems to suggest that if natural processes are simply allowed to operate, ecosystems will converge to some preferred state. Although the details are far from clear, we are beginning to appreciate that landscape change is more chaotic than convergent.

Specification of objectives requires a clear understanding of the specific elements for which a preserve was dedicated. These may include historical features, species preservation, or preservation of entire wilderness areas. With regard to specific objects or species populations, policy objectives will likely be clear. However, a great deal of confusion exists regarding what constitutes wilderness. Wilderness is usually defined in contrast to human-altered landscapes, where wilderness represents the lack of human intervention. Given this definition, the phrase "wilderness management" should be considered an oxymoron. However, the pervasiveness of human influence ranging from the dissection and fragmentation of landscapes to global climate change may create conditions in which the most potent form of human intervention may be restraint.

We cannot simply set aside a piece of real estate and expect that, in the absence of human intervention, "those dynamic processes and components" will go on functioning as if "technological humankind had not altered them." We have created a world that we are obliged to manage. Given this situation, we are obliged to formulate policy based on operational definitions of wilderness. In particular we need to be explicit about such goals as preservation of ecosystem processes, biodiversity, and heterogeneity.

It is essential that policymakers understand the potential constraints on management in wilderness preserves. Within the realm of the "natural," a wide variety of landscape configurations is possible. However, within the constraints of preserve design, not all these configurations are equally desirable. Million-acre fires may be natural phenomena on the Yellowstone Plateau, but the desirability of such fires in the context of the altered landscape can be determined only by evaluating the costs and benefits of events on this scale.

In many cases, policymakers arc faced with competing or conflicting preserve objectives. For example, the Organic Act of 1916 that established the National Park Service extols managers to "conserve the scenery in natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations ." It does not take a lawyer to detect the multitude of ambiguities and possible interpretations in this statement. For that matter, the 1963 Leopold Committee's assertion that the proper goal of national park conservation is the preservation of a "vignette of primitive America" is open to various interpretations. Some would view it as a mandate for the so-called "living museum" approach to park management, where the goal is to preserve "snapshots" of the past. Alternatively, the term vignette can be defined as a "moving picture" so as to include the process orientation of current Park Service policy.

The constraints on tire management posed by liability to other public and private resources are considerable. This is particularly true in wilderness preserves where goals include recreation or watershed management, and in situations where arbitrary borders separate wilderness from land dedicated to nonwildemess functions. The constraints on conservation of wilderness in an increasingly urbanized context are exemplified by issues such as air quality and smoke management. For example, burning in Sequoia National Park contributes to air quality problems in California's Central Valley. It may bc natural that wilderness fires inject particulates into the atmosphere, but the emission of these particulates may be deemed unacceptable by air quality authorities who must consider that the atmosphere is already polluted with a host of anthropogcnic emissions.

Fire policies must recognize the constraints set by preserve design. We have chosen to preserve relatively little of once vast expanses of wilderness, and the borders of most preserves bear precious little relation to the natural processes necessary for their preservation. The acceptability of fire events of particular intensities or spatial extent cannot be based solely on the naturalness of such events. Given the constraints of preserve design, many natural events may be deemed unacceptable or at least undesirable. This is particularly true where we can preserve only small fragments of formerly large landscapes. In these situations it is important to understand the ecological costs of not allowing large scale or high intensity events to occur.

Perhaps the most significant constraint on policy development is ignorance. Stewards of wilderness cannot claim, nor does the public have a right to expect, perfect knowledge. The only fair expectation is good faith. Policy makers and the public must understand the limits of our understanding.

When I was in my late teens, my grandmother took me to task for some transgression, the specifics of which now escape me. My excuse was that I was just trying to do what I thought was right. Grandma's reply? "Norman, you should not do what you think is right, you should do what is right!" I thought for a moment and said "Grandma, that's the dumbest thing i have ever heard."

The public's expectations are much like my grandma's, Managers must be ever cognizant of what I shall call Grandma's Law: "All we can ever do is what we think is right.' However, what managers consider right has changed markedly as our understanding has developed over the past several decades. Thus, I propose a corollary to Grandma's Law: "Just because you think you are right does not guarantee that you are.

Fire policies must allow for the variability and complexity of the process and its context. We are learning that variability is an essential component of fire regimes and that policies should not necessarily seek to replicate mean values of intensity, return time, etc. Furthermore, policy options and goals will vary considerably across the spectrum of fire regimes. Because we can prescribe low intensity tires like those that occur in grasslands with high scientific precision, we expect similar precision in the application of tire in heavy forest fuels. However, our management options in these latter situations may be more akin to those for large scale disturbances such as hurricanes and volcanic eruptions.

Finally, policies must be developed against a backdrop of constant change. In his classic paper on succession, Henry Chandler Cowles (1901) characterized succession as "a variable converging on a variable." Given the pervasiveness of human-caused environmental change, the notion of "natural" may be moot at best.

Management Considerations

Management involves the development of interventions to achieve specific policy objectives. Recognizing our considerable uncertainty and ignorance about the processes WC must manage, management should be thought of as a direct application of the scientific method. Its success depends not only on a clear understanding of available options (hypotheses), but also on a monitoring system that provides direct feedback to managers regarding management consequences (experiments and tests).

Fire management options include complete suppression, planned-ignition prescriptions, natural emission prescriptions, "let bum" strategies, and a range of fire surrogates. Where complete fire suppression is necessary, guidelines for managing the effects of suppression are critical. Such effects include those of employing tire retardants, plow lines, and heavy equipment. Where fires cannot be allowed to burn, managers may need to consider surrogates for burning such as mechanical field manipulation and artificial cutting.

Planned emission prescriptions must differentiate between the means and the ends. Historically, most prescribed burning protocols have been developed in the context of siivicultural management in which the end goals are field reduction and discouragement of competitors (i.e., reduced diversity). Management goals in wilderness areas will likely be quite different and require different burning protocols. In developing bum plans it is important to distinguish between fires set to restore fuel conditions to some "natural" state and fires set to simulate a "natural" process.

Prescribed natural ignition programs allow fires ignited by natural causes to bum so long as they are within prescribed guidelines. In a sense, such fire management programs substitute knowledge for intervention. They assume that threshold levels of fire behavior can be established beyond which tires can and should be suppressed. These is serious question whether such fire **programs** are realistic and natural. For example, such plans may call for the suppression of ecologically important but intense fire events. Furthermore, given the extent of landscape fragmentation and alteration, it is unlikely that fire regimes developed in this manner will simulate the full range of natural processes.

Only in the largest wilderness areas will an unmodified "let bum" fire management plan be a viable alternative. Nevertheless, wildfires will occur and fire management plans must provide clear guidelines for specific postdisturbance interventions. These guidelines must include appropriate measures for erosion mitigation, reforestation, and wildlife management interventions. Those who formulate guidelines for postfire interventions should consider the benefits of the intervention and their environmental and monetary costs, and should consider the likelihood of their success.

Any reasonable management system must have a built-in program for evaluating management's success in accomplishing policy goals. Such a monitoring program should be viewed as a set of research hypotheses especially designed to test whether management is providing the desired effects on specific dependent variables such as fire diversity, decomposition and nutrient cycling, and landscape heterogeneity. Monitoring programs not only provide information that can be used to adjust to management protocols, but also serve to inform basic scientific research programs.

Research Needs

it is clear that there is much that we do not know regarding the role of fire in wilderness ecosystems. I feel three areas deserve special attention. (1) There is much to learn about the causes and consequences of variability in fire regimes. For example, the Yellowstone fires taught us that models of fire behavior are not easily transferred among ecosystems. Even within a landscape, interactions between climate and fuels may result in multiple patterns of fire behavior. The consequences of variation in fire behavior are also little known. Fire often results in a pulse of resource availability which, although cphcmcral, may greatly influence patterns of species establishment. The variability in such pulses may have much to do with the biodiversity of landscapes throughout the fire cycle. (2) Although we know that variation in the spatial and temporal scale of fire events can greatly affect patterns of species response, the specifics of such patterns and their mechanisms are poorly understood. Implicit in much of wilderness fire management is the notion that many small events can be substituted for a single large event, but in most cases this assertion has not been tested. (3) Given the constraints on fire management programs, it is important to understand the ecological consequences of departures from "normal" fire regimes. Are them ecological costs associated with the exclusion of high intensity fires from certain parts of the landscape?

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