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THE FALLEN TREE--A SOURCE OF DIVERSITY

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ABSTRACT

When thinking of and dealing with diversity in a forest, conventional vision focuses on structure and habitat. Diversity, however, has another dimension--one that is only now being perceived: function. The basic components of structural and functional diversity are inseparably interwoven in a forest. A broadened philosophical view of management--a forest versus a commodity--is necessary if certain structurally related functions, such as retention of water and cycling of nutrients in large, fallen trees, are to be options in managed forests of the future. We have used an automobile engine as a metaphor in discussing some of the functions that "drive" the forest system because many of an engine's parts are unseen and little understood by the average person. Yet that person can get a learner's permit and then a license to drive the automobile. The average driver knows little about engines, with the result that many automobiles are barely functional. Future generations cannot afford the consequences of our ignorance while we learn how to manage forests.

INTRODUCTION

Aldo Leopold admonished us, the professional land managers, that we are the bankers of the future's resources, and that the future's currency is options. He wrote (1966 p. 176-177):

> The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little is known about it. The last word in ignorance is the man who says of an animal or plant: 'What good is it?' If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

We now stand at a philosophical crossroads--today's dollars or tomorrow's options. For land managers, the dilemma arises because we have the technological capability to remove all wood, over an inch in diameter, from a clearcut. We can also remove the stumps. And present management trends seem to be leading us in this direction. The challenge is that technological advances, geared toward faster, more thorough exploitation of resources, need to be tempered with a social conscience that begs restraint lest we inadvertently foreclose options.

Old-growth forests came with the land; we have neither planted nor nurtured them. As such, they would seem to be free for the taking. But old-growth forests are more than just large trees that grew for hundreds of years. A 600-year-old Douglas-fir (Pseudotsuga menziesii), for example, influences the site on which it grows for six centuries. Once fallen, it decomposes over a period of 200 to 400 years. Thus a single old-growth Douglas-fir can visibly affect a site for 800-1000 years, after which it becomes an unnoticeable but important component of the soil for an indefinite time (Franklin et al. 1981, Maser et al. 1979, in press).

The live, old-growth tree is the flywheel that maintains the even running of the forest's engine. The snag (a standing, dead tree) is a cog, and the fallen, decomposing tree is the thermostat that keeps the engine from overheating during summer drought. For all pretenses, we are eliminating the live, old-growth trees. It follows that we are also eliminating the supply of dead, old-growth snags and fallen trees simply because there is no commitment to manage our forests to produce such large trees in the future (Harris 1984, Harris et al. 1982, Meslow et al. 1981).

We are only beginning to appreciate the complex dynamics of fallen, old-growth trees (Franklin et al. 1981, Maser et al. 1979, in press). And our accumulation of data on the importance of such woody materials is far slower than is our cutting of the old-growth forests.

Fallen trees in an old-growth forest provide: (1) structural diversity that, in turn, provides specialized habitat for myriad plants and animals; (2) sites that concentrate long-term nutrient cycling; and (3) carry-over structural components--physical and functional links--and nutrient reservoirs between forest generations. There are, however, many direct and indirect relationships between large pieces of rotting wood and the seasonal and annual functioning of the forests that we do not understand. As yet, we often do not even know to ask questions, let alone which to ask. It is therefore both logical and prudent to save enough biologically representative stands of old-growth forest to retain options for the future should corrections in management objectives be necessary.

OLD-GROWTH TREES ON THE FOREST FLOOR

Habitat diversity is required to support species richness. Old-growth trees that have fallen to the forest floor greatly enrich habitat diversity over time. Fallen trees change in character as they gradually decompose and provide home, hearth, and pantry to many animals, from mites to mice. Many of these organisms depend on the fallen tree for part or all of their life cycles. Others may use it as a convenience (Maser et al. 1979, in press).

Animal use of a decomposing tree trunk depends on, and changes with, the age or stage of decomposition of the wood. In a general sense, species richness increases as the wood ages, but factors other than age help determine the clientele of a particular piece of wood. The size of a piece obviously influences what can live within, crawl under, or sit on top of it. But size also affects the rate at which a piece of wood decomposes. Different species of trees inherently differ in rates and patterns of decay. And the cause of a tree's death, such as heart rot, root rot, girdling by beetles, being blown over by wind, or some combination, determines the time it takes a fallen tree to recycle. The varied circumstances leading to a tree's demise add to the diversity of its inner workings once dead. This scenario is further compounded by the slope and aspect on which a tree falls and whether it comes to rest whole or fragmented, along or across the contours (Maser et al. in press).

In addition, the sponge-like capacity of rotten wood to hold moisture is critical to the functioning or even survival of many organisms during the late summer drought typical of the Douglas-fir region. When drought limits biological activity in the soil, rotten wood may still contain considerable available moisture, especially near the wood-soil interface. It is here that moisture-requiring animals, such as salamanders, survive the drought, and here that the tree feeder roots are most active when rootlets in dry soil away from the rotten wood have shriveled (Maser et al. in press).

Even during wet times, however, rotten wood supports growth of plant roots (Harvey et al. 1978); the roots' mycorrhizal fungi grow from rootlets into the wood and recycle nutrients into living parts of the system. The microbial components of the fallen tree are little explored, but it seems likely that complex exchanges occur between roots, mycorrhizal fungi, decomposer fungi, bacteria, and the myriad invertebrate inhabitants of wood. These organisms interact with the larger animals that inhabit or visit the rotting wood. The fallen, rotting, old-growth tree therefore influences the adjacent habitat, as nutrients are cycled away from it by plants and animals.

Few of these sequences have been studied in detail, but we can exemplify the kinds of interactions occurring in rotten wood through the behavior of California red-backed voles (Clethrionomys californicus). These small rodents feed primarily on truffles, the fruiting bodies of mycorrhizal fungi (Maser et al. 1978a,b; Ure and Maser 1982), and focus much of their activity around large pieces of rotten wood on the forest floor.

A predominant truffle in rotten wood of Douglas-fir forests is Rhizopogon vinicolor, a species particularly effective in protecting Douglas-fir from drought and in promoting its survival and growth (Parke et al. 1983). Rhizopogon vinicolor forms long, root-like structures, termed rhizomorphs. The rhizomorphs, which may form only under the influence of certain microbes, explore the wood for nutrients and moisture and translocate them to the tree. This beneficial fungus not only is a major source of food and water for the red-backed vole but also depends on the vole and other fungus-feeding animals for dispersal of its spores. The vole, which commonly burrows under large pieces of rotten wood, finds the truffle, eats it, and digests all but the spores. It later defecates the spores that can then germinate and form mycorrhizae with Douglas-fir at a new site. The vole may thus transport the spores away from the fallen tree, just as the fungus translocates moisture and nutrients from the rotten wood to its tree host. The fallen tree's influence can even be extended when a predator (for example, a weasel) captures a vole and carries it off. The nutrients and spores contained in the vole's body may be deposited a considerable distance away. Nutrients also flow away from the fallen tree, through Rhizopogon, to the host tree's crown and are later ingested by foliage grazers or dispersed with wind-blown pollen, seeds, twigs, and needles.

These kinds of interactions occur throughout the year, but during summer drought the large, rotten, fallen trees may be the primary, and at times the only sites, that are moist enough for intensive biological activity. Late season tree growth in the Douglas-fir region, dependent as it is on moisture and nutrients, may be tempered by availability of rotten wood for root growth and activity.

IMPLICATIONS

How well an engine functions is related to how well it is cared for. And how we care for a particular engine depends on how we perceive it--new or old, streamlined or clumsy, attractive or ugly. Perception is conditioned by our attitudes, our sense of values, and is based on our breadth of understanding of how the individual components function in relationship to each other and to the whole in time and space. If we are to understand an engine well enough to maintain it in prime working order, we must recognize that as a whole it is greater than the sum of its parts. We need to tinker with it long enough to understand how and why it works and which parts are necessary or interchangeable. During our tinkering we need to keep every cog and wheel; to discard a single part is to alter the entire engine and to risk malfunction. Only when we know enough to write a "maintenance manual" of how and why an engine functions as it does, will we perhaps know enough to risk discarding a part. Without this knowledge, the discarding of a seemingly useless part, such as an air filter, may irreversibly increase engine wear. It is therefore unwise to consider discarding even one component of the forest's engine because we do not yet have a complete parts catalog.

The live, old-growth tree, the snag, the fallen, old-growth tree together are a single component of the forest's engine that changes in function in relationship to the other parts in time and space. As we begin our preliminary draft of the maintenance manual, we need to develop some interim management guidelines to insure a complete, orderly representation of components that will allow future generations to complete the manual. Such guidelines include planning and executing management activities in forest stands in a way that: (1) minimizes disturbance to large, woody materials already in place on the forest floor--including those in advanced stages of decay; (2) leaves sources for both large snags and fallen, woody materials in the form of some live, old-growth trees, both healthy and diseased, perfect and imperfect; and (3) confines burning, as much as possible, to the highly combustible fuels, if fuel management or site preparation are needed.

These precautionary guidelines should at least reduce the chances for seriously degrading a site and habitat. Meanwhile, research is urgently needed to determine the long-term implications of planned or unplanned elimination of large pieces of rotten wood from the floor of future forests through intensive utilization and shortened rotations. Studies of the kinds of organisms that use rotten wood and how they interact are now underway. These studies must continue until the "parts catalog" is reasonably complete. The functions of large pieces of rotten wood and the processes that take place within them also need elaboration, with special reference to how these processes affect the overall ecosystem throughout the year as well as in the critical period of late summer drought. As we develop an understanding of these features of rotten wood, we can begin to learn how the rotting, fallen trees affect regeneration and stand development after timber harvest or other disturbance, especially planned rotation ages. We can then develop rationale and methods--the maintenance manual--for answering management questions: How many live trees per acre are needed to adequately support the critical functions focused in or unique to such large, fallen, rotting trees? What array of sizes and decay classes is needed to provide the diversity of habitats and substrates typical of a well-running forest engine? How can the desired number, size, and variety of decay classes best be added to the system over time through careful planning and management? How can the large pieces of rotting wood now present on the forest floor best be used for development of the new stand through timber harvest and other management objectives and operations?

Until a serious effort is devoted to finding sound answers to such questions, forest managers are in a difficult, sometimes impossible, position. They must try to keep the forest engine running smoothly, without present or future damage, while entire, critical chapters are missing from both their maintenance manual and parts catalog. We hope the missing chapters can be filled in promptly, with the help of forest managers, before so much old-growth forest is cut that the future's options are foreclosed.

In the last analysis, it is not only what we do but also why we do it that determines the future's options. To this end, Leopold (1966, p. 68) wrote:

> I have read many definitions of what is a conservationist, and written not a few myself, but I suspect that the best one is written not with a pen, but with an axe. It is a matter of what a man thinks about while chopping, or while deciding what to chop. A conservationist is one who is humbly aware that with each stroke he is writing his signature on the face of his land. Signatures of course differ, whether written with axe or pen, and this is as it should be.

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