Silviculture vs. nature: An ecological assessment of forest health alternatives

Bethanie Walder
The University of Montana

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Silviculture vs. Nature

An Ecological Assessment of Forest Health Alternatives

by

Bethanie Walder

B.A. Duke University, 1990

presented in partial fulfillment of the requirements

for the degree of

Master of Science

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June 19, 1995

Date
Hells Canyon National Recreation Area (HCNRA) was created in 1975 to protect and preserve the unique ecology and character of the deepest river canyon in North America. This canyon provides a vital east/west ecological linkage between the Eastern Cascades and the Northern Rockies. It is also a vital ecological linkage between different northern and southern vegetational zones, as many species are represented within the canyon which are only found much farther north or south. The forests of Hells Canyon, therefore, are a crucial ecological resource for this region of the country, and their biological uniqueness is legislatively protected by the HCNRA Act. Nevertheless, logging continues to threaten these resources, most specifically in the name of forest health and wildlife management.

Focusing on the Intermountain West in general and HCNRA in particular, this paper attempts to adopt an ecological rather than an economic definition of forest health by examining several forest health definitions that are commonly used by policy-makers. Once an ecological definition of forest health is accepted, natural disturbances and silvicultural practices can be analyzed for their ecological effects. This paper synthesizes scientific literature about the ecological benefits and drawbacks of insects, diseases and fire (understory and stand-replacing). In addition, it offers a method for evaluating whether or not these natural disturbances are restoring effective structure and function to the forests, and thus improving forest health. It also compares the ecological benefits and drawbacks of these disturbances to those of the silvicultural practices that are intended to mimic them.

As forest managers attempt to understand how to work more harmoniously with natural systems, they often are driven by political and economic desires to utilize practices that may not accomplish their ecological goals. The HCNRA Act directs that ecology will come before economy within Hells Canyon, therefore creating an opportunity for serious study of how an already degraded system might recover on its own.
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Introduction

The great forest health debate came roaring into households of the Intermountain West during the summer of 1994, in conjunction with fires that went roaring through our national forests during one of the bigger fire seasons in recent memory. The forest health debate is being waged between the timber industry, the Forest Service (FS) and environmentalists, as they all try to understand how best to manage our forests in light of past management mistakes. But, what is forest health? Webster's New Collegiate Dictionary (1977 p528) defines health as: "the condition of being sound in body, mind, or spirit; esp: freedom from physical diseases or pain."

Although it may be healthy for humans to be free from diseases, forests depend on diseases, insects and other disturbances to maintain effective structure and function.

The first section of this paper examines some of the opposing scientific, political and environmental aspects of Intermountain West forest conditions and the forest health debate. The second part of the paper examines ecological effects (benefits and drawbacks) of natural versus anthropogenic disturbances, specifically focusing on how these disturbances affect forest health.

The third section of the paper explores how all of this applies to Hells Canyon National Recreation Area (HCNRA). Named after the deepest river canyon in the United States, Hells Canyon NRA is located along the Snake River corridor along the west-central border of Idaho and the northeastern border of Oregon. HCNRA is managed by the Wallowa-Whitman National Forest (WWNF), although it also includes land within the Payette and the Nez Perce National Forests. It is part of the Blue Mountains region of Eastern Oregon, encompassing the easternmost extreme of the Columbia River Plateau. (The Malheur, Wallowa-Whitman and Umatilla National Forests make up the Blue Mountains.)

HCNRA was created in December 1975, through a Congressional Act designed in part to preserve and protect the unique ecosystems within its border, thereby enhancing recreational values. Section 7 of the HCNRA Act calls for the protection of these ecosystems and the cultural resources within the NRA. Section 7(7) allows grazing, mining and selective timber harvesting to take place, as long as they are...
compatible with the ecosystem protection provisions explained in 7(1-6). Twenty years after the creation of HCNRA, the Forest Service has yet to define compatibility of extractive activities within HCNRA ecosystems. The final part of this paper creates a framework for determining the ecological compatibility of timber management activities in HCNRA within the context of forest health.

In July 1994, long overdue Federal Land Use Regulations (LURs) were adopted for HCNRA. These new rules cover all activities conducted within the its boundaries. According to 36 CFR 292.46 (7-19-94), timber can be cut within HCNRA only under the following conditions:

Timber may be harvested only to protect and enhance ecosystem health, wildlife habitat, or recreational and scenic uses; to reduce the risk of harm posed by hazard trees; or to respond to natural events such as wildfire, flood, earthquake, volcanic eruption, high winds, and disease or insect infestation.

The rationales for continued timber harvest are quite specific according to these rules and regulations. The major difference between these rules and those for other national forests is the insistence that timber be harvested only to "protect and enhance" ecological or recreational conditions. Timber cannot be cut solely to provide wood products.

When considering timber management techniques, it is always possible to find economic justifications for cutting trees, and it is always possible to find ecological justifications for leaving the trees alone. Although this paper is specifically focused on how ecological concerns can be used to protect Hells Canyon National Recreation Area, the framework of this paper can be used elsewhere when determining the necessity of "treating" forests to improve forest health conditions. Recently, Forest Service Chief Jack Ward Thomas (1994 p89) made a revealing statement regarding forest health and its implications for different ecosystems:

The underlying objective of forest health is the sustenance of that system for very long periods of time.
Relatively high levels of mortality in an area from which you do not expect to extract timber, for example, might be perfectly acceptable, as long as that is sustaining itself over time.
Many of the previously unlogged roadless lands on national forests within the Intermountain West have been targeted for forest health "treatments" (Craig 1994, 1995). Many of these roadless areas are proposed for listing as wilderness. Although humans can use silvicultural practices to manipulate stand conditions, these anthropogenic disturbances rarely result in clear ecological benefits to forest ecosystems, but often result in measurable degradation.

We should consider Chief Thomas' (1994 pp92-93) view of forest health in Yellowstone National Park:

For example, to isolate Yellowstone and talk about that. ... It burns up; it burns hot, and the system that's associated with it comes back. We didn't want anything from it. It's perfectly okay. It's a national park. It's interesting, and we can observe the wild flowers, and it's beautiful.

Each national park is created by a congressional act, with specific mandates for management within its borders. Generally speaking, national parks are intended to preserve and protect our national resources and to enhance recreation. At times, wildlife, wildlife habitat, watershed and ecological integrity have suffered under this mandate. Fire suppression has continued throughout many of the national parks, and big game hunting occurs just outside park boundaries every season. Regardless, national park mandates do not include the harvesting of wood products from national park lands. Therefore, national park forest lands are not managed in the same way as national forest forest lands. Because we do not want the trees within national park forests for their wood fiber, we are not as concerned if they burn, or if they are killed by insects and disease. The forests which exist in national parks are not managed to improve wildlife habitat, forest health or recreation. These same considerations can apply for Hells Canyon National Recreation Area. If we assume that we do not want wood products out of the forests of HCNRA, what type of management will we employ? This paper provides an ecological framework for determining the appropriate vs. inappropriate applications of silviculture to improve "forest health" or "wildlife" conditions within HCNRA regardless of wood output.
Chapter One
The Great Forest Health Debate

The symptoms of poor forest health include: increasingly large and disastrous wildfires, tremendous insect and disease epidemics, changes in forest composition to more shade-tolerant and fire-intolerant species, declines in anadromous fish populations, degradation of aquatic and riparian areas, invasion of exotic plant species, ever more native plants and animals listed as threatened or endangered, and reduced soil fertility.

Stephen Mealey, USFS project leader, Upper Columbia River Basin EIS project.

Over the past decade, numerous dry summers have fueled wildfires across hundreds of thousands of acres of western forests. According to the media, timber industry officials, Forest Service representatives and politicians, these fires are just one symbol of a forest health crisis of unprecedented proportions in the intermountain west. The quotes below attest to the extent of this view:

Jay O'Loughlin - Director, Policy Analysis Group, College of Forestry, Wildlife and Range Sciences, University of Idaho:
If forest health is about trees at risk of mortality from insects, diseases, and wildfires, then large areas of Idaho's forests are in poor health, especially in the national forests that represent two-thirds of the state's timberlands.¹ (p1)

Herbert Malaney - Chief Region Forester, Boise Cascade Corporation, Southern Idaho Timber Region:
Today, the result of 100 years of excluding natures [sic] management prescription - fire - plus the absence of stand management activity on National Forest land by man is a sick and dying forest.¹ (p4)

Senator Dirk Kempthorne - (R) Idaho:
The fires of 1994 are indicative of a decade of forest health problems. Years of drought, fire suppression, declining logging and changes in forest composition have led to disease, insect infestations and hazardous fire conditions.¹ (p1)

¹August 29, 1994; Senate Subcommittee on Agricultural Research, Conservation, Forestry and General Legislation; Field Hearing on Forest Health; Boise, ID.

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Forest Service Chief Jack Ward Thomas:
The forest health problem and associated high intensity wildfires are indicators of an ecosystem that is not in balance and the concerns will not go away when cooler and wetter fall weather arrives.¹ (p2)

Stanley Hamilton - Director, Idaho Department of Lands, Idaho State Forester:
There are, however, large tracts of Idaho forest that have suffered and are currently suffering pest problems of an unprecedented scale, and are clearly in decline. In the recent past, forest insects and diseases have killed hundreds of thousands of trees throughout Idaho.¹ (p2)

Forest Health in the Blue Mountains: A Management Strategy for Fire-Adapted Ecosystems: (Mutch et al. 1992)
The fire-adapted forests of the Blue Mountains are suffering from a forest health problem of catastrophic proportions.

Blue Mountains Forest Health Report: (Gast et al. 1991, p1)
They [the Blue Mountains] presently face the probability of massively destructive forest health problems.

Eastside Forests Scientific Society Panel: (Henjum et al. 1994, p4)
Many ecologists believe that the combined effects of logging old growth and fire prevention have significantly increased the vulnerability of eastside landscapes to catastrophic disturbances, further threatening what are already severely reduced and degraded habitats.

Evolution of the Forest Health Debate

During the summer of 1994, “forest health” became the rallying cry for some members of the United States Forest Service (USFS) and the timber industry when discussing forest conditions and fire in the Intermountain West. But, like its recent predecessor (ecosystem management), there is no one definition of the term. Regardless, in the past few years the general understanding of “forest health” has developed from an ecological concept into a political creature, resulting in a mythological forest health crisis.

The concept of forest health has been around for years, probably even centuries. Recently it has led to the creation of several strategic plans and projects within the Forest Service, including Forest Health through Silviculture and Integrated...
Pest Management, 1988; Healthy Forests for America's Future: A Strategic Plan, 1993 and the Western Forest Health Initiative, 1994. Additionally, numerous forest health bills have been proposed in Congress in the past several sessions. Although none of these bills have become law, several were awaiting the President's signature while this paper was written.

Intensive forest management is at the root of the forest health "crisis." After one hundred years of fire suppression and intensive clear-cut and high-grade logging, forest conditions have changed drastically from the conditions the first European settlers experienced when they arrived in the Intermountain West (see e.g., Gast et al. 1991, Mutch et al. 1993; Henjum et al. 1994). Current insect and disease outbreaks lead to high tree mortality, often followed by fires. Disturbances such as this are a normal and necessary part of forest succession. This region has been experiencing drought conditions for nearly a decade. The effects of drought combined with high tree mortality from insect and disease disturbances can and will cause numerous fires to occur.

Without a single accepted definition of forest health, scientists, policy makers, timber industrialists and Forest Service employees have all had the opportunity to create their own definitions. In general, these fall into two categories: those which incorporate human economic desires into a political or social definition; and those which are based on scientific and ecological principles. Aldo Leopold (1966, p259) described this distinction in his Land Ethic essay:

In my own field, forestry, group A is quite content to grow trees like cabbages, with cellulose as the basic forest commodity...Group B, on the other hand, sees forestry as fundamentally different from agronomy because it employs natural species, and manages a natural environment rather than creating an artificial one. Group B prefers natural reproduction on principle. It worries on biotic as well as economic grounds about the loss of species like chestnut, and the threatened loss

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\[\text{\textsuperscript{2}Senator Larry Craig (R-ID) introduced the Federal Lands Forest Health Protection and Restoration Act in February 1995. On March 15, 1995 the Taylor-Young amendment to a Congressional Rescissions Bill passed the House, mandating a cut of 6.2 billion board feet of timber within two years. The Taylor-Young amendment has sufficiency language which supercedes all federal environmental regulations (National Environmental Policy Act, Endangered Species Act, National Forest Management Act, etc.) and disallows appeals or litigation.}\]
of the white pines. It worries about a whole series of secondary forest functions: wildlife, recreation, watersheds, wilderness areas. To my mind, Group B feels the stirrings of an ecological conscience.

Groups A and B both desire timber harvesting, yet they approach the task differently. Perhaps a "Group C" can be created which considers Leopold's "secondary forest functions" as primary concerns. This group would emphasize the importance of maintaining ecological function regardless of timber availability and resource extraction. Group C would embrace a precautionary approach to forestry. Is timber harvesting being conducted in conjunction with or in opposition to natural processes? Past management practices have led to current conditions. Should these conditions now be altered by additional intensive management, by natural disturbances or both? These questions depend on what people want out of our national forests.

Many assessments of forest health invariably depend on the assessor's intended "use" for the forest; does s/he fall into Group A, B, or C? In reality, this division should not matter: The actual definition of forest health should be purely ecological. The definition itself should not be based on or incorporate economic or political needs and desires. If forest health is to act as a basis for policy decisions, then decision-makers should be the ones to take the political, social and economic issues into account. If the definition already incorporates political, social and economic issues, then the ecological needs of the forest will not be considered fairly. By adopting a purely ecological definition of forest health, scientists and land managers can level the playing field between ecological and non-ecological needs in forest decision-making, and decisions aimed at improving forest health will not be economically motivated.

According to University of Idaho forestry professor Jay O'Laughlin (1994 p3), forest health is:

A condition of forest ecosystems that sustains their complexity while providing for human needs. Complexity includes the variation in ecosystem structure and function across time and space dimensions. Human needs range from spiritual and aesthetic fulfillment to commodity production.
O'Laughlin includes human needs in his definition of forest health, and therefore he includes management considerations. He continues (1994 p7):

Forest health in the Inland West is primarily about the purpose of our national forests. Until that purpose is decided, science can add only a little to debates about how to manage the forests by pointing out what might happen under various management alternatives. Scientists are ill-equipped to say what should be done with our public lands and resources. Those decisions are matters of public policy, a process that scientists can inform but should not dominate.

If this latter statement is true, then O'Laughlin has contradicted his own definition of forest health. After all, if scientists are to inform the public about the possible effects of management prescriptions, they should consider only the conditions, not whether those conditions meet human needs. If O'Laughlin wants to inform these decisions, he may want to rethink his definition of forest health. After all, he, as a scientist, is "ill-equipped to say what should be done."

Because scientific judgment is so often subject to political pressures (Ludwig et al. 1993), it is imperative that foresters, policy makers, environmentalists, timber workers and other concerned citizens agree on an unbiased scientific/ecological definition and use that as the basis for decisions regarding the future of our national forests. A FS science team (Hagle lecture 1994) completing research for the Eastside Ecosystem Management Project (EEMP) created the following definition:

A condition typified by succession and disturbance functions occurring within the natural range of amplitudes and periodicities.

Although this definition appears to offer an alternative with ecological integrity, it still poses one major problem. The definition places a lot of weight on the importance of the "natural range of periodicities and amplitudes." Alternative definitions have also been offered which, although more complex, may provide managers with more guidance when trying to assess forest health. For example, University of Arizona forestry professors Kolb, Wagner and Covington (1994 p12) describe a healthy forest ecosystem as one with the following characteristics:
• the physical environment, biotic resources, and trophic networks to support productive forests during at least some seral stages;
• resistance to catastrophic change and/or the ability to recover from catastrophic change at the landscape level;
• a functional equilibrium between supply and demand of essential resources (water, nutrients, light, growing space) for major portions of the vegetation; and
• a diversity of seral stages and stand structures that provide habitat for many native species and all essential ecosystem processes.

Within this definition, productivity refers to net primary productivity, not productive wood outputs. In addition, the idea of a functional equilibrium incorporates dynamic interactions between biotic and abiotic processes within a natural ecosystem: it is not meant to imply a static sense of stability. A continual cycle of regeneration and replacement will occur at all levels (individual tree to landscape level) within the forest. In the Intermountain West, natural disturbances are crucial for maintaining the balances described in the definition above. For the purposes of this paper, the definition by Kolb, Wagner and Covington is not only the most practical, but also the most sensible and useful.

The information used to determine some of these factors is sometimes taken from a narrowly determined range. As explained in relation to the Forest Service definition above, the natural (or historical) range of variability within ecological systems is now being used as a central tenet of much FS research regarding forest conditions and therefore forest health. The use of this historic range brings up a variety of questions.

**Historic Range of Variability**

It is imperative to consider some of the foundations of the concept of an historic range of variability (HRV). The range of variability is a central concept of the forest health debate, but what time frame does the FS consider historic? HRV is based on as long a time frame as the research allows for any particular site. In some
places, this research might be as far back as the early Pleistocene, but in other cases, it is only as far back as the oldest tree ring data (Johnson et al. 1994). Ponderosa pine forest types have only maintained stability for 2,000-3,000 years (Johnson et al. 1994). Studies which consider a 2,000-3,000 year time period when discussing historic range of variability will be the most useful for forest managers.

However, as currently used, the HRV refers to the conditions which existed when European settlers first arrived in the Intermountain West, roughly 1850 (Mutch et al. 1993, Wickman 1992, Hessburg et al. 1994). In this region, most settlers found open parklike stands of ponderosa pine spanning the majority of mid-elevational ranges. But 1850 was only 145 years ago; hardly an instant when considering evolutionary time. Since comparisons between past and current conditions typically consider only two points in time, this is not a scientifically sound comparison on which to base the majority of most current management prescriptions. In a Forest Service report assessing biotic and abiotic processes in eastside systems, Johnson et al. (1994 p21) explain the illusory nature of these views:

In a human life-span or two, eastside communities may seem predictable. On this scale, vegetation history can be explained by observed succession in the enduring harmony of climax communities. The idealized stable cycles, always returning to the natural state, are unfortunately just a few frames in a continuous movie (Graham, 1988). They are illusions of forest and steppe primeval—the pristine vegetation of the imagination.

Historical ecological conditions along the eastside of the Cascade Range were recently analyzed through a variety of paleontological studies using pollen core samples from lakes to understand historic vegetation conditions (Johnson et al. 1994). The findings reveal the diversity of vegetational changes in the Intermountain West throughout time, and imply that these changes will continue into the future. In particular, all of the different eastside studies show that ponderosa pine was not an important component of the vegetation until between two and four thousand years ago (Johnson et al. 1994). Between twelve and ten thousand years before present (BP) significant conifer forests covered the Eastside. Then, during an intense warming
period, the conifer forest vegetation was replaced by steppe vegetation for the next 6,000-8,000 years, depending on the location. At that point in time, conifer forests reinhabited the majority of this region. It was not until 2500 to 1000 years ago that modern forest type conditions began (Johnson et al. 1994).

The importance of this data cannot be underestimated in the search for understanding the forest conditions which exist today and the best ways forests can be managed. These paleontological studies are geographically incomplete and data is still needed for many areas, including the Blue Mountains. According to Johnson et al. (1994), two areas need much more study before any eastside forest history can be truly understood. The maritime forest communities of Northern Idaho and adjacent Washington and Montana make up the first location. Johnson et al. explain, "The second, and perhaps most important, area is the Blue Mountains of northeastern Oregon and adjacent Washington. Here, near total ignorance about vegetation history leaves room for imagination. ... (S)cientists may unravel the past and thereby achieve a wise view of future eastside ecosystems" (1994 p22).

Conifer forests have not and will not always exist in this region; they are a fluctuating component of the environment. It is possible that the conditions which allowed the conifer forests to establish themselves are no longer present. Johnson et al. also consider whether vegetation changes lag behind climate changes. If so, than vegetation is usually out of sync with climatic conditions, inciting rapid vegetation changes through disturbances such as disease and fire (Johnson et al. 1994). This lag time is caused by the long life spans of trees. The conditions which exist when the trees establish themselves on a site may be considerably different than those which exist as the trees mature over the centuries. The vegetation which has dominated the Intermountain West for the past two centuries (since European-American settlement), is likely only a single step in the evolutionary process. According to a paleoecological review by university professors Webb and Bartlein, "steady-state and climax theory are inappropriate for time scales of 200 years or longer" (1992 p166). If we manage within a 200 year time scale, we may inhibit ecological changes, but once we move beyond this time scale, it is difficult to adequately assess ecosystem stability.
A variety of paleoecological research reveals the importance of climate change in governing vegetation change (Webb and Bartlein 1992). Perhaps vegetation components would have begun changing on their own regardless of fire suppression. This raises clear concerns about FS management assumptions to return the land to pre-1850 conditions. A study of how these lands might evolve on their own is long overdue.

**The precautionary principle and forest management**

Although fire frequency and intensity may have increased in the last 150 years, managers can only assume that this current fire frequency is out of the range of variability. At this point in time, scientists still do not know what, if any, fire frequency is normal within an evolutionary time scale. Although the frequency of stand-replacing fires may have increased in this century, stand-replacing fires may be less frequent then they were a thousand years ago. Paleoecological studies can begin to reveal information relating to former fire regimes and stand composition.

Current forest management in the Intermountain west is based on scientific and observational data collected within the region in the past 150 years. This information is tacked onto centuries of European forestry studies. Yet, with all of the knowledge we have accumulated, we are only in the infancy of our understanding of ecological systems. Forest managers continually make assumptions about the outcome of the different silvicultural practices they utilize to manage public and private forests. These assumptions allow management to continue in the face of scientific uncertainty. Forest managers have yet to determine how to utilize these assumptions and the wealth of collected data to determine the tolerance thresholds of different ecological systems.

For example, what is the threshold at which natural systems can no longer recover on their own? At what threshold does stand-replacing fire cause more ecological harm than benefit within a stand? At what threshold does a lack of stand-replacing fire
cause more ecological harm than benefit? According to Conservation Biologist Reed Noss (1993), scientists can help inform the political debate about these issues by trying to determine the "critical thresholds" needed to maintain biological diversity. Anthropogenic management practices, then, must not take ecosystems below these thresholds. Determining these thresholds, however, is a difficult task.

Forest scientists have only limited knowledge of the long-term effects of the natural and anthropogenic disturbances which occur on public (and private) lands. The most ecological decision-making is based on determining the least-adversely impacting management options for a given place. Rarely, if ever, do forest managers consider the beneficial possibilities of leaving forests alone and maintaining a functioning, and therefore educational, natural ecosystem.

Reed Noss explains the significance of scientific assumptions, specifically as they relate to applied ecological investigation, in a discussion about Type I and Type II statistical errors. According to Noss (1992, 1993), Type II errors are more dangerous than Type I errors because they may lead to environmental destruction. Nevertheless, statistics generally aim to reduce the probability of Type I rather than Type II errors.

Type I errors occur if we reject the true null hypothesis (Sokal and Rohlf 1995). When this occurs, we claim an effect when, in fact, it does not exist. This error will usually result in protecting more than is necessary. If scientists claim that ecological degradation will take place but it doesn't, more land may be protected to avoid degradation (Noss 1992,1993). A Type II error, on the other hand, results when we fail to reject a false null hypothesis (Sokal and Rohlf 1995). We claim no effect when an effect actually exists. These situations typically result in protecting less than necessary (Noss 1992, 1993).
As silvicultural practices in the Intermountain West are currently advocated, the null hypothesis might be defined as follows: Silvicultural practices intended to improve forest health will have no effect on long-term ecological integrity and stability. We commit a Type I error if we assume that silviculture will affect ecological integrity and stability, and therefore we refrain from apparently damaging activities, erring on the side of safety and preserving more than we need to preserve. On the other hand, we commit a Type II error if we accept the false idea that silviculture will not threaten ecological integrity, and we proceed with ecologically damaging activities.

The significance of Type II errors is that they can permit activities that cause ecological degradation including biodiversity and habitat losses because we mistakenly assume that these activities are harmless. It is difficult, sometimes impossible, to recover ecological losses. For example, chinook salmon may become extinct if we mistakenly assume that forest management practices will not affect them. If we focus on reducing the probability of Type II errors, then we will utilize a more precautionary

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source: Sokal and Rohlf 1995

Ideally, when making decisions that affect ecological integrity, we will not err at all. But, since we do not know the effects of our actions, we cannot be sure whether or not the null hypothesis is true. Type I errors will lead to increased preservation and reduced development. Type II errors will have the opposite result. To reduce the possibility of ecological degradation, we should aim to reduce the possibility of Type II rather than Type I errors.

Box 1.1
approach to land management. In several policy and scientific arenas, a precautionary principle has been advocated to deal with the uncertainties and assumptions in scientific knowledge (see e.g., Ludwig et al. 1993, Greenpeace 1990, Ashford 1993). In particular, it gives us more options for the future by protecting what we have in the present. According to university professors Ludwig, Hillborn and Walters (1993):

Assigning causes to past events is problematical, future events cannot be predicted, and even well-meaning attempts to exploit responsibly may lead to disastrous consequences.

In the current debate over forest health, much of the focus rests on past mistakes and how to fix these mistakes through additional management. Alternatively, the precautionary principle directs us to consider natural processes and their ecological benefits before we consider anthropogenic management practices. Can nature manage her lands better than people? To determine this, forest managers need the opportunity (and the location) to observe natural processes for long periods of time. Instead of going in and trying to fix things ourselves, we can watch how nature deals with some of our past mistakes. The knowledge we gain from observing natural processes on our public lands can be used to implement improved silvicultural practices on our private lands. An approach like this is inherently precautionary.

Current research and decision-making are based on the assumption that people can mimic natural processes to maintain or improve forest function. Current practices favor development and management by readily accepting Type II errors. By changing this approach and accepting Type I errors, scientists err on the side of caution and favor environmental protection over development or exploitation. Even so, to some degree, humans will continue to manipulate and degrade the natural environment to provide resources desired by society. But by embracing a precautionary principle resource managers limit the areas where development occurs and increase the areas where natural processes can continue unaided (but observed) by humans.
Chapter Two
Understanding and Assessing Forest Health

Forest health is about the growing awareness that human activities over the past century have had some undesirable effects, and these effects are now becoming very apparent. The size and severity of recent wildfires and pest outbreaks are indicators of some undesirable ways we've altered forest ecosystems.

Western Forest Health Initiative (USDA 1994d)

Historic views of forest health

At the turn of the century, the United States Forest Service (USFS) began suppressing fire throughout the U.S. in order to minimize losses of merchantable trees within its forests. The Organic Act of 1897 states that, “The Secretary of Agriculture shall make provisions for the protection against destruction by fire and depredations upon the public forests and national forests...” (Gast et al. 1991). In conjunction with fire suppression and insect control, the USFS has also logged the majority of the old growth that formerly existed in the Blue Mountains.

When this land first came under federal control, the forests looked vastly different than they do today. Rebecca Ketchum, a traveler on the Oregon trail in 1853, left this picturesque journal description of her experience along the Grande Ronde River (in Wickman 1992 p1):

The country all through is burnt over, so often there is not the least underbrush, but the grass grows thick and beautiful. It is now ripe and yellow and in the spaces between the groves (which are large and many) looks like fields of grain ripened, ready for the harvest.

The “groves” to which Ketchum refers are the open, parklike stands of ponderosa pine which filled the mid-elevations of the Blue Mountains and were maintained by frequent understory burning. Seventy years later, not much had changed. Hank, of Hank's Station, a long time resident of the Blue Mountains recalls his first impressions (Ancient Forest Alliance 1993):
In 1920, when I first came into this Malheur Forest country, it was all Yellow Bellies, parklike stands of old ponderosa pine... the kind of forest you could drive your Model T through from Seneca to Burns without a road. Big pines as far as the eye could see...we thought we could never cut it all...

In the seventy years since, forest conditions have changed considerably in the Blue Mountains. Most of the old and large pine, western larch and Douglas fir have been logged out: The most valuable species to wildlife and the most fire-resistant tree species are also the most commercially valuable. Fire suppression activities have allowed forest succession to proceed toward climax species on many mid-elevation sites which were formerly dominated by seral species. The combined effects of logging and fire suppression have left the Blue Mountains covered with dense thickets of suppressed grand fir and Douglas fir (see e.g., Gast et al. 1991, Wickman 1992, Hessburg et al. 1994). These stands are now under near constant attack from a variety of insects and diseases, as nature uses her own forces to reinstitute nutrient cycling and forest succession in the wake of fire suppression.

Forest Service entomologist Boyd Wickman (1992 p3) explains some results of these structural and functional changes:

The increasing tree mortality, top kill, and growth loss caused by various pest agents, singly or in combination, have led to drastically declining productivity of Blue Mountain forests. This is affecting timber harvest goals projected by forest plans; it also is increasing the fire hazard and has contributed to several recent catastrophic forest fires. It is changing wildlife habitat on a landscape level: The Blue Mountains are suffering declining health on a landscape scale.

Wickman’s assessment of forest health focuses almost exclusively on tree mortality, declining productivity, and “catastrophic” fire. The beneficial effects of these natural processes are not mentioned. The commodity at stake is wood fiber, not forest ecosystems.

Historically, the Blue Mountains have never sustainably produced enough timber to meet the projected goals in the forest plans (Langston 1994). This ensures justification for continued cutting of the forests since young stands will generally have higher growth rates than mature stands. (Young trees grow faster than old trees,
creating the illusion that younger stands are more productive than mature stands.)
When the Forest Service first began managing the land near the turn of the century,
the forests were not meeting productivity goals because too much of the land was
covered with mature ponderosa forests. Therefore, many forest scientists argued for
increased management by logging older stands. At the turn of the century, more than
70% of the western forests were old growth, and wood fiber losses to death and decay
were about equal to gains from growth. The FS felt that the only way to save the
forests (and future timber supply) was to cut them down and replace them with young
forests (Langston 1994). The forest health crisis is only the most recent manifestation
of the same concept. If the forests can be made “healthier,” they will be more
commercially productive and silviculture can make this so.

Foresters began arguing for intensive regulation (timber management) shortly
after white settlers arrived in this region. In his 1864 book *Man and Nature*, George
Perkins Marsh (in Langston, 1994, p89) argued for saving the forests by regulating
and managing them:

The sooner a natural wood is brought into the state of an artificially regulated
one, the better it is for all the multiple interests which depend on the wise
administration of this branch of public economy.

In the Blue Mountains, cutting as much ponderosa pine as possible was the
quickest and most efficient way to bring the forests into this regulated and productive
phase. Now, many foresters (see e.g., Wickman 1992, Mutch et al. 1993 Hessburg et
al. 1994) say they want to bring back the seral species (ponderosa pine and larch).
Foresters can wait and see if this type of stand conversion will happen naturally, or
they can attempt to force these changes through silvicultural applications. The natural
return of seral species will be partially dependent on their presence in current stands
and on a return to natural fire regimes.

Creating altered forest conditions will require “intensive” forest management, as
discussed in Chapter One, and as discussed by George Perkins Marsh in 1864. Even
with 130 years gone by, foresters continue to think that they have the knowledge and
power to create exactly the productivity, species mixes and products that they desire
on any piece of national forest land. Many foresters believe that by managing for specific tree species on specific sites, disturbances can be reduced and productivity can be maximized (see e.g., O'Laughlin 1994, Gast et al. 1994, Hessburg et al. 1994, Wickman 1992). The alternative to this, they claim, is reduced productivity, tree mortality and "destructive" fires (O'Laughlin 1994). In addition, O'Laughlin (1994) feels that it is time for forest managers to move forward and to stop concerning themselves with what caused the problems we are facing today. Those who believe as O'Laughlin does, continue along a short-term path toward economic gain, cognizant of the problems that they may create for future forest ecosystems, yet unwilling to take full responsibility for all of the effects of their actions. Instead, these forest managers should learn from the mistakes of their predecessors and utilize management practices that allow them to adapt to the changing conditions of the forest over time.

Open parklike stands of ponderosa pines thrived on the effects of light surface fires. Both natural lightning strikes and Native American burning practices were responsible for the frequency of the fires. These fires burned approximately once a decade and kept shade tolerant tree species (Douglas and true firs) from developing underneath the ponderosa pines which are fire resistant (Hall 1979, Hessburg et al. 1994, Agee 1994, Mutch et al. 1993). As fire suppression effectively wiped out the frequent surface fires, a Douglas fir/true fir understory developed beneath the ponderosa canopy. The trees which made up the ponderosa canopy (overstory) were then systematically removed for their high timber value (Wickman 1992, Mutch et al. 1993, Gast et al. 1991). As the overstory was removed, the understory trees (which had developed since fire suppression) were exposed to increased light and therefore were "released" to grow larger and fill in the openings. Shade intolerant ponderosa pine couldn't regenerate underneath the fir. But, these firs are not well-adapted to the drier sites traditionally dominated by ponderosa and larch. Competition for limited water, nutrients and sunlight left these understory trees suppressed and vulnerable to insect and disease infestations (Wickman 1992, Mutch et al. 1993, Gast et al. 1991, Hessburg et al. 1994). But fir species have always been part of the ecosystem, and in certain places, at certain elevations they have proliferated as well.
Understanding Eastside forest communities

To understand some of the current views about forest health and the effects management practices have had and will have, it is first necessary to understand the relationship between elevational zones, temperature/moisture gradients, habitat types and fire. Generally speaking, the lower elevation, south-facing sites are the warmest and driest sites. As you move higher, or onto north facing slopes, temperature goes down and moisture content goes up.

Fire suppression has had its greatest effect on low- to mid-elevation, dry ponderosa pine dominated sites. Ponderosa stands can exist as a seral component of Douglas or grand fir climax sites. Or, on the hottest and driest sites they exist as the climax species of the ponderosa pine series. These forests intergrade with Douglas fir and grand fir series in wetter, higher areas, and merge with sagebrush desert, desert grasslands, western juniper or Oregon white oak woodlands in drier areas (Hessburg p32).

Understory fire played a crucial role in these communities, consuming the litter layer, brushy vegetation and any encroaching small trees. Understory mean fire return intervals (MFI) ranged from 10 to 20 years (Hall 1979, Agee 1993, Gast et al. 1991). These fires maintained the open conditions in the stand, which in turn helped keep

Box 2.1

Climax and Seral Communities

*Habitat typing* is one common way to categorize forest communities in the Intermountain West. Habitat typing classifies sites according to potential vegetative cover in the absence of disturbance (Kimmons 1987). This methods rely on the concept of climax communities. A *climax community* is the community or combination of species which will inhabit a given site if the community is left undisturbed. On many sites, the vegetation will go through a variety of changes as it progresses towards the climax. These intermediate stages are called *seres*, and the plants that compose them are called *seral* species. For example, ponderosa pine often exists as a seral species on a Douglas-fir or grand fir climax site.

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fires at a low intensity. It was only on sites where ponderosa persisted as a seral or climax species that a change in the fire frequency (due to fire suppression) had a severe effect on the natural vegetation.

Mid-elevation forests consisted of a variety of fir and ponderosa pine or larch, depending on slope, aspect and moisture content. In the Blue Mountains, grand fir climax communities range in elevation from 2500 to 6500 feet, while Douglas fir communities are fragmented occurring from 2100 to 5900 feet in the Blue Mountains, confined mainly to dry ridgetops and south and east-facing slopes (Hessburg 1994). In the lower reaches of both fir communities, ponderosa pine is the most common seral species. It is replaced by western larch at higher elevations. In sites dominated by seral ponderosa pine, the MFI was historically low, while on the cooler and wetter sites, fire played a more variable role, consisting of some underburns, small “jackpot” burns, and partial and complete stand-replacing burns. Western larch typically dominates in areas with moderate or high severity fire cycles (Hessburg 1994). This combination of fire events in conjunction with the effects of insects and diseases shaped the variable mosaic of habitats and conditions that once existed throughout the landscape of the Blue Mountains and the rest of the Intermountain West.

High elevation stands are mainly made up of Englemann spruce and subalpine fir. High elevations sites generally provide more moisture and a shorter growing season. Here, fires occurred at higher intensities and longer intervals, between 50-300 years (Thomas 1994, Agee 1994). In the highest and coldest environments, dominated by subalpine larch, fires rarely burn (Agee 1994). Stand-replacing fires with high mortality are most common on these sites (Agee 1994, Thomas 1994), but landscape and topographical conditions often kept these fires fairly small, resulting in diverse conditions throughout the landscape as a whole.

Lodgepole pine forests have a disturbance regime of their own. Lodgepole pine climax sites in the Blue Mountains are mainly limited to frost pockets — here lodgepole has a competitive advantage over other species (Agee 1994). Lodgepole pine naturally grows in dense stands, typically succumbing to mountain pine beetle, fire, or both at intervals of 60-300 years (Thomas 1994 p4). This moderate severity
disturbance regime results in the partial removal of approximately one third of the stand every 60 years (Agee 1994). The complex design of these stands results from the unique interactions between fire and insects. A unique feedback loop exists between the two disturbances, with fire scars weakening trees for insects and insect-caused tree mortality providing fuel for fires (Agee 1994).

**Assessing Forest Health**

Currently, methods for determining the state of forest health and for understanding where possible management techniques should be applied are poorly understood. As discussed in the first chapter, there is no single accepted definition of forest health. To understand forest conditions, it is first necessary to understand the basis of forest stand development and to realize that a variety of different factors may be considered when assessing forest health.

According to Chad Oliver and Bruce Larson's (1990) theory of forest stand dynamics, forest stands go through five stages of growth: 1) stand initiation; 2) stem exclusion; 3) stand reinitiation; 4) transition old growth; and 5) true old growth. Although this theory was developed for westside forests, the concepts of succession pertain to eastside forests as well when stand-replacing events occur. Each of these stages lasts for a different length of time depending on the soils, climate, available sunlight, native vegetation species, disturbance regimes, and past management practices. Initially, this process begins after a stand-replacing natural or human-caused disturbance occurs. The surface fires described in the previous section are an example of a minor natural disturbance which does not restart the five stage succession, while a stand-replacing fire would. A clear-cut is a human-caused disturbance which could restart the process, but the area is often further manipulated through selective plantings and other treatments to control revegetation and maximize the economic value of the
new stand. This enables foresters to "control" forest succession and attempt to meet certain outcomes on managed sites.

During the stand initiation stage, new individuals and species colonize the site. After several years, the stem exclusion stage begins: no new species colonize the site, and existing species begin to crowd out lesser competitors, assert dominance and close the canopy, reducing available sunlight. This eventually leads to the stand reinitiation stage in which competition kills off the weaker trees and species, allowing more sunlight to reach the forest floor, stimulating ground vegetation and advance regeneration of the dominant overstory species. Transition old growth contains a variety of age and size classes, but most importantly it still contains some relic trees from the original stand initiation. A stand reaches the true old growth stage when all the relic trees have died and the remaining stand is made up of trees which developed under the initial overstory (Oliver and Larson 1990). The length of time required for this (without a stand-replacing disturbance) dictates that many stands never reach the true old growth stage. The structure and function that many species depend on is often reached during the transitional old growth stage.

Small-scale disturbances and underburning fires affect forest succession in a variety of ways. For example, open parklike stands of ponderosa pine which are maintained by underburning fire can be considered as a fire disclimax community. As long as frequent surface fires burn on these sites, the sites will never progress to Douglas or true fir dominance. These stands may be considered old growth, although they may not meet Oliver and Larson's definition. In addition, for species which generally exist without fire, constant mortality and replacement take the place of stand-replacing events. Disease centers, isolated insect patches, avalanches, etc. may create openings for regeneration on these sites.

So, how is forest health actually assessed in the national forests? As previously mentioned and explained by Chief Thomas, this depends on the intended use of the forest. Within the Forest Service, the definitions of forest health vary depending on the land allocation (USDA 1991). The FS tends to assess forest health on its ability to produce salable trees. But, without an accepted scientific definition of
forest health, an inherent ambiguity exists within any management technique utilized by the Forest Service to "improve forest health." The term can be manipulated to justify nearly any type of management practice.

Speaking simply, if the forests are here to produce timber, then insects, disease and fire are bad. If the forests are here to maintain ecosystem processes and functions, then insects, diseases and fire are a necessary component of the system. In reality, the question is not as black and white as this. Disturbances are a natural and important part of the ecosystem, but there may be situations where these disturbances do affect the ability of the forests to meet their intended uses. In particular, this may occur if high tree mortality greatly increases fire risks near an urban/wildland interface. High tree mortality in plantations managed for wood fiber is also a problem. In situations like these, silvicultural practices may be appropriate for reducing the intensity of natural disturbances and protecting commodity values or private property.
Chapter Three
Natural Disturbances

Management is needed to prevent the catastrophic collapse of entire ecosystems, especially in wilderness.

Stephen Mealey, USFS project leader, Upper Columbia River Basin EIS project

The intermountain western landscape which greeted the first European settlers in the late 1800's was much different than the landscape we see today. Diverse mosaics of habitats and habitat types were spread throughout the region. These mosaics were created by the complex interactions between insects, diseases and fire (Schowalter 1991, Hessburg et al. 1994). Without any one of these three natural disturbances (as well as other stochastic events like windstorms, avalanches and floods), the landscape would have been entirely different, perhaps more similar to what we see today. Forest managers took fire out of the equation in the early 1900's. Then they added high grade logging and road building, drastically altering the forest conditions which exist, and creating the conditions which led and lead to an abundance of natural stand-replacing disturbances.

As explained in the first two chapters, by utilizing an ecological definition of forest health land managers and decision makers will be better able to understand and appropriately apply silvicultural practices to forest lands. An ecological (and precautionary) approach considers the ecological effects (benefits and drawbacks) of natural as well as anthropogenic disturbances. Informed and effective management decisions depend on good scientific data. This chapter will provide a synthesis of the scientific information available about the possible ecological effects of three types of natural disturbances which are common in Hells Canyon National Recreation Area. The silvicultural practices which are intended to mimic these natural disturbances will be evaluated in the next chapter.

Silviculture is basically the practice of managing trees to increase wood fiber production. Because of this, the majority of the research available regarding natural disturbances focuses on how to reduce their effects, giving little attention to the
ecological benefits of these natural disturbances. This chapter synthesizes existing
data to create an outline of the ecological benefits and drawbacks of natural
disturbances. Before proceeding, two clarifications are necessary. First, the effects as
listed are just possibilities; every effect does not occur in conjunction with each
disturbance. Because of this, every proposed action must be considered on a site-
specific basis so the possible effects can be more precisely determined. Second,
labeling these effects as benefits and drawbacks inherently biases the discussion
towards our human perception of what is good and bad in nature. Even if this
perception is based on an ecological versus an economic bias, the ecological view is
still a human construct. In the past we have mistakenly assumed some natural
processes were "bad" when they were actually "good." We may make the same
mistakes again. By adopting a precautionary principle for national forest management,
we may be able to avoid some future mistakes.

In order to use the information presented in this chapter effectively,
disturbances must be considered on a site-specific basis. Disturbances affect different
sites in different ways. Below is a discussion of some of the site characteristics which
should be considered when assessing forest conditions.

Site characteristics

Disturbance effects vary depending on the type of site, climate, topography,
etc. Overall site characteristics which apply to all disturbances will be discussed first.
Following this, the ecological benefits and drawbacks of individual natural
disturbances will be examined. This information can be used to determine whether or
not the activity and its effects are appropriate for a particular site. If a landscape
exacerbates rather than buffers or absorbs natural disturbances, more frequent stand-
replacement events can occur (Perry 1995) as the landscape tries to regain a balance
between disturbance and succession. To help resolve whether or not to allow a natural
disturbance to continue or to implement silvicultural practices, managers develop desired future conditions for certain areas.

The concept and creation of a desired future condition, however, must be seriously considered. The FS vision of the early 1900s was to create young vigorous stands of trees and to extirpate fire from the national forests. If the vision is flawed, so too is the management. And, it is difficult to know whether or not the vision is flawed until after plans have been implemented.

The following issues should be considered when evaluating active and potential natural disturbances: management history for the site and surrounding landscape; current stocking levels, stand structure and species composition; climate and soils; and desired future conditions. Each of these factors play into the decisions which land managers have to make.

**Management History**

As previously explained, past management has severely affected the ability of current stands to incorporate and respond to natural and management disturbances. Road building, timber harvest, and fire suppression have had significant impacts on current conditions (Henjum et al. 1994). The overall result has been the creation of relatively continuous stands of shade-tolerant species in the low- to mid-elevation forests. This is not as predominant on Hells Canyon NRA as it is in other areas of the Interior West, mostly because of the steep slopes and varied topography of the canyon. (According to timber sale information from the HCNRA ranger district (USDA 1993), the flatter areas of the NRA have been subjected to higher levels of past management practices, thus creating conditions more comparable to the rest of the intermountain west.) Aquatic habitat has suffered from both dam building and terrestrial management practices.

The effects of terrestrial management practices have been largely responsible for the degradation of salmonid populations in anadromous fish-bearing streams (Henjum et al. 1994). Because of the extent of the adverse effects associated with road building, previously unmanaged areas and roadless areas should be excluded from
anthropogenic management. These areas have enormous ecological value as the last remaining ecosystems which are relatively intact (Henjum et al. 1994) and which can act as core habitat and biodiversity reserves as well as study areas.

Stocking Levels, Stand Structure and Species Composition

The current composition of the intermountain western forests is different from any recorded composition or structure that forest scientists have analyzed from approximately 150 years of historical data. This data includes first-hand information collected by foresters since the mid-nineteenth century as well as tree ring data (this data can date back hundreds of years). Bearing in mind the issues raised in Chapter Two regarding the accuracy and time frame of historical data and historic range of variability, it is still relevant to consider the current variance from pre-settlement conditions.

The low- and mid-elevation areas which are currently experiencing pervasive insect and disease problems exist in an already unnatural state because of past management practices. Historically, these sites were not composed of large numbers of host species for these insects. Current insect and disease disturbances are naturally moving these stands back toward a more original species composition and structure (Perry 1994, Schowalter 1991). (Nature can only succeed in returning sites to ponderosa pine dominance if some ponderosa still remain on or adjacent to the site.) Essentially, insect populations are no more abundant than they have ever been in this region, relative to the number of host species per insect (Gast et al. 1991; Perry 1988a, 1994; Hessburg 1994). The organisms still require the same conditions they have always required, but post-European settlement management practices have altered the quantity and continuity of these conditions. Epidemics cannot occur without an abundance of susceptible host species, and once pest populations begin to grow, natural ecological controls such as insectivorous birds and animals lose their effectiveness (Torgersen 1994, Perry 1994). Species composition and stand structure combined with natural predators help determine stand resistance or susceptibility to insect outbreaks (Torgersen 1994). In addition, increased stress due to competition for
water, nutrients and sunlight can increase a stand's susceptibility to insects and diseases.

Diverse species composition within stands offers several safeguards against severe insect or disease disturbances. For example, insect population dynamics depend on a variety of conditions besides available host species. Chemical defenses (of the trees), insectivorous fauna, tree species diversity and climatic factors are all important (Schowalter 1991). Since different tree species are susceptible to different insects and diseases, species diversity is a natural barrier to epidemics. All plant species also emit unique chemical "odors" that travel through the air (Murlis et al. 1992). Specific insects are attracted to specific chemicals, but when a diversity of species exist in one area, the chemicals intermix and it is more difficult for insects to locate suitable host trees (Schowalter 1991). The more diverse the species composition of a stand, the less likely an insect or diseases occurrence will become stand-replacing. During the drought of the 1920s and 30s, the vast monocultures of ponderosa pine in the Intermountain West became easy prey for a western pine beetle epidemic (Hessburg et al. 1994). Monocultures are less adaptable to change (Noss 1993) and less resistant to epidemic infestations (Schowalter 1994).

Typically, increasing susceptibility to stand-replacing insect and disease epidemics is coupled with increasing fire intensity and severity. Figure 3.1 (Agee 1994) provides a graphic depiction of the different types of sites which exist and their most common fire regimes based on physical characteristics of fire disturbance regimes in the Pacific Northwest. Although considerations for management of natural disturbances can be made based on habitat typing and potential climax species, it is advantageous to consider temperature and moisture factors as well. In Hells Canyon, temperature and moisture may be more important than straight habitat typing because of the extreme elevational changes and the relatively isolated canyons.
Fire Regimes of the Pacific Northwest

Figure 3.1

From Agee 1993
Topography, Climate and Soils

In higher elevation stands, topographical features such as rocky outcroppings or other natural barriers isolate small stands and pockets of trees, limiting the spread of insects, disease and fire. Within Hells Canyon, much of the forest exists in stringers down the many side canyons. These isolated stringers slow the spread of insects and airborne or root-borne diseases. On the other hand, in the flatter portions of the NRA, especially along the Imnaha River, continuous bands of drier habitats occur. Even in areas where old growth exists, it is likely to be adjacent to a dense stand or a stand with high insect or disease mortality. In situations like this, structurally sound, late-successional/old growth stands may be at high risk from stand-replacing fire, even if they depend on surface fire to maintain their current structure.

Eastside soils (and therefore vegetation) are strongly influenced by volcanic ash and pumice (Harvey et al. 1994). Volcanic ash deposits increased the water-holding capacity of the soil compared to that which existed before Mount Mazama erupted approximately 6,600 years ago (Harvey et al. 1994). Soil moisture availability plays an important role in the intensity of natural disturbances. Moisture stress reduces an individual tree’s ability to withstand insects and may increase susceptibility to some diseases as well. As more trees compete for less moisture, the overall stand susceptibility to both pests and fire increases. Drought is one of the key precursors to higher intensity disturbances (Hessburg et al. 1994), especially infestation by herbivorous insects (Mattson and Haack 1987).

Desired Future Condition (DFC)

In order to understand whether or not a natural disturbance is appropriate for a particular site, managers create a vision of what they desire the landscape to look like in the future, and at what point in the future it should look like this. Many DFCs are based on what forests looked like in the past, (when perhaps they were not subject to as many stand-replacing events), but basing future decisions on past practices is not necessarily appropriate and little scientific evidence exists to support this type of
planning. Fire ecologist James Agee (1993) explains some of the problems which may occur if managers attempt to reset the ecological clock:

An ecological progression over time may not be capable of reversal; although this has been documented mainly for alien plant invasions, it may also be true of past ecosystem states that we define as desirable.

DFCs should incorporate some of this uncertainty and the dynamic processes which occur within natural systems. By doing this, DFCs may be flexible enough to allow stand-replacing natural disturbances to occur with more frequency as nature moves the intermountain western forests to their next stage of development. For example, an independent citizens group developed the following DFC for the forested lands of HCNRA (CMP Tracking Group 1995):

Native forest habitat, structure and function, and a diversity of forest conditions (e.g., burned areas, diseased areas, old growth, diverse forest plant communities, successional stages later than grass, seedlings) will be protected and restored as possible through natural forest processes reflected in the natural capability of the land. Native fauna as well as the habitat on which it is dependent will be maximized.

**Natural Disturbances**

Natural disturbances occur at varying degrees along a gradient ranging from small scale, individual tree mortality to stand-replacing and landscape level events. Successional development varies with different levels of disturbance. While a stand-replacing disturbance will clearly restart the successional process, smaller scale events can be more difficult to assess. The rest of this chapter will focus on the ecological benefits and drawbacks of insects, diseases and stand-replacing as well as understory fire. Other stochastic disturbances such as avalanches, windstorms, floods, etc. will not be considered. Prior to the detailed discussion of each of the natural disturbances, a table summarizing the ecological benefits and drawbacks is given.
<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increases tree vigor &amp; stand productivity:</strong></td>
<td><strong>Decreases tree vigor &amp; stand productivity:</strong></td>
</tr>
<tr>
<td>1) long-term vigor increases in trees that survive defoliation (19,29,46,78)</td>
<td>1) large amounts of standing dead trees increase risks of stand-replacing fire (epidemic)</td>
</tr>
<tr>
<td>2) tree mortality reduces competition and increases vigor in residual trees -</td>
<td>2) increases susceptibility to additional endemic and epidemic disturbances (19)</td>
</tr>
<tr>
<td>reduces susceptibility to pests (19,29,45,46,49,57,78,79)</td>
<td></td>
</tr>
<tr>
<td>3) defoliators can increase tree survivability in droughts by reducing water</td>
<td></td>
</tr>
<tr>
<td>loss transpiration (45,79)</td>
<td></td>
</tr>
<tr>
<td>4) increases nutrient cycling, soil function, and stability (19,29,46,47)</td>
<td></td>
</tr>
<tr>
<td>5) down woody material increases soil moisture retention (29,44,78)</td>
<td></td>
</tr>
<tr>
<td><strong>Increases stand complexity:</strong></td>
<td><strong>Decreases wildlife habitat:</strong></td>
</tr>
<tr>
<td>6) in concert with disease and fire, insects help maintain the shifting mosaic of</td>
<td>3) jack-strawed dead trees can impede movement of megafauna (19)</td>
</tr>
<tr>
<td>small even-aged patches within a larger uneven-aged landscape - this reduces the</td>
<td>4) epidemics can lead to high tree mortality which reduces thermal and</td>
</tr>
<tr>
<td>likelihood of epidemic disturbances (19,29,73,78,80)</td>
<td>hiding cover for ungulates (epidemic) (89)</td>
</tr>
<tr>
<td>7) long-term structural changes allow natural fire to regain its role as an</td>
<td>5) increases in peak stream flows cause problem for unstable</td>
</tr>
<tr>
<td>ecosystem regulator</td>
<td>streambanks (epidemic) (19)</td>
</tr>
<tr>
<td><strong>Increases wildlife habitat:</strong></td>
<td>6) reduced streamside shading increases water temperatures - can stress</td>
</tr>
<tr>
<td>8) increases wildlife snags (benefits cavity nesting birds and mammals), increases</td>
<td>or kill fish (epidemic) (74,82)</td>
</tr>
<tr>
<td>coarse woody material to the forest floor (benefits small mammals, invertebrates),</td>
<td></td>
</tr>
<tr>
<td>and increases large woody debris to streams (improves stream structure, number of</td>
<td></td>
</tr>
<tr>
<td>pools, spawning habitat) (29,44,88)</td>
<td></td>
</tr>
<tr>
<td>9) changes in stand structure can increase browsing habitat for ungulates</td>
<td></td>
</tr>
<tr>
<td>(epidemic) (19,78,89)</td>
<td></td>
</tr>
<tr>
<td>10) increases in snags lead to increases in insectivorous bird populations which</td>
<td></td>
</tr>
<tr>
<td>help maintain endemic levels of insects (epidemic) (60,89)</td>
<td></td>
</tr>
<tr>
<td>11) snow retention in created openings can increase peak flows and improve streambed</td>
<td></td>
</tr>
<tr>
<td>scouring (19)</td>
<td></td>
</tr>
</tbody>
</table>

* Defoliators and beetles are the two types of insects which have the above effects on intermountain western forests. Unless otherwise specified, the effects occur through both epidemic and endemic levels of insects. (The numbers refer to citations from the reference list.)
Insects

The forested lands of the Intermountain West are host to a variety of native insect species. Simply, these insects can be divided into two categories, defoliators (e.g., spruce budworm, tussock moth), and bark beetles (i.e., mountain pine beetle, western pine beetle). Decomposers, or insects which live in dead trees, are not considered here. Although insects and disease effects together are significant, this section focuses on insects only. The general ecological benefits and drawbacks of insects at both endemic and epidemic levels will be discussed.

Insect and Disease Interactions

Insects and diseases most often work together to change stand structure and composition. For example, many bark beetles have disease receptors in their wings. When they enter the bark, they introduce disease to vulnerable parts of the tree (Partridge 1994). Alternately, diseases can weaken trees to the point where they can no longer ward off insect attacks (Hessburg et al. 1994). The interactions between insects, diseases and fire create feedback loops. These feedback loops drive forest succession and maintain structurally and functionally sound ecosystems.

Box 3.1

Tree Vigor & Stand Productivity

Insect benefits - Increased tree vigor, nutrient cycling, growth, and resistance to "pests;" reduced respirational losses:

Numerous studies on defoliators in this region reveal their positive effects on overall forest health. Trees surviving tussock moth defoliation, for instance, typically experience increased growth levels beginning the year after defoliation ends, and continuing for decades (Mattson and Addy 1975, Gast et al. 1991, Schowalter 1991, Hessburg et al. 1994). Tree growth increases are attributed to two main factors: 1) increased nutrients in the soil (e.g., from the increase in litter deposited by caterpillar frass), and 2) reduced competition due to tree mortality (Mattson and Addy 1975, Gast...
et al. 1991, Schowalter 1991, Hessburg et al. 1994). Increased productivity is a long-term rather than a short-term benefit. The short-term drawbacks are limited to patches of tree mortality and decreased productivity during defoliation, but the long-term effects are clearly positive. Dead trees first become snags and eventually fall to the forest floor, where they release nutrients and increase soil moisture retention (Hessburg et al. 1994). Down wood will only increase moisture retention if the log is flat on the ground, otherwise it will dry out quickly and decompose slowly. Moisture stored within downed logs acts as an important reservoir for roots and seedlings in droughty times.

Reduced competition for water and nutrients also increases trees’ ability to produce chemical defenses against

Vigor and Suppression

Tree health is often characterized as vigorous or suppressed. Increases in tree vigor will reduce trees’ susceptibility to some insects and diseases. Competition can reduce vigor and stress trees. Suppression can kill trees if the tree has too little growing space to provide the photosynthate necessary to sustain respiration and provide root and tissue renewal (Oliver and Larson 1990). Suppressed trees typically have just enough nutrients and photosynthate to survive, these trees are unable to sustain themselves under additionally limited conditions (Oliver and Larson 1990).

Tree vigor can be determined by casual observation or by careful measurement. In casual observation, the color, density and amount of foliage are evaluated to determine the most vigorous trees (Smith 1990). More specifically, tree vigor can be defined as, “the current growth (grams of stemwood produced) per square meter of crown leaf surface” (Mitchell et al. 1983). For this definition, stem growth can be determined by measuring the diameter at breast height (dbh) and width of the last annual growth ring, while foliage area can be determined by measuring sapwood depth (Mitchell et al. 1983).

Suppressed or stressed trees are usually more susceptible to insect and disease infestations. However, some “pests” actually prefer older, vigorous trees (Oliver and Larson 1990). (Western pine beetle, for example, typically prefers older, large diameter ponderosa pine). In addition, stress and competition from vigorous understories can have fatal effects on the overstories on nutrient- or moisture-limited sites (Oliver and Larson 1990).
insects and to withstand certain diseases (Mattson and Addy 1975, Schowalter et al. 1986, Mattson and Haack 1987, Schowalter 1991). Increased tree vigor is often associated with decreased tree density and consequently reduced susceptibility to insects (Mitchell et al. 1983). Epidemic infestations help put stands back into conditions dominated by endemic insect levels, especially through contributions to soil fertility and species diversity (Mattson and Addy 1975, Schowalter 1991). Infestations allow these endemic insect levels to continue to modify stand structure and diversity at a smaller scale.

Finally, defoliating insects reduce the leaf area on trees which reduces photosynthetic capabilities. Defoliation by chewing insects in particular, reduces transpiration rates (Schowalter et al. 1986). In times of drought, this can be particularly beneficial, because as transpiration is reduced, scarce water is conserved. (This is a double-edged sword though, since reduced transpirational cooling also increases tree temperature and may lead to increased insect infestation (Mattson and Haack 1987).)

Insect drawbacks - Increased fuel loading/tree mortality:

Endemic levels of insects do not cause any measurable drawbacks. The greatest drawback from epidemic level infestations in forested stands is increased fuel loading. Since outbreaks are often associated with dense stands and occur in conjunction with drought conditions, the likelihood of stand-replacing fires is heightened. (But as the section on stand-replacing fire shows, the ecological drawbacks are limited, and often outweighed by the ecological benefits.) Dead trees often fall to the ground in jack-strawed patterns, allowing for rapid drying, slow decomposition and high flammability.

During insect infestations, productivity can be severely reduced. Although beetle infested stands may see increased productivity due to thinning, mortality levels will be higher than those associated with defoliators (Gast et al. 1991). Beetles often act as secondary pests, killing trees which are weakened, but not killed, by defoliators or diseases. This has been especially common during the recent tussock moth
outbreaks in the Blue Mountains (Gast et al. 1991). Increased stress caused by insects not only predispose trees to diseases, but many bark beetles also carry pathogens into the trees as they invade.

**STAND COMPLEXITY**

**Insect benefits - Increased structural diversity (by maintaining populations of dead and dying trees); altered successional stage development:**

Bark beetles and defoliating insects help create varied landscape conditions in forested stands as weaker trees are killed. Each insect type has a different effect on the different stand components. For example, endemic levels of western pine beetles typically attack large diameter older ponderosa pine, creating occasional openings and thinning out the weaker trees (Hessburg et al. 1994, Schmid 1987). Epidemic levels caused extensive mortality throughout the landscape when drought conditions were severe (Hessburg et al. 1994).

Douglas fir tussock moth outbreaks can reduce the grand fir components within stands, helping move stands back to stocking by resistant, seral species such as ponderosa pine (Gast et al. 1991). Small understory trees suffer the most immediate mortality from defoliating insect infestations (Gast et al. 1991). For example, intense feeding by western spruce budworm leads to reduced height growth, serious tree defects and tree top death (Carlson and Cates 1991). But mortality of immature understory trees enables stands to naturally proceed toward more resistant structural conditions and successional stages. Although Douglas fir tussock moth may defoliate large areas of the landscape, only small patches of trees within these areas will actually be killed (Gast et al. 1991). Epidemic insect levels can reshape stands into earlier seral conditions, while endemic levels are more likely to move stands toward later seral or climax conditions. Mortality associated with epidemic infestations increases fuel loading and susceptibility to stand-replacing fire. Stand-replacing fire, however, will reinitiate forest succession (Schowalter et al. 1986). Epidemic and endemic levels of insects (on their own and in conjunction with fire and disease) will create the mosaic of even-aged patches within an uneven-aged landscape that will best
allow the forest to absorb the effects of different disturbances (Schowalter et al. 1981, Schowalter 1991) and support a wide variety of species through increased structural diversity.

Natural tree regeneration is rarely a problem in patches opened by insect-caused mortality. The increased nutrient levels in the litter layer and soil provide excellent habitat for seedlings, and adjacent living trees provide the seed sources (Mattson and Addy 1975, Schowalter et al. 1986, Gast et al. 1991). As trees are defoliated, more light reaches the forest floor and understory vegetation increases (Schowalter 1991, Gast et al. 1991).

Large-scale infestations can lead to complete stand conversions or patchy openings. Reseeding from nearby remnant trees of resistant species will change the susceptibility of the new stand from one series of disturbances to another. Resistant species will colonize the site. Although these species may be resistant to the former stressful conditions, they will ameliorate the site for a different set of disturbances (Schowalter et al. 1986). The site may move from one dominated by stand-replacing events to one dominated by small-scale disturbances, just as it had formerly moved in exactly the opposite direction because of logging and fire suppression.

One example of this occurs on Englemann spruce/subalpine fir sites. Spruce beetles typically kill large diameter, old spruce trees. Epidemics can begin in blowdown left from a windstorm. As the beetles breed within the blowdown and consume all of the available food they are forced to spread to the adjacent live trees. An epidemic is likely to kill the majority of the spruce in an area, converting the stand to one dominated by subalpine fir. Insects and diseases will then interact to eventually convert the stand back to one dominated by spruce (Gast et al. 1991).

As these examples show, endemic and epidemic insect infestations have profound and important effects on stand structure and forest succession. Stand-replacing disturbances are as important as individual or small-scale events in maintaining functioning forest ecosystems.
Insect drawbacks- Increased fuel loading/tree mortality:

The problems with increased fuel loading and tree mortality are similar to those described under the Insect drawbacks section on tree vigor on page 35.

**WILDLIFE**

Insect benefits - Improved habitat availability and quality; increased wildlife populations; increased food availability for insectivorous wildlife:

Structural changes in forest habitat affect all types of wildlife in their ability to find shelter and food. Specific changes will benefit some species and harm others. Habitat fragmentation is also a problem as habitat connectivity is lost to human or natural disturbances. As stated in the Hells Canyon NRA Act and the Federal land use regulations regarding HCNRA, one of the goals for vegetative manipulation within the NRA is the improvement of wildlife habitat. What types of disturbances improve habitat, which reduce habitat, and when should these be applied? In particular, it is important to think about the effects of past management on wildlife habitat. When habitat quality and availability reaches a critically low threshold because of past management practices, it may be detrimental to allow natural processes to continue if they may further degrade habitat for sensitive, threatened or endangered species.

**Mammals**

Whenever stand conditions or structure change, different habitat types are created and lost, benefitting a variety of species. Enough habitat must be maintained to provide for all of the different flora and fauna typically associated with a certain area.

Structural changes caused by insects can improve habitat for a variety of species. In particular, insect-caused thinning and reduced canopy closure will encourage herbaceous growth on the forest floor and improve food availability for a variety of species. Increases in berry-producing shrubs will improve habitat for bears, small mammals and birds. Downed logs also provide habitat for various vertebrates, decomposers and invertebrates (Hessburg et al. 1994).
Increases in forage plants will improve habitat for browsing ungulates such as elk, deer and sheep. The ecological factors which most limit large ungulate populations are forage, water and cover (Thomas et al. 1979b). Small openings provide forage areas while adjacent forests provide hiding and thermal cover. Natural disturbances create shifting patterns of small and large openings within the forest. As these openings progress through forest succession, diverse wildlife habitats are created.

Birdlife

According to Forest Service entomologist Torolf Torgersen (1994), irregularly shaped openings, mixed successional stages, and a variety of crown closures and canopy layers encourage a broad assemblage of insectivorous fauna. (Torgersen's comments focus on the ability of group selection cutting to create these conditions, but the evidence above shows that these conditions are natural results of insect, disease and fire events.) Insectivorous fauna provide key regulation of endemic insect populations (Perry 1988a, Thomas et al. 1979a). Although they cannot control epidemics, they do help maintain forest stability and expand the time periods between outbreaks. As insects alter species composition and structural diversity of the landscape or specific stands, the amount of habitat available to natural insect enemies increases (Torgersen 1994). Snag dependent birds and mammals represent a major portion of the insectivorous fauna of the Blue Mountains (Thomas et al. 1979a). Thus insects and insectivorous fauna can exist together in a type of stable equilibrium, but stands without one or the other—or with severe imbalances between populations—will be more prone to stand-replacing events (Perry 1988a).

Forest Service Handbook #553 *Wildlife Habitats in Managed Forests of the Blue Mountains* (Thomas et al. 1979a), explains that 39 bird and 23 mammal species use snags for nesting or shelter. Snags (dead or partly dead trees at least 4 inches in diameter at breast height (dbh) and at least 6 feet tall) are a typical component of late successional/old growth stands. As a specific stand ages, individual trees succumb to endemic levels of insects and diseases, creating snags of varying sizes.
Aquatic wildlife

Coarse woody material is also an imperative part of healthy streams as the logs help stabilize banks and create pools for fish spawning (Maser et al. 1979). Stand-replacing and small-scale disturbances are important to aquatic life. In particular, fallen snags are an important source of coarse woody material. The negative impacts of past management practices (e.g., logging and dam building) have seriously degraded anadromous fish-bearing streams, causing many eastside anadromous fish populations to decline to sensitive, threatened or endangered status (Henjum et al. 1994).

Insect drawbacks - Habitat fragmentation; reduced habitat availability/quality:

Every structural change is beneficial to some wildlife species and harmful to others. For example, in the short-term, the patches created by some insects and diseases may consist of jack-strawed down woody material that might inhibit wildlife movement (Gast et al. 1991). In the medium term, forage will increase, attracting large ungulates. In the long-term, these sites will be reforested, providing hiding and thermal cover as other areas open into browsing habitat.

Mammals

During widespread defoliation or beetle events, both hiding and thermal cover for large ungulates may be reduced. This can be a problem in Hells Canyon where only 20 percent of the land area is forested. Maintaining forest cover to provide habitat for sensitive, threatened or endangered wildlife species may be justifiable, but only if forest cover is the limiting factor for population stability. For example, if road access to prime elk habitat limits the population more than lack of forest cover, no justifiable argument can be made for trying to control an insect infestation by artificial means in order to maintain forest cover. In addition, elk habitat needs may be subordinated to the needs of threatened or endangered species until their populations are stable. Management that improves elk habitat while degrading habitat for imperiled species is counterproductive.
Aquatic life

Spruce beetle mortality in Englemann spruce has caused problems for already stressed riparian and aquatic wildlife. A recent epidemic wiped out the majority of the Englemann spruce in Hells Canyon NRA. The epidemic traveled along the riparian corridors, reducing stream shading and potentially causing problems in the future. The cumulative effects of management practices and natural disturbances can overcome the natural resiliency of ecological systems (Scott 1994). In largely unmanaged and undamaged systems, species can move to healthy streams when individual streams are affected by natural disturbances. In systems as they exist today, relatively few high quality streams remain. Fish will have nowhere to go if the remaining high quality streams are degraded. Since anadromous fish populations are already threatened or endangered, the loss of Englemann spruce is potentially devastating for these populations while the riparian zones undergo natural reforestation (Scott 1994).

Aquatic habitat can also be threatened by insect-caused mortality in non-riparian areas. Mountain pine beetle outbreaks, for example, can have significant effects on water yields when entire stands of trees are killed. As more snow accumulates on the ground, spring melt rates and peak run-offs are likely to increase (Gast et al. 1991). As the area becomes reforested, the effects will be reduced.

Habitat fragmentation

Travel corridors and habitat fragmentation are an important wildlife consideration. Habitat fragmentation has an indirect influence on species mortality through increased pressure from predators, competitors and parasites, and from altered moisture, wind and light conditions (Henjum et al. 1994). Stand-replacing insect events may cause some habitat fragmentation, but without logging, fragmentation is minimized. Fragmentation is most closely related to logging and road building—the negative effects of fragmentation will be discussed in more detail in the next chapter.
### Table 3.2

**Ecological Effects of Natural Disturbances:**

**Diseases***

<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases tree vigor &amp; stand productivity:</td>
<td>Decreases tree vigor &amp; stand productivity:</td>
</tr>
<tr>
<td>1) excellent nutrient cycling increases soil function and stability (root/stem) (58)</td>
<td>1) trees can live with many different diseases for long periods of time, but vigor is reduced, susceptibility to insects is increased (21,81)</td>
</tr>
<tr>
<td>2) tree mortality reduces competition and increases vigor in residual trees - reduces susceptibility to pests (root/stem) (19,29,45,46,49,57,78,79)</td>
<td>2) trees infected with root pathogens have increased susceptibility to windthrow (19)</td>
</tr>
<tr>
<td>3) down woody material increases soil moisture retention (29,44,78)</td>
<td></td>
</tr>
<tr>
<td>Increases stand complexity:</td>
<td>Decreases stand complexity:</td>
</tr>
<tr>
<td>4) changes in stand structure reduce likelihood of future epidemic disturbances (root/stem) (78,79,80)</td>
<td>3) dwarf mistletoe increases fuel loading at the individual tree scale, especially if brooms are close to the ground (29)</td>
</tr>
<tr>
<td>5) in concert with insects and fire, diseases help maintain the shifting mosaic of small even-aged patches within a larger uneven-aged landscape (19,22,29,73,78,80)</td>
<td>4) small and large scale fuel loading can increase, especially if trees fall down in a jack-strawed pattern</td>
</tr>
<tr>
<td>6) small openings created by disease centers provide sunlight for shade-intolerant tree regeneration</td>
<td></td>
</tr>
<tr>
<td>7) stands move toward dominance by species tolerant of the on-site pathogens (root/stem) (21,22,58)</td>
<td></td>
</tr>
<tr>
<td>8) long-term structural changes allow natural fire to regain its role as an ecosystem regulator (19)</td>
<td></td>
</tr>
<tr>
<td>Ecological Benefits</td>
<td>Ecological Drawbacks</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Increases wildlife habitat:</td>
<td></td>
</tr>
<tr>
<td>9) increases wildlife snags (benefits cavity nesting birds and mammals), increases coarse woody material to the forest floor (benefits small mammals, invertebrates), and increases large woody debris to streams (improves stream structure, number of pools, spawning habitat) (29,44,88)</td>
<td></td>
</tr>
<tr>
<td>10) changes in stand structure can increase browsing habitat for ungulates (19,78,89)</td>
<td></td>
</tr>
<tr>
<td>11) increases in snags lead to increases in insectivorous bird populations which help maintain endemic levels of insects (60,90)</td>
<td></td>
</tr>
<tr>
<td>12) snow retention in created openings can increase peak flows and improve streambed scouring (19)</td>
<td></td>
</tr>
<tr>
<td>13) dwarf mistletoe brooms provide excellent nesting habitat for a variety of small mammals and birds (19,29,78)</td>
<td></td>
</tr>
</tbody>
</table>

* Diseases can affect root systems, stems (cankers/blister rusts), heartwood, or physical structure (dwarf mistletoe). Unless otherwise noted, effects are caused by all types of diseases. (The numbers refer to citations from the reference list.)
Table 3.3

<table>
<thead>
<tr>
<th>Disease</th>
<th>Highly Susceptible Species</th>
<th>Moderately Susceptible Species</th>
<th>Tolerant Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>laminated root rot (Phellinus weirii)</td>
<td>PSME, ABGR</td>
<td>LAOC, ABLA, PIEN</td>
<td>PIPO, PICO</td>
</tr>
<tr>
<td>armillaria root rot (Armillaria ostoyae)</td>
<td>AGBR</td>
<td>PIPO, PSME</td>
<td>LAOC PICO</td>
</tr>
<tr>
<td>annosus root/butt rot (Heterobasidion annosum or Fomes annosum)</td>
<td>p-group annosum (PIPO) s-group annosum (ABLA, PSME, ABGR)</td>
<td>(p)-ABLA, PSME ABGR (a)-PIPO</td>
<td></td>
</tr>
<tr>
<td>black stain* (Ceratoeya wageneri)</td>
<td>PIPO, PSME, AGBR</td>
<td>PICO</td>
<td></td>
</tr>
<tr>
<td>schweinitzii root/butt rot (Phaeolus schweinitzii)</td>
<td>PSME</td>
<td>all conifers</td>
<td></td>
</tr>
<tr>
<td>tomentosus root/butt rot (Inonotus tomentosus)</td>
<td>PIEN</td>
<td>PIPO, PICO, ABLA</td>
<td></td>
</tr>
<tr>
<td>western dwarf mistletoe (Arceuthobium campylopodum)</td>
<td>PIPO</td>
<td>PICO</td>
<td></td>
</tr>
<tr>
<td>Douglas-fir dwarf mistletoe (A. douglasii)</td>
<td>PSME</td>
<td>other conifers occasionally affected</td>
<td></td>
</tr>
<tr>
<td>lodgepole pine dwarf mistletoe (A. americanum)</td>
<td>PICO</td>
<td>LAOC</td>
<td></td>
</tr>
<tr>
<td>larch dwarf mistletoe (A. laricis)</td>
<td>LAOC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>indian paint fungus (Echinodontum tinctorium)</td>
<td>ABGR</td>
<td>ABLA</td>
<td></td>
</tr>
<tr>
<td>western gall rust (Endocronaria harknessii)</td>
<td>PICO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>elytroderma needle blight (Elytroderma deformens)</td>
<td>PIPO</td>
<td>PICO</td>
<td></td>
</tr>
<tr>
<td>larch needle blight (Hypoderma laricis)</td>
<td>LAOC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Recently discovered in the Blue Mountains, not widespread (source: Gast et al 1991; Chapter II).

---

**Species Abbreviations**

- **ABLA**: *Abies lasiocarpa* (subalpine fir)
- **ABGR**: *Abies grandis* (grand fir)
- **LAOC**: *Larvix occidentalis* (western larch)
- **PIEN**: *Picea engelmannii* (Englemann spruce)
- **PICO**: *Pinus contorta* (lodgepole pine)
- **PIPO**: *Pinus ponderosa* (ponderosa pine)
- **PSME**: *Pseudotsuga menziesii* (Douglas fir)
Diseases

Many of the ecological effects of diseases which are discussed in this section are similar to those of insects. Five main categories of intermountain western pathogens exist: 1) root/butt rot; 2) structural disease; 3) stem decay; 4) heart rot; and 5) needle blight. Each of these types of pathogens may have different effects on the overall structure, function and composition of forested lands. Diseases occur at endemic and epidemic levels. Because they move slowly through space and time, symptomatic signs rarely appear before trees are completely infected, or until after they are already dead. (Trees can grow and live for very long periods of time while infected with some types of diseases.)

Root rots and dwarf mistletoe have received a great deal of attention recently as their presence has increased dramatically since intensive forest management began. In general, disease occurrences multiply with increased management activities associated with logging. The three main problems are: excessive site disturbances, tree wounds from logging activities, and root pathogen biomass increasing in residual stumps (Schmitt et al. 1991). These activities most often lead to increases in localized centers of disease activities, but they can also lead to landscape-level disease occurrences. The increases appear to be out of range with historical disease occurrences (Hessburg et al. 1994), although the different pathogens which affect trees in the intermountain west are as old as the tree species themselves.

Since disease levels were elevated by increases in management, it is backward to assume that large-scale increases in management will reduce disease occurrences. Silvicultural methods which do not compact the soil or cause residual tree wounding may help alleviate some disease epidemics, but even the most careful silvicultural practices cannot guarantee no residual damage. Generally speaking, as management level increases, so does disease incidence, and the effects are most dramatic in association with partial cutting (Schmitt et al. 1991). Planting tolerant species, on the other hand, is somewhat effective in reducing certain disease occurrences.
Nevertheless, species tolerant of one type of pathogen are susceptible to others. For example, ponderosa pine is resistant to some strains of *Armillaria* and *annosus* root diseases and susceptible to other strains. Overall, it is important to consider the role diseases play in nutrient cycling within the forest, as well as their contributions to maintaining effective structure and function within the forest.

**Root rots**

Diseases (in concurrence with insects and fire) are creating the types of forest conditions that eventually will be less susceptible to stand-replacing disturbances. Different tree species are susceptible to different types of diseases (Table 3.3). In many instances, young Douglas and grand fir which have grown up underneath ponderosa pine (in the Douglas or grand fir series) are now succumbing to a variety of root diseases (e.g., *Heterobasidion annosum* or *Armillaria ostoyae*) (Hessburg et al. 1994). Ponderosa pine is resistant to the specific strain of *H. annosus* which attacks firs (and vice versa). *Armillaria* generally acts as a secondary root disease in seral species such as ponderosa, only affecting low vigor, drought or otherwise stressed trees (Hessburg 1994). But, in highly active disease centers it acts as a primary disease. Some root diseases can live for more than 1500 years in the soil (Hagle 1994) supporting the theory that certain tree species are best suited to certain sites.

**Dwarf mistletoe**

For most coniferous species in the Intermountain West a strain of dwarf mistletoe exists. As an obligate parasite, it requires a living host, and it has found hosts throughout the region. Despite the excellent habitat provided by dwarf mistletoe, foresters and land managers dislike its "negative" effect on stand productivity. Over time, it can severely stunt growth and reduce productivity. In addition, it changes the wood structure and reduces wood value. But, these are socio-economic, not ecological concerns.
TREE VIGOR & STAND PRODUCTIVITY

Disease benefits - Increased tree vigor, growth, nutrient cycling, and resistance to "pests":

Endemic levels of disease can increase stand productivity in the same way that endemic levels of insects do. Small-scale mortality reduces competition between the remaining trees for scarce nutrients, sunlight and water. Additionally, the small openings created by disease centers may encourage regeneration of shade-intolerant species. As disease-tolerant tree species colonize the site, species diversity increases, reducing susceptibility to large-scale insect infestations.

Epidemic levels of disease may change the direction of succession or result in a complete stand conversion. The regenerated, tolerant stand may be more productive than the original stand (if it is well-adapted to the site conditions). But even the invading species will eventually host their own pathogens on the site.

According to University of Idaho forest pathologist Arthur Partridge, pathogens and fungi are the most effective nutrient cyclers in nature, and are the principle recyclers for wood and other plant matter. In situations where a stand or perhaps even a landscape is out of balance, the effects of pathogens on nutrient availability cannot be duplicated by any artificial means. The interactions between insects and diseases, and the increased nutrient inputs into the soil are crucial for the vitality of the forest. The most nutrient rich part of a tree is typically mined and returned to the soil after the tree has been on the ground for just two years (Schowalter 1991). Without these inputs, the remnant trees might be unable to increase their vigor to grow into the spaces left by their dead neighbors. After 100 years of fire suppression, a case may be made that increased biomass has led to the likelihood of increases in stand-replacing events. Pathogens help reduce that biomass and return it back to the soil so it can be used by remnant trees and regenerating trees. As explained in the section on insects, downed logs also help retain soil moisture.
Root diseases

Most root diseases move very slowly through the soil from root system to root system, although some diseases spread through airborne spores and others spread via insect vectors (Gast et al. 1991). Root diseases tend to move out in circular patterns, creating patches of dead trees which then become openings. As susceptible tree species succumb to root diseases, the tolerant trees remaining on the site have less competition for water, nutrients and sunlight, and their vigor and productivity may increase (Schowalter 1991). (Productivity increases will depend on the severity of suppression in remnant trees. Trees with high vigor ratings are likely to respond to increased nutrients, sunlight and water, while severely suppressed trees probably won't.)

Other diseases

Western gall rust (a stem decay), is common in dense young stands of lodgepole pine. It increases productivity by killing young trees, thus thinning stands and increasing vigor. Since some lodgepole pines exhibit genetic resistance to gall rust, the pathogen selectively thins the stand (Gast et al. 1991). Stem decays may selectively thin stands, whereas root rots are more apt to create patchy openings.

Dwarf mistletoe does not increase tree vigor. But, in conjunction with surface fire, it can increase stand productivity as infected trees burn up and create openings for new growth. In open parklike stands, this individual tree mortality ameliorates conditions for regeneration of shade-intolerant species in particular.

Disease drawbacks - Increased fuel loading; reduced vigor:

Root diseases

Once a tree is infected by root disease, it can take decades for symptoms to appear and longer for mortality to occur, depending on both the specific pathogen and the tree's initial vigor level. Mortality rates increase when root-diseased trees succumb to insect infestations. Fuel load increases will most typically be in small patches, leading to jackpot burning. If conditions are appropriate, a jackpot fire can spread into
a crown fire and spread to adjacent healthy trees. The interactions between fire, moisture and seed sources dictate the type of site conversions which occur (Hagle 1994a). Without seed from intolerant species, a conversion cannot take place; without fire, a specific disease or insect may remain on the site and attack susceptible regeneration. The introduction of disease-tolerant species does not guarantee increased productivity. If the tolerant species is not well-adapted to the site, it is likely it will succumb to some other pest because of general low vigor.

Dwarf mistletoe

Over time, dwarf mistletoe severely reduces tree vigor and productivity. The characteristic dwarf mistletoe brooms act as nutrient sinks, reducing nutrient availability for the uninfected parts of the trees (Hessburg 1994). This nutrient stress eventually results in stunted growth for the tree itself, and decreased cone and seed production. Since dwarf mistletoe is an obligate parasite, it dies when the tree dies. Host trees can live for decades with dwarf mistletoe, and according to some research, it does not predispose the hosts to attacks by other pests (Schwandt 1984). (It takes approximately 15 years for infected trees to move up one of six steps on the disease rating scale (Schwandt 1984).)

Dwarf mistletoe can also affect the way a tree burns in a fire. If brooms are hanging low to the ground, they will catch fire and may cause the tree to torch out. In closed stands, tree torching can change a surface fire to a stand-replacing fire. If mistletoe brooms are far removed from the ground, then they will have little effect on natural fire resistance and are unlikely to lead to fire-caused mortality. In western larch specifically, mistletoe brooms break off the tree easily, often resulting in increased slash at the base of the tree which can lead to fire mortality through scorching (Hessburg 1994).
**STRUCTURAL COMPLEXITY**

**Disease benefits - Increased structural diversity:**

The patchy level of mortality from diseases greatly enhances structural diversity within stands. Historically, root diseases were most common in areas infrequently visited by fire (Hessburg et al. 1991). These areas typically consisted of more shade-tolerant trees which tend to be more susceptible to root diseases in this region. Many of the areas now experiencing excessive root disease problems occur in areas where fire was suppressed for the past 80 years. As fire is removed from the ecosystem, root diseases and insects increase in occurrence to reduce the accumulating biomass. Root diseases affect many aspects of forest structure by: 1) enhancing animal habitat focal points; 2) diversifying patch/opening sizes; and 3) increasing amount of edge habitat (Hessburg et al. 1994). When these stand features interact with fire, a structurally complex and diverse forest results.

As explained in the section on insects, structural diversity is important for maintaining healthy wildlife populations, as well as maintaining an ecosystem which can absorb disturbances.

**Disease drawbacks - Increased fuel loading/tree mortality:**

The drawbacks caused by diseases regarding increased fuel loading and tree mortality are similar to those described under the *Insect drawbacks* section under tree vigor on page 35.

**WILDLIFE**

**Disease benefits - Improved habitat availability and quality; increased wildlife populations; increased habitat availability in dwarf mistletoe:**

Wildlife benefits vary depending upon the types of structural changes which occur. The effects of various structural changes were discussed in the wildlife effects section for insects.

Dwarf mistletoe brings some additional benefits which other diseases do not create for wildlife. Although mistletoe can reduce tree vigor and productivity, the
brooms which develop provide excellent habitat for small mammals and birds (see e.g., Schowalter 1991, Hessburg et al. 1994, Gast et al. 1991). The thick masses of branches offer secure nesting and hiding habitat, especially thermal cover during the winter.

Root diseases, stem decays, butt rots and heart rots affect the structure of the tree. Root disease and butt rot may make a tree more prone to blowdown, increasing the components of down woody material on the ground (Gast et al. 1991). Once the trees have died, the snags are used by a variety of wildlife species for both feeding and nesting. Many wildlife species have trouble excavating cavities in very hard snags. Woodpeckers seem to prefer nesting in trees with heartrot (Thomas et al. 1979a). Invertebrates inhabit softer snags, aid in decomposition, and act as a food source for a variety of cavity nesters. Standing snags and down woody material together provide critical habitat for innumerable species.

**Disease drawbacks - Reduced habitat availability/quality:**

Diseases alone cause relatively few drawbacks to wildlife populations. The only changes are those that come with natural succession, as the habitats change, so do the species who use them. But, diseases often trigger insect mortality by weakening trees and reducing their defenses. Additional ecological drawbacks of diseases are similar to the endemic and epidemic drawbacks of insects explained on page 35 and on pages 40-42. Further effects on wildlife may occur when combined with increased fire risks, but these will be discussed in the following section on fire.
Table 3.4 Ecological Effects of Natural Disturbances: Understory Fire*

<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases tree vigor &amp; stand productivity:</td>
<td>Decreases tree vigor &amp; stand productivity:</td>
</tr>
<tr>
<td>1) stimulates ponderosa pine growth (23,52)</td>
<td>1) ladder fuels and thick litter layers in areas where fire has been suppressed can cause old growth mortality or stand-replacing fires on sites formerly dominated by understory burns (52)</td>
</tr>
<tr>
<td>2) improves overall vigor and resistance to pests (34,52)</td>
<td>2) wounds create openings for insects and pathogens (76)</td>
</tr>
<tr>
<td>3) increases biodiversity (52)</td>
<td></td>
</tr>
<tr>
<td>4) stimulates cone crops (52)</td>
<td></td>
</tr>
<tr>
<td>5) reduces invasions by exotics (52)</td>
<td></td>
</tr>
<tr>
<td>6) fire sterilizes sites from certain pathogens and kills insects (2)</td>
<td></td>
</tr>
<tr>
<td>7) smoke inhibits certain pathogens (2,19)</td>
<td></td>
</tr>
<tr>
<td>8) increases nutrient availability (34)</td>
<td></td>
</tr>
<tr>
<td>Increases stand complexity:</td>
<td>Decreases stand complexity:</td>
</tr>
<tr>
<td>9) re-establishes a more natural vegetative species mix (52)</td>
<td>3) promotes monocultures, which are generally more susceptible to stochastic events (54)</td>
</tr>
<tr>
<td>10) maintains an open parklike structure within the stand, thus maintaining conditions which dampen epidemic disturbance levels and maintain endemic levels (2,78)</td>
<td></td>
</tr>
<tr>
<td>11) promotes the regeneration of shade-intolerant species (78)</td>
<td></td>
</tr>
<tr>
<td>Increases wildlife habitat:</td>
<td>Decreases wildlife habitat:</td>
</tr>
<tr>
<td>12) increases forage (1,52)</td>
<td>4) repeated understory fires consume down woody material quickly (1)</td>
</tr>
<tr>
<td>13) adds snags and down woody material for small mammals and cavity nesting birds (88)</td>
<td>5) understory fires can maintain an open enough canopy that hiding and thermal cover are reduced (1)</td>
</tr>
<tr>
<td>14) increases snow accumulation, earlier spring melting, changes peak flows (88)</td>
<td></td>
</tr>
</tbody>
</table>

* Understory fires are most appropriate on low-elevation dry or moist to dry sites. These sites may be more common on south-facing slopes as well. Understory burning is most likely on sites which still contain seral species in the overstory. Understory mean fire return interval is typically between 5-20 years. (The numbers refer to citations from the reference list.)
**Table 3.5 Ecological Effects of Natural Disturbances:**

**Stand-replacing Fire**

<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increases tree vigor &amp; stand productivity:</strong></td>
<td><strong>Decreases tree vigor &amp; stand productivity:</strong></td>
</tr>
<tr>
<td>1) can improve long-term nutrient conditions, especially when site is recolonized by nitrogen-fixers</td>
<td>1) nutrient leaching and volatilization of soil chemicals (1)</td>
</tr>
<tr>
<td>2) ends insect outbreaks (19)</td>
<td>2) soil erosion and hydrophobic soils both limit regeneration and stand productivity (1)</td>
</tr>
<tr>
<td>3) promotes regeneration of serotinous species (1)</td>
<td>3) reduced vigor in surviving trees - increased susceptibility to insects and disease (37)</td>
</tr>
<tr>
<td></td>
<td>4) increased susceptibility to windthrow along newly created edges (1)</td>
</tr>
<tr>
<td></td>
<td>5) smoke may increase atmospheric carbon and contribute to global warming - affecting future climate and therefore stand conditions (1)</td>
</tr>
<tr>
<td><strong>Increases stand complexity:</strong></td>
<td><strong>Decreases stand complexity:</strong></td>
</tr>
<tr>
<td>4) standing snags and surviving trees ameliorate site conditions enough to improve post-fire regeneration by providing summer shade and winter thermal cover (64)</td>
<td>6) on sites where lodgepole was present, lodgepole monocultures may develop and begin the lodgepole, insect, fire cycle (this is not necessarily a drawback) (2)</td>
</tr>
<tr>
<td>5) creates a mosaic of stand conditions throughout the landscape - this breaks up habitat continuity and reduces potential stand-replacing insect/disease events (2)</td>
<td>7) snags and downed trees provide fuels for a reburn which may convert the stand to shrub vegetation for a long period of time (2)</td>
</tr>
<tr>
<td>6) stand-replacing fires restart forest succession (78)</td>
<td></td>
</tr>
<tr>
<td><strong>Increases wildlife habitat:</strong></td>
<td><strong>Decreases wildlife habitat:</strong></td>
</tr>
<tr>
<td>7) increases availability of wildlife snags</td>
<td>8) short term loss of habitat, including thermal and hiding cover (1)</td>
</tr>
<tr>
<td>8) creates uniquely necessary conditions for fire-dependent species like the black-backed woodpecker (30)</td>
<td>9) increases in sedimentation through erosion and hydrophobic soils can reduce spawning habitat (1,2)</td>
</tr>
<tr>
<td>9) long-term habitat stability is improved through diverse landscape structures and habitat conditions (2,78)</td>
<td>10) loss of streamside shading can lead to increased stream temperatures</td>
</tr>
<tr>
<td>10) increases forage for ungulates (1,52)</td>
<td></td>
</tr>
<tr>
<td>11) inputs coarse woody material into streams and onto the forest floor</td>
<td></td>
</tr>
</tbody>
</table>

*Stand-replacing fires are common in higher elevation, cooler and moister sites - often on north-facing slopes. They typically leave some vegetation unburned, creating a mosaic of habitat types within the landscape. Fire return intervals vary from 50 to 300 years. (Numbers refer to reference list.)*
Fire

The effects of insects and diseases would be of far less concern if they didn't create fuel for the annual summer wildfire season. The interactions of these three disturbances, in conjunction with climate, topography, geology, etc. were responsible for the diverse landscapes Europeans first witnessed when they arrived in this region. Many historical accounts from early settlers focus on two things, the smoke which occurred all summer long, and the large-diameter, widely-spaced parklike stands of ponderosa pine, western larch and Douglas fir (Wickman 1992, Mutch et al. 1993).

As a disturbance, fire occurs on a gradient ranging from single tree to stand-replacing burns. This section of the chapter will look at the ecological effects of underburning and stand-replacing fires. For more information about the background of fire in this region and some of the concerns regarding fire risks and fire uses, see the discussion of natural versus human-caused disturbances in Chapter 5.

Numerous factors affect the intensity, spread and duration of any fire. These factors include: topography, weather, fuels, soil, distribution of natural fire breaks, time of day, season, vegetation structure, pre-existing fire behavior, and multi-year weather patterns (Frost 1994). Fuels, the third item on this list, are partially determined by previous disturbances. Insect- and disease-caused mortality increases the available fuels on any given site. The more expansive the mortality, the more expansive the fuels. But insects and diseases affect more than just fuel levels. Each level of disturbance will create a different fire model, and each type of fire will have different ecological effects.

Underburning

At the turn of the century, open parklike stands of ponderosa pine were common at low and mid-elevation levels throughout the Intermountain West. This stand structure was maintained by frequent surface fires. These fires were lightning- or human-caused, and occurred every 8 to 20 years (see e.g., Hall 1977, Agee 1993/
This high frequency, low intensity fire cycle is dependent on several landscape and site features. Fire tolerant species such as ponderosa pine, and older, thick-barked Douglas fir or Western larch must be present. Fine fuels are necessary to carry the surface fire through a stand. Grazing greatly diminishes fine fuels and can reduce the spread of surface fire (Agee 1994, Hall 1977). Fire intensity will be further influenced by weather conditions, wind and topography.

As explained in Chapter Two, low intensity surface fires enabled seral species to dominate the drier landscapes. Understory fire can only be returned to the landscape on sites where seral species are still present and dominant in the overstory. If the litter layer surrounding these older trees is too thick (litter layers were traditionally quite thin on frequently burned sites), the trees may die from root kill. If the understory is too high, as it burns, the

**Box 3.3**

**Forest Service Fire Terminology**

The FS refers to naturally ignited fire as either prescribed natural fire (PNF) or wildfire. (Management-ignited fires are called prescribed fires (PFs).) Designation as a PNF or a wildfire depends on whether or not the FS wants to suppress the fire. All wildfires are suppressed. Fires which are in prescription (PNFs) are those which fall under an existing fire plan. The FS will let them burn unless they start to go out of prescription. Prescriptions, and therefore suppression, are based on numerous factors, including weather, time of year, fire location, moisture conditions, topography and available resources. Fires which move out of prescription may be renamed as wildfires and then suppressed.

Funding for monitoring and handling PNFs vs. wildfires comes from different sources. In general, the FS has a “blank check” for suppressing wildfires, but PNFs are funded on a forest by forest basis. Fires can only be managed as PNFs if adequate funding is available (USDA 1994a). Some fires may be named wildfires simply because a particular national forest has no fire plan, or because they do not have enough money to monitor or contain the PNF if it threatens to go out of its prescribed boundaries. Although it is a complex program, the PNF program offers a first step toward reintroducing natural fire into the ecosystem.
taller trees act as fuel ladders, bringing fire into the crowns of the overstory (Agee 1993, Gast et al. 1991). Densely stocked sites with single canopies of fire intolerant trees such as grand firs are likely to burn entirely. Finally, on higher elevation, moist or wet sites, understory fire is unnatural and inappropriate if human-caused.

**TREE VIGOR & STAND PRODUCTIVITY**

Underburning benefits - Increased tree vigor and growth; increased resistance to "pests" maintains low intensity disturbance regimes:

*Vigor and growth*

Surface fire kills shade-tolerant conifers which regenerate under the overstory. As the understory develops, competition for scarce water and nutrients increases, leaving the understory suppressed and the overstory stressed. When mean fire intervals (MFI) remain between 8 and 20 years, the understory is repeatedly removed before its competition stresses the overstory trees. High frequency understory burning improves the vigor and vitality of plant communities, increases biodiversity, stimulates cone crops from seral species, decreases the rate of invasion of exotic species and reestablishes a natural species mix (Mutch et al. 1993).

Evidence suggests that ponderosa pine growth is significantly reduced without frequent surface fires. Research by Forest Service ecologist Frederick Hall (1977) shows that ponderosa pine needles contain a selective inhibitory substance which builds up in the soil, reducing pine growth. Periodic fire destroys the substance, increasing ponderosa productivity. Fires alter the composition of the soil in other ways as well, improving nutrient availability and changing the chemical balance. Fire further increases nutrient availability by converting undecomposed organic matter into a form which plants can readily use (Kimmons 1987).

*Resistance to pests*

Frequent surface fires help keep disturbance events at endemic rather than epidemic levels for several reasons. First, unstressed, vigorous trees are able to put energy into internal defenses against insects and diseases (Schowalter 1991). Second,
stands with low densities and wide spacings are more resistant to certain types of insects such as bark beetles (Agee 1994). Third, smoke from fires inhibits the development of some pathogens including dwarf mistletoe (Agee 1994). Mistletoe was also reduced by fire as it pruned dead branches and consumed individual tree crowns with low-hanging witches' brooms (Agee 1994).

**Underburning drawbacks - Fire wounds:**

Tree mortality is the only barrier to increasing stand productivity or tree vigor from surface fires. Tree mortality is typically limited to two types of trees, shade-tolerants which are invading the site, or disease or insect infested overstory trees. But, as explained above, it is this tree mortality which stimulates long-term productivity by reducing overall competition and stress among the surviving dominant trees.

Fire can wound trees, creating entries for insects and diseases. The combined effects of insects and diseases can increase the overall mortality and intensity of the disturbance. In addition, the absence of fire over long periods of time has led to increased duff layers. Even during a surface fire, these can smolder at high temperatures for several hours, eventually killing the roots and therefore the tree (Agee 1993). The thick bark of fire resistant trees does not help them avoid root scorch.

**STRUCTURAL COMPLEXITY**

**Benefits - Parklike structure is maintained; increased openings for natural regeneration of shade tolerant species; low intensity disturbance levels are maintained:**

*Open structure, natural regeneration*

The open parklike stand structure which existed in the lower- and mid-elevation forests were traditionally maintained by repeated burning, either natural or

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1Tree mortality is often used as an indicator of forest health or stand conditions. Although tree mortality may reduce productivity in the short, immediate term, it often increases productivity in the long term. In reality, it is a socio-economic rather than an ecological drawback.
human-caused, and were most likely a combination of the two. These open parklike stands were actually made up of a series of even-aged clumps within an uneven-aged landscape (Agee 1993). Even in an open setting, trees fall prey to insects and diseases. As previously mentioned, these dead trees can burn in surface fires. The newly opened sites are recolonized with shade intolerant trees. The litter layer in the opening stays very low while the trees are young, leaving few fine fuels for the spread of surface fires. (Ground vegetation does increase as the herbaceous layer regenerates.) As the trees grow, they are thinned by fire until eventually, widely spaced trees fill the site.

**Disturbance levels**

As explained in the sections on insects and diseases, stand structure greatly effects susceptibility to different disturbances. Stands maintained in an open manner by surface fire are likely to have low intensity, high frequency disturbances. Since frequent surface fires continually reduce the fine and medium sized fuels, the likelihood of stand-replacing fires is limited. The open-canopy allows heat to dissipate quickly, reducing the likelihood of a hot fire. Densely stocked stands of suppressed trees or dead trees, in combination with hot dry weather, can create a firestorm which can burn through even the healthiest of adjacent open parklike stands. An open structure will reduce competition as well, reducing the likelihood of epidemic insect infestations. Even these stands are susceptible to epidemics though. Western pine beetles in particular, prefer large diameter old ponderosa (Hessburg 1994, Agee 1993). After several successive years of drought, the trees become particularly susceptible and epidemics can occur.

**Underburning drawbacks - Monocultures are less resistant to stochastic events:**

The biggest drawback of understory burning is that it promotes near monocultures of ponderosa pine. Although western larch and Douglas fir are usually interspersed with the ponderosa, the pine are (or were) by far the dominant species on drier sites. Ecologically, monocultures are less adaptable to change than landscapes
with a greater diversity of species and habitats (Noss 1993). Continuous tracts of open parklike stands can be an invitation to disaster by native or exotic pests.

**WILDLIFE**

**Benefits - Increased forage for ungulates; wildlife snags:**

**Mammals**

High frequency, low intensity surface fires help maintain excellent browsing conditions for ungulates (Mutch et al. 1993, Hall 1977). A healthy layer of ground vegetation develops under the open-canopied overstory. Surface fires only kill the above-ground components of the ground vegetation, typically resulting in increased production after fire. Species that are not adapted to fire quickly decline in areas with high MFIs. With greater than 50% crown cover, forbs and shrubs are the dominant components of the understory. When crown cover is less than 50%, the ground vegetation is dominated by grasses (Agee 1993). Although underburning increases forage production, it decreases thermal and hiding cover for large ungulates in particular, by maintaining such open conditions.

The addition of downed woody material benefits the soil and ground-dwelling wildlife as explained in previous sections on insects and disease benefits to mammals.

**Birds**

As individual or groups of stressed trees are consumed by fire, wildlife snags are created. The benefits of this are similar to those mentioned in the sections on insects and disease to birds.

**Aquatic life**

Underburning has little effect on aquatic habitat. The maintenance of open conditions allows more snow to accumulate on the ground during the winter and also leads to earlier spring melting. Since underburning has only limited effects on soil conditions, it does not contribute significantly to stream sedimentation.
Underburning drawbacks:

Many wildlife species prefer open stands of large old trees as maintained by underburning fire. The open stands provide little thermal and hiding cover for large ungulates. In addition, high frequency, low intensity underburns tend to consume down logs fairly quickly (over several consecutive fires), providing only limited additional habitat for small mammals (Agee 1993). Generally speaking, continued underburning fires exclude certain species from these open stands precisely because of the stand structure. Mammal and bird species which require denser habitat will nest and feed in more amenable places. Water quality is rarely affected by underburns.

AIR QUALITY

Underburning benefits/drawbacks:

Air quality is a major concern throughout the intermountain region. Surface fires will increase smoke and decrease air quality in the short term. But these fires will also help reduce the likelihood of future stand-replacing fires which cause more intensive air quality concerns. Stand-replacing fires can burn and smolder for months, whereas surface fires burn for much shorter periods of time. The overall smoke output is lower and lasts for less time.

Stand-Replacement Fires

Higher elevation, cooler, wetter forests had naturally longer MFLs than lower elevation forests. Therefore, although they burned less frequently, the fires were more intense and resulted in substantial mortality. Fires ignited when climatic and fuel conditions were responsive to lightning strikes. (In Hells Canyon, temperature and elevation play important roles in determining the types of forests that develop in particular sites. The dramatic elevational changes create a wide variety of forest conditions.) Fire suppression has not significantly altered conditions in high elevation sites, although logging and associated activities have.
The ecological effects of fire at the stand-replacing or partial stand-replacing level can be more dramatic than the effects of underburning fire. Most stand-replacing fires burn in patchy mosaics, leaving pockets of untouched green vegetation interspersed with completely and partially burned areas. The discussion below combines partial and complete stand-replacing fires because the actual effects are similar, but the scale is different. In addition, many of the benefits of stand-replacing fire can also be classified as drawbacks.

Stand-replacing fires occur on lower as well as higher elevation sites. On lower elevation sites, they often occur on drier sites which are covered with dense forests of suppressed, drought-intolerant trees.

The ecological effects of stand-replacing fires are both simple and complex. The simplicity is that stand-replacing fires replace entire stands of trees, restarting forest succession. The complexity comes from: 1) the patchy and incomplete nature of stand-replacing fires, and 2) the interrelationships and importance of interactions between soils, water, vegetation, wildlife and fire that scientists still do not understand.

**Tree Vigor & Stand Productivity**

Stand-replacing fire benefits - Improved nutrient conditions; reduced pest susceptibility:

Stand-replacing fires do not increase tree vigor — they kill the majority of trees within a stand. But, they can improve nutrient conditions for tree regeneration after a fire. Post fire reforestation is dependent on a variety of factors: intensity of burn; species composition prior to the burn; species composition of adjacent unburned areas; moisture availability in seeding years after the burn, etc. Standing snags left by a wildfire measurably improve regeneration conditions. They provide shade during the summer, and some thermal cover during the winter, generally ameliorating climate conditions for seedlings (Perry 1995).

Any insects which are present at the time of a stand-replacing fire will be killed. This effectively stops insect epidemics by killing the insects and their host trees (Gast et al. 1991). Fire also has a sterilizing effect on the soil, which may help
reduce some pathogens. Even if pathogens are reduced, they are rarely destroyed, and if host species regenerate in the area, the disease inoculum increases.

**Stand-replacing fire drawbacks - Increased susceptibility to insects; increased pathogens and windthrow in fire weakened trees:**

Throughout a stand-replacing fire, numerous patches of trees will survive, some with no fire damage at all, others partially scorched. These trees are weakened and at increased risk of insect death after the fire (Oliver and Larson 1990). Most often, weakened trees exist along the edges of unburned patches. Insects will attack and kill these weakened trees, and as the population builds, it can move on to green trees. Species diversity will help keep insect infestations from killing the patches that remain. In addition, edge trees are susceptible to windthrow, and fire-scarred trees are susceptible to fungal attacks.

**STAND COMPLEXITY**

**Stand-replacing fire benefits - Forest succession is restarted; increased landscape mosaic; increased species diversity; reduced susceptibility to pests:**

The greatest benefit that stand-replacing fires offer is the overall increase in landscape level diversity. This diversity increases overall forest stability by breaking up continuous stands of trees which may be hosts to insects or diseases. Stand-replacing fire completes the work of insects or diseases in transforming stands to a condition which will be less susceptible to disturbance (at least for awhile). This is especially important in the drier, low elevation sites, where fire intolerant species have encroached. As insects and fire both remove these intolerant trees, they create space for the site to be re-dominated by shade-intolerant species, if the soils and moisture conditions will still support this. All sorts of wildlife species benefit from the increases in the variety and amount of available habitat.

The type of regeneration which occurs after a stand-replacing burn will depend upon a variety of factors. For example, if lodgepole pine were present on the pre-fire site, it is likely that the site will return as a lodgepole site shortly after the fire.
Lodgepole pines have serotinous cones which require intense heat to release the seeds. If no serotinous species were initially on the site, reforestation may be slower, but more diverse. Seeds will be spread by animals and wind, and reforestation will be concentrated around seed production from adjacent patches of unburned forest.

Stand-replacing fire drawbacks - Increased erosion; reduced regeneration in hydrophobic soils; post-fire monocultures; increased fuels for reburns:

In a severe fire, soil structure and stability may be extremely damaged. In particular, hydrophobic (water-hating) soils can be created after high intensity fires. When this occurs, water-repellant conditions are typically already in place before the fire burns through (Agee 1993). This can occur at or below the surface of the soil and can lead to landslides and intensively damaging erosion (Agee 1993). This also inhibits reforestation of the area. Hydrophobic soils cannot be prevented, but their effects on aquatic and terrestrial resources are becoming more dramatic in combination with the effects of human management practices. Over time, soils eventually regain their wettability as they are exposed to rain and snow (Agee 1993).

Stands which contained lodgepole pine before a fire may become monocultures afterwards as the lodgepole gain a competitive edge through their serotiny. Lodgepole pine climax communities occur on limited frost pocket sites within the Blue Mountains (Agee 1994). Multi-cohort stands of lodgepole pine are maintained by complex interactions between insects, disease and fire (Agee 1994). Lodgepole also recolonizes as a seral species on subalpine fir climax sites.

When a severe fire burns through an area, most of the fuels are not completely consumed. Many trees are scorched or heat-killed without actually burning. These trees provide extensive fuels for another fire. If a second fire comes through before the regenerating stand has reached reproductive maturity, the site will be effectively deforested for many years. This occurred on the Tillamook Burns in Oregon, and the Great Burn of 1910 throughout Idaho and Montana. Sites which experience reburns often become shrubfields (Agee 1993). Shrubs such as Ceanothus are nitrogen fixers, and help ameliorate the site for eventual reforestation.
WILDLIFE

Stand-replacing fire Benefits - Increased structural diversity; increased post-fire forage for ungulates; increased down logs for small mammal habitat; increased habitat for fire-dependent species; increased snag availability; increased coarse woody material for streams:

Mammals

High intensity fires rarely kill individual large animals, although fire-associated deaths can occur in animals with small home ranges (Agee 1993). Although thermal and hiding cover may be lost in the short term, the long-term structural diversity associated with stand-replacing fires is beneficial to most mammals. In addition, the initial grasses and forbs which revegetate the site provide increased forage for animals; down logs and standing snags provide habitat for smaller mammals.

Birds

Numerous insectivorous bird species thrive in burned-over areas. After a fire has died down, heat-seeking insects invade the site and begin infesting the burned trees. These insects attract insectivorous birds to the site. An entire fire wildlife community has evolved, and the members of this community depend on stand-replacing fires for their most beneficial habitat. Some constraints do exist. For example, the black-backed woodpecker prefers large-diameter, broken-topped snags for nesting. For feeding it prefers bugs that are drawn to recently burned, blackened trees. In most instances, nesting requirements can only be met by large-diameter snags which were present before a fire (Hutto 1993). The unique habitats created by wildfires cannot be mimicked by silvicultural practices because we do not know all of the different conditions that are created by the interactions between fire, smoke, heat, soils, vegetation and wildlife. Insects and other wildlife adapted to fire disturbed sites find those sites using certain cues. Without fire, those cues and conditions will not be available to these animals.
Aquatic life

One main benefit from high intensity fire is the increased inputs of coarse woody material to streams. In addition, increased snow accumulation will occur in the winter, with earlier melt occurring in the spring. This will lead to increased peak flows, which can be negative or positive to streams. In conjunction with the increased sedimentation from fire-induced erosion, increased peak flows can help scour the channel bottom and remove some of the sedimentary build-up from streams.

Stand-replacing fire drawbacks - Reduced thermal/hiding cover; increased stream sedimentation; reduced shading; increased temperatures:

Mammals

The loss of thermal and hiding cover can cause problems for large mammals in large stand-replacing fires. Severely reduced cover will cause large mammals to move through an area quicker or to abandon it altogether.

Birds

While creating habitat for some cavity nesting birds, particularly those associated with fire communities, high intensity fires also destroy former nesting sites for other birdlife. If enough nesting and feeding areas remain, the destruction of a few nests won't be a problem. But if the landscape conditions in the area are already fragmented, birds may have difficulty finding suitable places to nest and feed.

Aquatic life

As mentioned in the section on stand structure, high intensity fires can greatly affect soils and soil structure, which then influence erosion. Increasing erosion leads to increased sedimentation in the streams. Increased sedimentation reduces spawning sites for anadromous fish. High intensity fire can also lead to increased stream temperatures if the trees along the bank are killed. Riparian areas, however, see far fewer fires than other landscape types (Agee 1993).
**AIR QUALITY**

Stand-replacing fire benefits - None

Stand-replacing fire drawbacks - Increased particulate matter; increased carbon release:

Air quality is a major concern throughout the intermountain region. It is truly more of a socioeconomic or a human health concern than an ecological concern. But, since it plays such a big issue in the potential allowability of fires, it must be discussed.

The biggest ecological problem is that the carbon released into the atmosphere adds to global warming which may be leading to drastic environmental changes. Increased particulate matter, however, is a pressing human health issue. Since it is really a health problem, it will be discussed at greater length in Chapter 5 which considers how ecological benefits and drawbacks can be used to determine whether or not to implement silvicultural treatments within the NRA.

**Chapter Summary**

The information presented in this chapter is intended to act as a reference for the ecological benefits and drawbacks of the most common natural disturbances throughout the Intermountain West. It is a synthesis of the best available scientific data regarding the important and often little understood functions of natural disturbance systems. It is presented as a foundation for comparison of the information in the next chapter — the ecological benefits and drawbacks of several silvicultural practices. By comparing the information within these two chapters, a person interested in forest issues and management should have enough data to understand whether or not any proposed actions are rational or even necessary.
Chapter Four
Silvicultural Practices for Improving Forest Health

*Thinning to alter species composition and reduce stand density is the most important part of a forest health management strategy. Root diseased areas require different approaches.*

Jay O'Laughlin, Idaho State University, College of Forestry

Since discussion of the "forest health crisis" began in the late 1980s, widespread thinning projects have been advocated to improve the overall forest health within the Intermountain West region. In particular, thinning is lauded as a tool which helps reduce the risk of stand-replacing disturbances. At the same time, wood products are removed from the forest. For precisely this reason, it is imperative that both forest managers and concerned citizens are aware of the *ecological* benefits and drawbacks of thinning. This is especially timely given that forest health prescriptions are being created for every forest in the Intermountain West, and the majority of these plans may depend heavily on large-scale thinning or salvage programs, as well as prescribed fire (Taylor-Young Rider 1995, USDA 1994d, Craig 1994). Forest health "problems" are also being used to justify entering roadless and current or proposed wilderness areas (Mealey (in Devlin 1995), Craig 1994, USDA 1994d). Applying broad-based, general prescriptions to entire landscapes is unlikely to solve any problems, and may even make things worse.

This chapter will explore the benefits and drawbacks of three human management treatments which are intended to improve forest health: understory thinning, group selection harvests and prescribed burning. A table summarizing the ecological benefits and drawbacks is presented prior to the detailed discussion of each silvicultural practice. The benefits and drawbacks will be considered in the same manner as in the previous chapter.
Table 4.1 Ecological Effects of Anthropogenic Disturbances: Overstory Thinning*

<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases tree vigor &amp; stand productivity:</td>
<td>Decreases tree vigor &amp; stand productivity:</td>
</tr>
<tr>
<td>1) reduces competition for nutrients, sunlight and water</td>
<td>1) soil compaction reduces soil fertility and spread root disease (19,64,78,105)</td>
</tr>
<tr>
<td></td>
<td>2) root disease infects untreated stumps, spreading disease to residual trees (15,78)</td>
</tr>
<tr>
<td></td>
<td>3) increases chance of windthrow (19,57)</td>
</tr>
<tr>
<td></td>
<td>4) residual tree wounding increases susceptibility to insects and disease (15,19,78,105)</td>
</tr>
<tr>
<td></td>
<td>5) introduction of exotic species reduces biodiversity (28,53,60)</td>
</tr>
<tr>
<td></td>
<td>6) slash burning fires can escape into wildfires (64)</td>
</tr>
<tr>
<td></td>
<td>7) reduces nutrient cycling by removing biomass (57)</td>
</tr>
<tr>
<td>Increases stand complexity:</td>
<td>Decreases stand complexity:</td>
</tr>
<tr>
<td>2) may release understory</td>
<td>8) does not reduce spread of insects, disease or fire</td>
</tr>
<tr>
<td>3) can recreate desired stand conditions (2)</td>
<td>9) favors shade tolerant species and even-aged mgmt</td>
</tr>
<tr>
<td></td>
<td>10) does not favor fire reintroduction</td>
</tr>
<tr>
<td></td>
<td>11) does not mimic natural processes or restore natural patterns (2)</td>
</tr>
<tr>
<td></td>
<td>12) reduces old growth structure and function</td>
</tr>
<tr>
<td>Increases wildlife habitat:</td>
<td>Decreases wildlife habitat:</td>
</tr>
<tr>
<td>3) increased sunlight stimulates forage production (19,89)</td>
<td>13) reduces wildlife snags</td>
</tr>
<tr>
<td>4) blowdown increases habitat associated with down woody material (88)</td>
<td>14) reduces interior habitat (28,57,64)</td>
</tr>
<tr>
<td></td>
<td>15) fewer coarse woody material inputs to streams</td>
</tr>
<tr>
<td></td>
<td>16) reduces streamside shading</td>
</tr>
<tr>
<td></td>
<td>17) road building increases sedimentation, fragments wildlife habitat and creates access for hunters</td>
</tr>
</tbody>
</table>

* Overstory thinning is suitable on sites with a vigorous understory and no root disease. But, sites like this are already “healthy,” so overstory thinning will not actually improve conditions. It is not suitable on sites without a clearly dominant overstory. (The numbers refer to citations from the reference list.)
Table 4.2  Ecological Effects of Anthropogenic Disturbances: Understory Thinning*

<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases tree vigor &amp; stand productivity:</td>
<td>Decreases tree vigor &amp; stand productivity:</td>
</tr>
<tr>
<td>1) increases vigor through reduced competition for nutrients, sunlight, and water (19,29,57)</td>
<td>1) soil compaction through repeated entries and heavy machinery reduces soil fertility and productivity, spreads root disease to susceptible species (19,64,76,105)</td>
</tr>
<tr>
<td>2) host-species removal reduces insect or disease problems (49)</td>
<td>2) root disease infects untreated stumps and spreads to residual trees (15,76)</td>
</tr>
<tr>
<td>3) understory thinning moves stands toward more seral structures, or towards old growth structure, this restores endemic levels of disturbances, and reduces susceptibility to stand-replacing events (57,101)</td>
<td>3) residual tree wounding increases susceptibility to insects and disease (15,19,76,105)</td>
</tr>
<tr>
<td>4) restores open parklike structure, allowing reintroduction of understory fire</td>
<td>4) introduction of exotic species reduces biodiversity (28,53,60)</td>
</tr>
<tr>
<td>5) reduces fuel loading</td>
<td>5) removing biomass reduces nutrient cycling (58)</td>
</tr>
<tr>
<td>6) increases structural diversity</td>
<td>6) reduced down woody material reduces soil moisture retention</td>
</tr>
<tr>
<td>7) does not mimic the beneficial effects of smoke and fire in reducing insect and disease events</td>
<td>8) requires repeated entries to maintain open structure in lieu of fire reintroduction</td>
</tr>
<tr>
<td>9) favors natural regeneration of shade-tolerant tree species unless some openings are wide enough for intolerant regeneration</td>
<td></td>
</tr>
</tbody>
</table>

*Understory Thinning

Increases stand complexity:

- soil compaction through repeated entries and heavy machinery reduces soil fertility and productivity, spreads root disease to susceptible species (19,64,76,105)
- root disease infects untreated stumps and spreads to residual trees (15,76)
- residual tree wounding increases susceptibility to insects and disease (15,19,76,105)
- introduction of exotic species reduces biodiversity (28,53,60)
- removing biomass reduces nutrient cycling (58)
- reduced down woody material reduces soil moisture retention
- does not mimic the beneficial effects of smoke and fire in reducing insect and disease events
- requires repeated entries to maintain open structure in lieu of fire reintroduction
- favors natural regeneration of shade-tolerant tree species unless some openings are wide enough for intolerant regeneration
<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases wildlife habitat:</td>
<td>Decreases wildlife habitat:</td>
</tr>
<tr>
<td>7) increased light to the forest floor increases forage materials (52)</td>
<td>10) reduces inputs of coarse woody material to streams</td>
</tr>
<tr>
<td>8) improves wildlife habitat for some species (e.g., improves thermal and</td>
<td>11) increases stream sedimentation from soil erosion</td>
</tr>
<tr>
<td>hiding cover for wild ungulates), particularly if thinning is aimed at</td>
<td>associated with logging</td>
</tr>
<tr>
<td>moving stands toward late successional/old growth conditions (19)</td>
<td>12) reduces wildlife snags</td>
</tr>
<tr>
<td>9) as structural diversity increases, insectivorous bird habitat improves</td>
<td>13) reduces down woody material to the forest floor</td>
</tr>
<tr>
<td>thus maintaining endemic insect populations (90)</td>
<td>14) associated road building creates hunting access,</td>
</tr>
<tr>
<td></td>
<td>fragments habitat and increases stream sedimentation</td>
</tr>
</tbody>
</table>

*Understory thinning is suitable on low and mid-elevation dry or moist/dry sites (grand fir, Douglas-fir and ponderosa pine) with a clearly suppressed understory and dominant overstory. It is unsuitable on higher elevation, cool and moist sites (subalpine fir, lodgepole pine); on single-canopy sites; and in previously unroaded areas. Many of the drawbacks of understory thinning are associated with the absence of benefits that would come if the thinning occurred naturally. For this reason, fewer citations are listed. (The numbers refer to citations from the reference list.)
Thinning

The silvicultural practice of thinning can be applied at varying stages during the life cycle of a forested stand, and it can be utilized to manipulate different layers of the canopy. It is imperative to determine which types of applications will actually benefit forest health, and which will simply provide wood products. It is equally imperative to understand appropriate vs. inappropriate timing of thinning projects.

Thinning can be accomplished through overstory or understory removal, or partial removal of a single canopy. Overstory removal is another term for high-grade logging, which has few truly ecologically beneficial qualities. According to forestry professors Chad Oliver and Bruce Larson (1990 p123):

Minor disturbances—such as “high-grade” logging—which kill vigorous dominant trees leave unvigorous residual trees which do not rapidly grow into the unoccupied growing space. On the other hand, a silvicultural thinning in the same area which removes the less vigorous trees would allow the residual overstory to grow rapidly.

High-grade logging is one of the practices which put the forests into their current conditions (Gast et al. 1991, Mutch et al. 1993, Henjum et al. 1994), it will not improve forest health. Removing diseased or insect infested overstory trees may appear to improve forest health in the short term, but the ecological drawbacks of overstory removal far outweigh the ecological benefits (see table 4.1). For this reason, it will not be discussed in any further detail in this chapter.

Understory and partial thinning

Understory thinning generally refers to the removal of part or all of the understory in a particular stand, usually to increase growth of residual trees. As stated in the most commonly used terms, thinning can occur both commercially and pre-commercially. The basic difference is that trees are small in size remain in the forest during pre-commercial thinning projects, while they are removed for commodity value during commercial thinning. Designating thinning as commercial or pre-commercial inherently biases the discussion toward the economic value of the trees and the
potential economic cost of the thinning rather than the ecological value of the practice. Partial cutting is likely to be commercial, removing some trees from the overstory for their commercial value, and leaving other trees to achieve increased growth, for future commercial value. This practice does not always effectively mimic natural processes. According to Oliver and Larson (1990 p226), thinning can be used to meet the following goals:

- To obtain wood or a positive cash flow
- To obtain an early return on investment
- To increase volume growth per area [of remaining trees]
- To remove diseased, poorly formed trees, or undesirable species
- To recover anticipated mortality
- To keep a logging crew together and machinery operating (to recover at least some of the fixed costs)
- To maintain the vigor of the remaining stand
- To prepare the stand structure for nontimber uses (e.g., animal habitat)

Only the final two rationales even consider forest health. The first six rationales are aimed more at producing high volumes of wood fiber, or just keeping people employed. An ecological (rather than an economic) rationale should be used for FS or timber industry thinning project proposals that are intended to improve forest health conditions. A noncommercial thinning category may be an alternative that would help the FS make this distinction. In noncommercial thinning, the cut trees remain on site (or are chipped or removed to reduce extreme fire hazards), but the thinning does not take place with a future harvest in mind. In this sense, understory thinning can have beneficial effects if implemented appropriately.

Each type of silvicultural practice can have a positive effect on forest health if site conditions are appropriate for that specific practice. The basis for understanding the appropriateness of sites is covered in the section on forest conditions and habitat types in Chapter Two. For example, understory thinning in a subalpine stand that traditionally developed a multi-layered canopy under an infrequent, high intensity fire regime is entirely inappropriate. On sites that were maintained by infrequent stand-replacing fire, thinning does not mimic natural disturbance regimes. Instead, small
group selection or prescribed fire may be possible silvicultural treatments. The one natural condition that understory thinning is intended to mimic is light surface fire. Therefore, it should only be applied in places where this was the traditional fire regime.

Even on these sites, current conditions may make understory thinning an unlikely candidate for improving ecological conditions, or returning the site to a more natural structure. Unvigoruous, single cohort stands (i.e., those with only one age class of trees) rarely respond to thinning. Single-cohort stands are typically single-canopied as well. With no distinction between the understory and overstory, understory thinning cannot take place. Noncommercial partial thinning can be implemented (Leaving the thinned trees on the ground to replenish the soil), but it rarely has the intended effect. Instead, repressed trees lose stability and wind firmness when the stand is thinned. Residual trees may fall to periodic strong winds, freezing rains, wet snows or other factors before they can grow stable (Oliver and Larson 1990).

Previous management left many low- and mid-elevation stands with single- or multi-canopied suppressed Douglas and true fir compositions (Gast et al. 1991, Hessburg et al. 1994, Agee 1994). If no seral species are present on the site, thinning cannot restore past patterns (Agee 1994). In such stands, the fir understories were never truly released when high-grade logging removed the ponderosa or western larch overstory. What remains is a single-canopied suppressed stand that is unlikely to respond to thinning. But, these stands have the highest susceptibility to insects, disease and fire. Although thinning may be inappropriate for these sites, a series of prescribed fires under wet conditions may improve site conditions (Agee 1993, Mutch et al. 1993).

Thinning of multi-canopied and multi-aged fir stands is often proposed. Cases such as these must be considered on a stand by stand basis. If vigorous trees with healthy crowns are left on the site, thinning may actually be a viable way to improve growing conditions in the stand. If the tree crowns are small, the only way a tree can respond is through increased height or outward growth of upper crown branches.
(Oliver and Larson 1990). As a species, Douglas fir is the most likely to respond to late thinnings, but this will depend on a good growing site (Oliver and Larson 1990).

Ponderosa pine series sites present a different situation. Here, a ponderosa understory has regenerated, but fire suppression has left the regenerating stands thick, suppressed and susceptible to western pine beetle attacks and stand-replacing fire (Gast et al. 1991, Agee 1994). In young ponderosa stands, thinning can actually lead to some increased growth and vigor, especially if the residual trees are those with large crowns (Oliver and Larson 1990, Agee 1994). But suppressed ponderosa rarely respond well to late thinnings, remaining unvigorously and eventually dying (Oliver and Larson 1990).

The rest of this section will consider the possible ecological benefits and drawbacks of understory thinning when applied on appropriate sites.

**TREE VIGOR & STAND PRODUCTIVITY**

*Understory thinning benefits - Increased tree vigor, growth, and resistance to "pests":*

As explained in Chapter Three, tree vigor generally increases when competition is reduced. Mechanical thinning of the understory will reduce competition for nutrients, water and sunlight. As the stand is thinned and host species for different pests are removed, overall pest susceptibility decreases.

*Understory thinning drawbacks - Increased soil compaction and tree wounding; reduced nutrient levels in the soil:*

The proposed ecological benefits of thinning are the same as the benefits of natural disturbances, but they come with different and potentially more serious drawbacks. In particular, mechanical thinning can exacerbate some of the problems which thinning is trying to fix. Tree susceptibility to pests increases when they are stressed by compacted, displaced or eroded soil, or if the tree itself is injured (Gast et al. 1991, Wickman 1992). When heavy machinery is used in thinning, it leads to soil compaction, increasing the spread and susceptibility to root diseases. Soil compaction
also reduces pore space, water infiltration, aeration, and healthy plant rooting, thus reducing tree growth (Perry 1995). The effects of soil compaction can last for decades.

Residual trees are often scarred during thinning projects. This scarring provides entry points for insects and pathogens (Filip and Schmitt 1990). If root diseases are present on the site, the inoculum of the root diseases will increase in residual stumps, although for some diseases this can be stopped by treating the stumps with borax (Filip and Schmitt 1990). All of the above problems will be increased in incidence and severity with the repeated partial entries that are required to maintain open-growing conditions in the absence of natural disturbances (Schmitt et al. 1991).

Neither mechanical nor manual thinning adds significantly to nutrient cycling. Even if trees removed through thinning are left on site, their decomposition will take much longer than that which occurs through insect or disease disturbances. It is important, however, to consider fuel loading Other differences between natural and silvicultural disturbances will be discussed in the following chapter.

**STAND COMPLEXITY**

**Understory thinning benefits - Reduce susceptibility to stand-replacing fire; open conditions are recreated:**

When understory thinning is used to mimic the effects of high frequency, low intensity fire, it can help recreate desired conditions on ponderosa pine sites in particular. For this to occur, it is necessary that remnant seral species still exist in the overstory (Agee 1994). Understory thinning on these types of sites can also increase structural diversity throughout the landscape. As explained in the previous chapters, landscape structure and conditions precipitate different levels of disturbances. A recreation of open conditions will diffuse the likelihood of natural stand-replacing disturbances. In addition, this type of condition will enable managers to reintroduce natural or prescribed fire (or both) into the area.
Understory thinning drawbacks - Decreased woody material on the ground; increased need for repeated entries, shade-tolerant species are favored; increased biodiversity losses:

Understory thinning will not reduce the litter layer in the same way that an understory fire will. Again, soil nutrient availability will be different and less than it would under natural disturbance regimes. An excessive litter layer can cause fire-resistant ponderosa to die from root scorch through soil heating. In addition, excessive amounts of down trees can seriously increase the risk of stand-replacing fires on the site.

Continued understory thinning favors the regeneration of shade-tolerant species, unless patches are occasionally opened for the regeneration of intolérants. In the absence of natural disturbances, human-created open stands can only be maintained through continual management practices of thinning or burning. Without repeated stand manipulation, “unhealthy” conditions will again arise — especially if fire is not allowed to return to its natural role in the system.

One of the least-studied problems associated with harvesting and human impacts on forest systems is the loss of native biodiversity, particularly associated with the introduction of non-native species. According to the Eastside Forests Scientific Societies Panel (Henjum et al. 1994 p172):

Declining diversity is a strong signal that the health and integrity of an ecological system are at risk. The loss of biodiversity in eastside forests is thus a manifestation of declining ecological health in the region. Such impoverishment of biological systems leads the way for secondary crises such as fire, disease, and pest outbreaks.

Ongoing research by the Sierra Biodiversity Institute explores the effects of road building and human entries in previously unentered forest stands on the introduction of non-native species to the stand. Species such as spotted knapweed, black stain rot, tansy ragwort and gypsy moth are examples of these (Perry 1988a). Exotic plant species typically out-compete native species, while exotic insects and pathogens can completely destroy their host species. The effects of white pine blister rust and gypsy moth provide examples of the profound effects exotics can have.
Although these are fairly extreme examples, the lesson is relevant: As humans continue to manipulate ecosystems, we will also continue to introduce non-native species to those areas we are manipulating. Some of these species may be harmless, while others may cause as much damage as blister rust. Thinning projects should avoid roadless areas and other previously unentered stands.

**WILDLIFE**

**Understory thinning benefits - Increased forage and down woody material on land and in streams:**

Any benefits from understory thinning have the *potential* to be the same as those from understory burning. But typically, many of the benefits associated with understory burning are absent without fire, and are therefore absent with understory thinning. Understory thinning will increase sunlight and moisture to the forest floor, which has the potential to increase forage availability. Trees left on-site after logging will increase the availability of down woody material.

Understory thinning may be beneficial to threatened and endangered wildlife species if the thinning project is specifically focused on protecting, restoring or enhancing habitat for threatened or endangered species. For example, endangered salmon populations may not be able to tolerate habitat degradation due to natural processes in addition to degradation previously caused by management activities.

**Understory thinning drawbacks - Similarities to understory fire; increased habitat fragmentation:**

Some important benefits created for wildlife by natural disturbances are absent if understory thinning alone is employed. For example, many native understory shrubs thrive with frequent surface fires and stagnate without them (Agee 1993). These shrubs provide significant forage for ungulates. In conjunction with prescribed fire, however, understory thinning may be quite beneficial (see section on prescribed fire).

If excessive, understory thinning can reduce either nesting or feeding habitat for birds. Aquatic system effects will be similar to those of understory fire. In
addition, repeated understory thinning promotes a relative monoculture, which will reduce wildlife habitat for some species, but increase it for others.

**Effects on Fuels**

**Understory thinning benefits - Decreased fuel loading:**

Understory thinning reduces standing and down fuels if biomass is removed from the site. As discussed in Chapter Three, both stand-replacing and understory fires are an important part of eastside ecosystems. But, at certain times, or in certain places, it may be detrimental to allow fires to burn. In particular, forest managers are concerned about the likelihood of stand-replacing fires in systems which formerly thrived on understory burning (Mutch et al. 1993, Hessburg et al. 1994, Agee 1994). In these situations, understory thinning may offer some advantages over natural disturbance methods. But these advantages will be more pronounced if thinning is coupled with prescribed burning. To understand the benefits of thinning in regards to fuel loading it is easiest to reconsider the drawbacks of stand-replacing fire, and to realize that understory thinning can alleviate some of those potential drawbacks. In addition, it is important to consider the ecological benefits of understory burning and to understand that these benefits cannot be recreated by silviculture alone.

**Understory thinning drawbacks - Increased fine and intermediate fuels in slash:**

Understory thinning can increase fuel levels if logging slash is left on the site to dry out. The overall effects of fire depend on the amount and type of slash left behind. Noncommercial thinning, for example, may cause unacceptable increases in heavy fuels. In some situations, thinned material may need to be removed from the site to adequately reduce fuel loading. Logged trees can be either taken out of the forest, chipped and used for mulch, or composted. They can be added to streams which are in need of coarse woody materials. (They can be used for posts and poles, but this must be secondary to the ecological benefits of the thinning.) In addition, thinning to reduce fuel loading should be uneven and unpatterned. Certain areas of unthinned areas should be left to provide a variety of habitats and stand conditions.
Table 4.3  Ecological Effects of Anthropogenic Disturbances: Group Selection*

<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases tree vigor &amp; stand productivity:</td>
<td>Decreases tree vigor &amp; stand productivity:</td>
</tr>
<tr>
<td>1) small openings create varied microclimatic conditions which allow regeneration of all different species (83)</td>
<td>1) if the size of the cut is too large, it effectively creates a clearcut (12,83,87)</td>
</tr>
<tr>
<td>2) the surrounding trees aid natural regeneration (83)</td>
<td>2) reduces windfirmness in edge trees (60)</td>
</tr>
<tr>
<td>Increases stand complexity:</td>
<td>Decreases stand complexity:</td>
</tr>
<tr>
<td>3) over long term - mimics shifting mosaics of even-aged stands within an uneven-aged landscape mosaic (83)</td>
<td>6) requires continued fire suppression in the short term</td>
</tr>
<tr>
<td>4) over long term - reduces habitat continuity, eventually increasing resistance to insect and disease epidemics</td>
<td>7) offers little short-term relief from insect or disease disturbances</td>
</tr>
<tr>
<td>5) allows regeneration of shade-intolerant species (83)</td>
<td>8) increases in edge effect reduces interior stand conditions (57,60)</td>
</tr>
<tr>
<td>6) over long term - allows reintroduction of understory fire</td>
<td>9) patchy openings can experience severe temperature fluctuations which inhibits regeneration and increases susceptibility of residual trees to insects/diseases (57,83)</td>
</tr>
<tr>
<td>Increases wildlife habitat:</td>
<td>Decreases wildlife habitat:</td>
</tr>
<tr>
<td>7) over long term - provides diverse wildlife habitats</td>
<td>10) edge effect reduces interior habitat and increases predatory access to interior prey species (28,57,64)</td>
</tr>
<tr>
<td>8) increases forage production in openings</td>
<td>11) associated road building increases hunting access and fragments habitat (64)</td>
</tr>
<tr>
<td>9) increases edge effect (57)</td>
<td></td>
</tr>
</tbody>
</table>

* Group selection is suitable on sites which naturally experienced spot burns, root disease centers or other small openings. It is only suitable if the size of the group selection is limited to twice the height of the trees in the surrounding stand. Group selection is unsuitable if the size is too large and on sites with continuous stands of suppressed trees. (The numbers refer to citations from the reference list.)
Group Selection

Group selection offers a completely different type of silvicultural opportunity for forest health improvements. (It is also one of the harvesting practices allowed within the Hells Canyon National Recreation Area.) The basic idea behind group selection is to mimic the small patches which are created in natural systems by cutting small groups of trees out of the forest. Forest stands that still have remnant ponderosa pine, western larch or Douglas fir in the overstory may benefit from group selection cutting if it is done to recreate the conditions that formerly existed there.

If applied in this way, group selection can help alleviate some forest health problems and restore stands to former conditions. It mimics small-scale natural disturbances more closely than either overstory or understory thinning. For example, when bark beetles kill a small clump of old growth ponderosa pine and then fire comes through a burns the dead pine, a small opening is created that will support natural regeneration of shade-intolerant species. Group selection cutting can mimic this type of interactive disturbance between insects and fire. Special consideration for short-term vs long-term benefits must be considered when discussing the ecological benefits and drawbacks of group selection. Stand conversion from shade-tolerant climax to shade-intolerant seral species is incredibly slow through this process, and therefore so are the benefits associated with it. But, in the long-term, it can help create more sustainable forest conditions.

It is most effective if forest managers are trying to recreate a series of small even-aged patches within an uneven-aged landscape. In addition to the example mentioned above, group selection cutting is also effective at mimicking the conditions of small jackpot burns, of disease centers, or of small insect infestations. For group selection to effectively mimic natural conditions, the maximum width of the cutting unit should be no greater than twice the height of the mature trees within the stand (Smith 1986). Since the width is limited to twice the height of the mature trees, the outer perimeters of the opening will receive shade from surrounding trees and partial
Group Selection

Based on silviculturist David Smith's (1986) definition that the maximum width should be set at twice the height of the mature trees, the following formula can be used to calculate appropriate group selection size on a site-specific basis.

\[
\frac{\left(\pi \times (\text{avg tree height})^2\right)}{43,560}
\]

\(43,560 = \text{sq. feet per acre}\)

<table>
<thead>
<tr>
<th>area diameter</th>
<th>tree ht.</th>
<th>acres</th>
<th>hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>50</td>
<td>.18</td>
<td>.07</td>
</tr>
<tr>
<td>140</td>
<td>70</td>
<td>.35</td>
<td>.14</td>
</tr>
<tr>
<td>160</td>
<td>80</td>
<td>.46</td>
<td>.18</td>
</tr>
<tr>
<td>180</td>
<td>90</td>
<td>.58</td>
<td>.24</td>
</tr>
<tr>
<td>236</td>
<td>118</td>
<td>1.00</td>
<td>.40</td>
</tr>
<tr>
<td>320</td>
<td>160</td>
<td>1.85</td>
<td>.74</td>
</tr>
<tr>
<td>332</td>
<td>166</td>
<td>1.99</td>
<td>.80</td>
</tr>
</tbody>
</table>

From this table, it is apparent that average tree height must be greater than 118 feet to justify a one-acre cut, and greater than 166 feet to justify a two-acre cut. Group selection as a forest health management tool will be most effective on sites which are already suppressed. Suppressed sites do not have an average tree height of 166 feet. Therefore, group selection size will typically be under one acre.

Box 4.1
cutting is one silvicultural tool that may help recreate this structural condition. It is most aptly applied in stands where small patchy disturbances formerly took place, and can be continued now without threatening the overall landscape. A stand without remnant seral species would probably benefit more from a stand replacing fire than from a series of group selection cuts.

**Tree Vigor & Stand Productivity**

**Group selection benefits - Regeneration of all species types:**

Group selection offers excellent opportunities for reproduction of both shade tolerant and intolerant tree species, if the cutting unit size falls within the description explained above. This will allow greater species diversity, since gaps provide microenvironmental conditions suitable for the regeneration of species from almost the entire spectrum of local vegetation (Smith 1986). Increases in species diversity will also reduce risks of stand-replacing insect and disease disturbances. Through the long-term process of stand conversion, group selection can lead to greater stand productivity.

**Group selection drawbacks - Oversized cuts:**

Group selection cuts which are too large will mimic clearcuts. As long as the guidelines explained in Box 4.1 are followed, group selection will mimic the effects of small-scale natural disturbances. In addition, group selection has fewer residual drawbacks than understory thinning. Since logging is limited to a small patch, the amount of scarring and damage to residual trees is limited (Smith 1986). Limiting damage to residual trees helps maintain vigor in these stands. Soil compaction will also be confined to a smaller area, although this may be negated over time as numerous group selections are required to completely convert a stand.

When trees are removed in group selection cuts, the residual edge trees often lose their windfirmness (Perry 1988a). Although blowdown increases the amount of woody material on the ground, it also reduces interior habitat within the remaining stand. This will be discussed further in the section on wildlife.
STAND COMPLEXITY

Group selection benefits - Increased mosaic of even-aged patches within an uneven-aged landscape; increased ability to manage for shade-intolerants:

Group selection can recreate the necessary structural conditions for shade-intolerant regeneration. As explained in the previous chapter, ponderosa typically regenerated in small patches as older trees succumbed to insects or disease and then burned in fires, creating small openings. This provided a mosaic of habitat conditions within the generally homogeneous stands of seral species. This stand structure effectively dampened disturbances, typically keeping their strength and impacts at the small-scale level. This pattern also mimics the conditions created by small-scale blowdown, root disease centers, and small-scale insect infestations. Appropriately implemented group selection cuts can recreate this stand structure.

Natural regeneration and a return to historical conditions will be possible in areas which have viable seed sources in seral species in the adjacent uncut areas.

Group selection drawbacks - Oversized cuts; temperature fluctuations; increased edge effects:

Oversized group selection cuts can cause unmitigatable microclimatic problems. Without forest cover, daytime temperatures can be much hotter than the surrounding forests, while nighttime temperatures can be much cooler. Cool temperatures may cause risk of frost damage, or increase susceptibility to fungus spores such as stem rust (Smith 1986). Sites such as these may also be susceptible to frost heaves, pushing regenerating seedlings out of the ground.

Improperly placed group selections can increase edge effects and reduce interior forest conditions in the remaining stand. Interior trees may experience slowed growth (similar to thinning shock), or they may be subject to sun scald, windthrow or water sprouts (Oliver and Larson 1990). Interior vegetation structure influenced by edge effects varies depending on site conditions and the type of edge effect. These varied effects can reach between 15 and 400 feet into the residual stand (Oliver and
Larson 1990). If cuts are placed too close together, the intact forest between the cuts may lose its interior habitat to edge effect.

Group selection may not allow for the reintroduction of natural fires or for the safe use of prescribed fire to maintain open growing conditions on sites dominated by severely stressed Douglas and true firs. Group selection cutting only creates small-scale structural changes in the short term. It will take decades, or centuries, to alter completely the stand structure to the desired conditions. In the meantime, insects, airborne pathogens and fire can travel across the distance left by the group selection cuts.

**WILDLIFE**

**Group selection benefits - Increased array of diverse habitat types:**

Ideally, in group selection cutting some standing snags and downed logs will be left on site to provide the most wildlife habitat. Excess trees will be removed from the opening to avoid excessive fuel build-ups and to allow grasses and forbs to recolonize the site. This will provide forage for ungulates. A variety of climatic conditions will exist within the cutting area, allowing diverse understory species to recolonize the site (Smith 1986).

Group selection activities may have some impacts on aquatic resources. In particular, created openings will retain more snowfall in the winter with later spring runoff. Depending on the number of group selections within one small watershed, peak flows, sedimentation and stream temperatures may be affected.

**Group selection drawbacks - Increased habitat fragmentation:**

*Habitat fragmentation*

As discussed in the previous chapter, habitat fragmentation must be considered when comparing silvicultural and natural disturbances. Habitat fragmentation is most closely associated with permeation of habitat by human activities such as road-building and logging (Perry 1995). As explained in the section on stand complexity, group selection cutting can severely reduce interior habitat. This affects a variety of wildlife
species. In particular, it enables predators to gain easier access to the interior forests, and therefore easier access to prey species such as ground nesting birds (Perry 1995, Henjum et al. 1994). Wildlife populations can be impacted by fragmentation in a more indirect way via changes in microclimate, light, wind or moisture conditions (Henjum et al. 1994). If group selection is applied on sites which were formerly open stands and which will become open stands, the types of wildlife that inhabit the site will change from those which require interior species to those which require or prefer more open sites. With this in mind, it is important that not all mid-elevation habitat is converted to open conditions in order to maintain diverse habitat types for all wildlife species.

The negative effects of habitat fragmentation can be reduced by maintaining corridors between the fragments (Perry 1995). These corridors will allow species to move safely between suitable habitat sites. Maintaining corridors will guarantee wildlife viability in the event of natural as well as human-caused stand-replacing events.

Aquatic life

The effects of group selection on aquatic life will depend on the number of cuts and their proximity to water sources. A large number of cuts will create effects similar to those within a clearcut — particularly increased erosion and stream sedimentation. These effects are also similar to those associated with stand-replacing fires, but may be less severe. To improve forest health, group selection cutting should be minimal, and should occur over a long period of time. Therefore, group selection should not negatively effect aquatic life unless it is used inappropriately.

FUELS

Group selection benefits - Reduced fuel loads through long-term stand conversion:

In the short-term, group selection cutting does not reduce the risk of stand-replacing fire, or increase our ability to reintroduce understory fire. The group
selection patches are basically too small to make a big difference in overall condition of the stand. But over the long-term, the stand may be converted into one which can tolerate and even thrive on the effects of surface fires.

Downed logs which are in full contact with the ground will retain soil moisture and provide refugia for invertebrates during a fire.

**Group selection drawbacks - Constant management required:**

To realize a long-term goal of reintroducing fire to the landscape, managers will need to maintain open conditions in the small group selection sites. Without natural fire or repeated cutting, it is likely that shade-tolerant species such as grand fir and Douglas fir will recolonize the understory, increasing competition for nutrients and increasing susceptibility to certain insects and diseases which will then increase fuel loading. To keep this from happening on a site which is being converted to open, parklike conditions, repeated thinnings or prescribed fire will be needed. Prescribed fire will be difficult to utilize because the small group selections will probably be surrounded by denser stands of stressed trees. The risk that a prescribed fire will reach into these adjacent stands is probably too great. Therefore, managers will need to manually or mechanically remove the understory, possibly leading to residual tree damage, soil compaction and the other drawbacks mentioned within the section on thinning.
Table 4.4  
Ecological Effects of Anthropogenic Disturbances:  
Prescribed Fire*  

<table>
<thead>
<tr>
<th>Ecological Benefits</th>
<th>Ecological Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases tree vigor stand productivity:</td>
<td>Decreases tree vigor &amp; stand productivity:</td>
</tr>
<tr>
<td>1) reduced competition increases residual tree vigor (34,52)</td>
<td>1) fire scarring provides openings for insects and disease - reduces vigor in scarred trees (19,76)</td>
</tr>
<tr>
<td>2) increases nutrient availability in the soil (19,23,34)</td>
<td>2) spring burning causes following problems (1)</td>
</tr>
<tr>
<td>3) underburning increases vigor in ponderosa pine stands by changing soil chemical characteristics (23)</td>
<td>* flushing buds are susceptible to damage;</td>
</tr>
<tr>
<td>4) smoke from fires may inhibit insect and disease abundance (2,19)</td>
<td>* shrub carbohydrate reserves in the roots (for regeneration) are at a yearly low;</td>
</tr>
<tr>
<td>5) a series of wet season underburns can reduce fuel loading and restore original stand structure (1,52)</td>
<td>* can weaken and kill sprouting shrubs;</td>
</tr>
<tr>
<td>6) may allow reintroduction of natural fire as ecosystem regulator (precluding the need for continued silvicultural management and fire suppression)</td>
<td>* can kill seeds of native herbaceous perennials (in moist soils);</td>
</tr>
<tr>
<td>Increases stand complexity:</td>
<td>* can kill fine conifer roots which may predispose trees to moisture stress during the dry season.</td>
</tr>
<tr>
<td>7) increases diversity of wildlife habitat</td>
<td>3) fires may become stand-replacing (see drawbacks of stand-replacing fires).</td>
</tr>
<tr>
<td>8) increases forage (1,52)</td>
<td>4) promotes monocultures - monocultures are generally more susceptible to stochastic events (53)</td>
</tr>
<tr>
<td>9) increases in standing snags benefit cavity nesting birds and small mammals (88)</td>
<td>Decreases wildlife habitat:</td>
</tr>
<tr>
<td>Increase wildlife habitat:</td>
<td>5) spring burning can affect nesting and breeding conditions, fall burning can reduce animals' physical condition as they prepare for winter (98)</td>
</tr>
<tr>
<td>6) increases stream sedimentation</td>
<td></td>
</tr>
</tbody>
</table>

* Prescribed understory burning is suitable on dry and moist/dry sites which traditionally supported seral species and still have a seral component in the understory. It is unsuitable on sites not traditionally dominated by understory fire (e.g., cool, moist, higher elevation sites), when the weather is extremely dry and fire may go out of prescription, or near the urban/wildland interface. (The numbers refer to citations from the reference list.)
Prescribed Fire

Prescribed fire offers an important management alternative to purely extractive silvicultural practices. Generally speaking, the benefits and drawbacks will be similar to those of understory burning. But, because prescribed fire is more controlled, managers who utilize it must consider certain additional factors. The most important things to consider are time of year and types of fuel loading. The fire season in the Intermountain West generally occurs between June and August. Most plant and animal species are best adapted to deal with fires which burn at these times. Most prescribed fires, however, occur in the spring or fall when weather conditions offer the easiest fire control.

Prescribed fire benefits:

Prescribed fire is an excellent tool for maintaining low fuel loads in open stands of seral species. The importance of these benefits was described in the section on underburning in the previous chapter. Prescribed fire is important because naturally ignited fires do not always occur frequently enough to maintain the desired conditions. The low intensity, high frequency fire regime that is so often attributed to lightning was manipulated tremendously by Native American burning practices (Box 4.2) (Barrett and Amo 1982, Agee 1993, Mutch et al. 1993). To truly restore the conditions which white people found in the Intermountain West in the 1850s, an aggressive prescribed burning program may be necessary, in conjunction with natural fires reintroduction.

Off-season burning (spring/fall) can help reduce fuel loads and therefore reduce the risks of stand-replacing fire. This will also help change stand conditions so natural fire can regain its role as an ecosystem regulator. Several fire ecologists (Mutch et al. 1993, Agee 1994) have suggested that a series of prescribed fires under moist conditions can help reduce fuel loads over time so that natural fire can eventually be reintroduced into the system.
Prescribed fire drawbacks:

Spring-season burning can adversely affect wildlife breeding and nesting activities (USDA 1994a). Fires during the spring calving season can influence mortality in both mothers and their offspring. Spring fires can also reduce nesting materials for birds and mammals. Fall-season burning, on the other hand, can reduce animals' physical condition as they prepare for the winter season (USDA 1994a).

Plants are also adversely affected by off-season burning. According to fire ecologist James Agee (1993 p18), spring burning can have the following adverse effects:

- flushing buds are susceptible to damage;
- shrub carbohydrate reserves in the roots are at a yearly low;
- burning can weaken and kill sprouting shrubs;
- burning in moist soils can kill seeds of native herbaceous perennials;
- spring burning can kill fine conifer roots which may predispose trees to moisture stress during the dry season.

Native American Burning Practices

The importance of fire in seral ponderosa pine ecosystems is undeniable, but substantial evidence suggests that fire frequency—averaging 5-20 years—was not caused by lightning ignitions alone. Some investigations suggest that Native American ignitions substantially increased fire occurrence in lower elevation forests in and near the major valleys of western Montana (Barrett and Arno 1982 p650). In most instances, it appears that they set fires in the areas they were using for hunting, generally areas relatively close to their camps. Therefore, all low- and mid-elevation forests were not "managed" by Native Americans.

Where lightning was the main cause of fire, mean fire intervals (MFI) were typically longer, sometimes between 30 to 70 years (Barrett and Arno 1982). Seventy year fire intervals in low- to mid-elevation forests would leave stands looking similar to stands of similar elevation and composition in wilderness areas today—where logging has not taken place, but fire suppression has. Clearly, all low- to mid-elevation areas in the ponderosa pine, Douglas fir and grand fir series did not contain open, parklike stands of ponderosa. An aggressive prescribed fire program may be necessary to truly restore open parklike seral conditions to large areas of the landscape.

Box 4.2
On sites with extremely high fuel loading, it is likely that managers will attempt to remove some of the fuels before utilizing prescribed fire. If excessive fuels cannot be removed, the risks of stand-replacing fire are increased. This risk will be minimized by burning excessive fuels only under the wettest and most neutral burning conditions.

Chapter Summary

Although silviculture can be used as a tool for improving forest health conditions, the adverse ecological effects of management treatments often outweigh the ecological benefits. The next chapter will compare these different effects to provide forest managers and concerned citizens with a tool for understanding how to best treat forest health concerns within the national forests of the Intermountain West, and within the timber management lands of the Hells Canyon National Recreation Area in particular.
Chapter Five
Legal Mandates and Hells Canyon National Recreation Area

Hells Canyon NRA was created to "assure that the natural beauty, and historical and archaeological values of the Hells Canyon area... are preserved for this and future generations, and that the recreational and ecologic values and public enjoyment of the area are thereby enhanced."

Preamble to the Hells Canyon NRA Act, 1975

On December 31, 1975, the Hells Canyon National Recreation Area was established by the United States Congress. The language contained in the act is crucial to the protection of the ecosystem, yet it is also ambiguous. The most critical ambiguity or inconsistency lies in Section 7 of the HCNRA Act which establishes the objectives for managing the area:

1) the maintenance and protection of the free-flowing nature of the rivers within the recreation area;
2) conservation of the scenic, wilderness, cultural, scientific, and other values contributing to the public benefit;
3) preservation, especially in the area generally known as Hells Canyon, of all features and peculiarities believed to be biologically unique including, but not limited to, rare and endemic plant species, rare combinations of aquatic, terrestrial, and atmospheric habitats, and the rare combinations of outstanding and diverse ecosystems and parts of ecosystems associated therewith;
4) protection and maintenance of fish and wildlife habitat;
5) protection of archaeological and paleontologic sites and interpretation of these sites for the public benefit and knowledge insofar as it is compatible with protection;
6) preservation and restoration of historic sites associated with and typifying the economic and social history of the region and the American West; and
7) such management, utilization, and disposal of natural resources on federally owned lands, including, but not limited to, timber harvesting by selective cutting, mining, and grazing and the continuation of such existing uses and developments as are compatible with the provisions of this Act (emphasis added).

The inconsistency between the objectives of Section 7(1-6) and Section 7(7) has allowed countless management problems within the NRA. Can timber harvesting,
mining and grazing ever be compatible with the first six parts of the act? Webster’s *New Collegiate Dictionary* (1977) defines compatible as “capable of existing together in harmony.” But, resource extraction (timber harvesting in particular) is rarely in harmony with the protection, conservation and preservation of ecosystems. Grazing has caused extensive problems on the native grasslands of Hells Canyon, and mining impacts are counter to ecological protection within the canyon. But timber harvesting is the focus of this discussion. As explained in the previous chapters, although timber harvesting can at times be ecologically justified, it is most often economically based and counter to ecological health.

For timber harvesting to be compatible with the provisions of the act [Section 7(1-6)] , it must benefit, improve or restore forest health. In July 1994, the FS created and adopted long overdue land use regulations (LURs), initially required by the Act in 1975 to provide guidance for its implementation. But, the LURs do nothing to distinguish what activities are compatible; they simply reinforce the language of the HCNRA Act. As quoted in the introduction, 36 CFR 292.46 (7-19-94) explains these rules:

Timber may be harvested only to protect and enhance ecosystem health, wildlife habitat, or recreational and scenic uses; to reduce the risk of harm posed by hazard trees; or to respond to natural events such as wildfire, flood, earthquake, volcanic eruption, high winds, and disease or insect infestation.

As explained in the beginning of this paper, if forest or ecosystem health is used as the basis for land management decisions, it should be an ecological rather than an economic definition. If political or economic needs are brought into the definition, then the decision will be biased automatically against true ecosystem needs. As explained in previous chapters, at times timber harvesting can be beneficial to ecosystem health. But when is it more beneficial than natural processes? In most instances, timber harvesting causes additional ecological drawbacks which would not occur naturally. Can the idea of greater ecological benefit be used to prove compatibility?
No timber harvest which degrades or is likely to degrade ecosystems should be justifiable under the LURs. The introduction to the new LURs explains that the rules are intended to "ensure that HCNRA will be administered in such a way as to protect the values for which it was established" (36 CFR part 292 summary). Yet these LURs reiterate the explanation in the HCNRA Act where, "Congress also expressly recognized as 'valid' certain timber harvesting, grazing and rivercraft uses of the area that predated the establishment of the HCNRA" (36 CFR 292 background). Although these activities were recognized as valid, to occur within the NRA, they are supposed to be compatible with it's protection.

The Wallowa-Whitman National Forest (WWNF) has attempted to create options for extractive activities which are compatible with the protection of the unique characteristics and ecosystems of Hells Canyon. With timber harvest in particular, the FS has tried to define harvesting in terms of wildlife needs and ecosystem health. Wildlife habitat and ecosystem health improvements can occur without logging, yet they are now being used as the justification or basis for timber harvesting. In a 1979 report on wildlife habitat in the Blue Mountains, USFS wildlife biologist Jack Ward Thomas (1979 p13) explained that wildlife management is merely a by-product of timber management:

> Large-scale wildlife management usually results from the manipulation of forest vegetation primarily for wood production. Timber management is wildlife management. (Emphasis in original.)

Wildlife management is not timber management. Rather than looking for new ways to justify timber sales, the FS might consider "new," less impacting ways to manage for wildlife habitat — e.g., road closures, domestic grazing allotment reductions, and restoration of native vegetation. Ideally a precautionary approach to wildlife habitat needs on forested lands will consider first the ecological benefits and drawbacks of no timber management and then, if necessary, the ecological benefits and drawbacks of management.

This precautionary approach can be applied to any proposed management on the HCNRA to determine whether or not the proposed activity is compatible with the
HCNRA Act, the LURs and also the Comprehensive Management Plan (CMP). The chart in figure 5.1 provides a matrix for decision-making based on the precautionary principle. Although the information provided within the text of this paper focuses specifically on timber sales, equivalent information can be gathered to determine the compatibility of grazing allotments, mining, recreational activities etc. It is a tool to help the Forest Service comply with their own regulations regarding the management of Hells Canyon NRA. In addition, it can also be applied to other public lands which have similar legal frameworks for ecosystem protection. A look at the current status of the CMP is necessary before the decision-making chart can be further explained.

**Hells Canyon Comprehensive Management Plan**

Since 1981, the Hells Canyon NRA has been managed according to its Comprehensive Management Plan. FS management based on the CMP has been largely ineffective in terms of protecting and enhancing the unique habitats of Hells Canyon. Concerns about mismanagement led to Congressional oversight hearings in late 1993, at which point the FS agreed to revise the CMP. (The original CMP (USDA 1981) included plans for a ten-year revision which was due in 1991.) The WWNF has been working for nearly a year on an Environmental Impact Statement (EIS) to make "non-significant" amendments to the CMP. Non-significant amendments are those which do not require that the WWNF Forest Plan be amended as well. This process makes unlikely any real changes in management direction or action through a CMP revision. By limiting themselves to only non-significant amendments, the FS is most likely limiting the amount of change they will attempt.

Regardless of the changes they are going to make, the FS is still working from the old CMP, which contains management objectives and directives for all activities and resources within the NRA, including wildlife, timber, insects and diseases, fire, water and soils, and fisheries. The CMP (USDA 1981 p23) contains the following two management objectives for timber resources:
1. Perpetuate healthy stands of diverse tree species, sizes and age classes.
2. Emphasize stand condition, scenery, wildlife habitat, and recreation needs over optimum wood fiber production.

Although the FS must emphasize stand condition over *optimum* wood production, it does not have to emphasize stand condition over *all* wood production. These management directives do not offer any concrete direction for discerning compatibility between timber extraction and protection of the HCNRA ecosystems. The HCNRA is currently divided into several different management areas. Timber harvest generally occurs on the 77,308 acres categorized as Dispersed Recreation/Timber Management (DRTM). Salvage logging also has taken place on lands allocated to forage production. The majority of the timber cut in the NRA (since its designation in 1975) has been logged under a salvage justification. The land of Hells Canyon NRA is designated as follows:

<table>
<thead>
<tr>
<th>Management Area</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber Management</td>
<td>0 acres</td>
</tr>
<tr>
<td>Dispersed Recreation/Timber Management</td>
<td>77,308 acres</td>
</tr>
<tr>
<td>Forage Production</td>
<td>158,240 acres</td>
</tr>
<tr>
<td>Dispersed Recreation/Native Vegetation</td>
<td>130,404 acres</td>
</tr>
<tr>
<td>Wildlife Management</td>
<td>0 acres</td>
</tr>
<tr>
<td>Wilderness</td>
<td>219,290 acres</td>
</tr>
<tr>
<td>Snake River</td>
<td>17,546 acres</td>
</tr>
<tr>
<td>Rapid River</td>
<td>8,382 acres</td>
</tr>
<tr>
<td>Private Land</td>
<td>41,318 acres</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>652,488 acres</strong></td>
</tr>
</tbody>
</table>

*Using the decision-making chart*

The chart in figure 5.1 can be used to help determine how to more effectively protect and enhance the forested lands of Hells Canyon. It is intended to be an analysis tool to help determine whether or not management activities should even be proposed for a certain area. The legal framework which protects Hells Canyon provides a unique opportunity for management based on ecological rather than economic concerns.
Overall Vision/Desired Future Condition

HCNRA management goal
1. Protect and enhance forest health
2. Protect and enhance wildlife habitat

Consider the natural disturbances that are affecting the site.
*small-scale to stand-replacing gradient*

Analyze the ecological effects of natural disturbances.
*benefits & drawbacks*

Are natural disturbances moving the area toward the DFC?
*Criteria - HCNRA Act, Federal Land Use Regs (LURs) and Comprehensive Mgmt Plan (CMP)*

Consider the possible consequences of no management.
*no effect*

Social/economic effects:
For management disturbance to be chosen over natural disturbance, it must qualitatively outweigh the natural process in accomplishing forest health objectives and enhancing wildlife habitat, or it must clearly outweigh natural disturbances in terms of reasonable social and economic alternatives.

Final Decision (one or more of the following choices):
1. Allow natural disturbance to continue
2. Implement management practice
3. Reanalyze the situation

Figure 5.1

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If, for example, the FS proposes a timber sale which is intended to improve forest health or wildlife habitat, the ecological consequences of the timber sale can be compared to the ecological consequences of no management by using the decision-making chart. A typical Environmental Assessment (EA) or Environmental Impact Statement (EIS) may not include all of the ecological benefits of leaving the site alone, or all of the ecological drawbacks of the management practice. Therefore, the tables which summarize the information presented in chapters three and four about the ecological drawbacks and benefits of natural vs. anthropogenic disturbances can be utilized to help determine whether or not the proposed sale will actually provide the net benefits described. The following case study provides a more detailed explanation of how to use this flow chart.

**Bluebird Vegetation and Wildlife Project - A Case Study**

The Bluebird Vegetation and Wildlife project was initially proposed in the late 1980s as the Bluebird Timber Sale. Since then, it has gone through several iterations, finally resulting in the permanent cancellation of the project in February, 1995. (It was withdrawn twice previously, but is apparently permanently withdrawn now.) Although this project is not going to occur, it provides an excellent case study for understanding how to use the *Forest Health Compatibility and Decision-Making in Hells Canyon NRA* flow chart. All of the information about the Bluebird project comes from the Environmental Assessment that was prepared for the most recent version of the project in December 1993 (USDA 1993c).

Before going through each step in the flow chart, it is important to have a brief understanding of the site history and project proposal. The project area is in the northwestern corner of HCNRA, on a gently sloped site at approximately 5,300 feet in elevation (Figure 5.2). It is directly adjacent to, and partially overlapping with a portion of the 60,000 acre Tepee Butte Fire which burned in 1988. The site has experienced both fire suppression and high-grade logging since coming under Forest
Figure 5.2

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Service management. (Fire suppression occurred both before and after the NRA was designated, logging occurred before the NRA was designated.) Aside from the openings created by the Tepee Butte fire, several natural meadows already exist within the analysis area. The stand was initiated approximately 300 years ago, and the majority of the older ponderosa pine, western larch and Douglas-fir were logged off the site prior to NRA designation. The current stand has five vegetative strata:

A - emergents
B - Douglas fir, grand fir and lodgepole pine - 140-180 yrs old
C - grand fir and Englemann spruce - 100-120 yrs old - no crown differentiation, suppressed
D - grand fir and Englemann spruce - 50-60 yrs old
E - forest floor tree reinitiation of grand fir and Englemann spruce.

The first step in the flow chart is to consider the overall vision/desired future condition for the area. The Hells Canyon NRA has yet to create an actual "desired future condition" for the NRA. Without a desired future condition it is difficult to determine whether or not the proposed action or the natural disturbance are effective. As explained in Chapter Three (p. 33) the following (draft) desired future condition was developed by an independent citizen's group tracking the CMP revision process (CMP Tracking Group 1995):

Native forest habitat, structure and function, and a diversity of forest conditions (e.g., burned areas, diseased areas, old growth, diverse forest plant communities, successional stages later than grass, seedlings) will be protected and restored as possible through natural forest processes reflected in the natural capability of the land. Native fauna as well as the habitat on which it is dependent will be maximized.

Since the Forest Service does not have their own DFC, this draft DFC will be applied to the Bluebird case study. Once the FS develops their own DFC, forest management within the NRA will be tiered toward it. Although independent citizen groups may create their own DFCs for a particular national forest or recreation area, it is unlikely that the FS would actually tier their management toward an independent DFC. Any analysis of FS proposals should actually assess how the proposal meets the desired future condition as stated by the Forest Service. The importance of having
some type of long-term vision or DFC should not be undervalued. It is difficult to plan and manage at the landscape level without this. If the FS has no DFC, proposals are typically tiered to the management direction that is given within the comprehensive management plan or the forest plan. This is the case within the HCNRA, and it is addressed in the next step.

The second thing to consider when using the flow chart is the HCNRA management goal regarding timber projects. These two goals (from the CMP) are listed under step two on the flow chart. The specific project goals stated within the EA are: "1) improving forest health; and 2) enhancing big-game habitat within the project area" (USDA 1993c). These are rewritten, practically verbatim, from the goals listed in the CMP (also listed under step two on the flow chart).

The third step is to consider the natural disturbances that affect the project site. The different vegetative strata of the Bluebird site are host to a variety of natural disturbances. First, trees within the A stratum are experiencing decline associated with old age. The rest of the strata are affected as follows:

- B-stratum - Douglas fir bark beetles
  - grand fir - Indian Paint fungus (stem decay) and spongy sap rot
  - lodgepole pine - mountain pine beetle
- C-stratum - suppression, overcompetition for moisture, light, nutrients
- D-stratum - western spruce budworm
- E-stratum - western spruce budworm

To complete the fourth step it is necessary to determine the ecological benefits and drawbacks of these different disturbances. Use the information presented in Chapter Three to do this. The tables which summarize the effects of insects, disease, and fire can all be used to understand the potential effects of these disturbances and whether or not they will help this particular area meet the desired future condition for HCNRA forest lands. It may be necessary to do further research into soil types, aspect and vegetation, for example, to determine which of the effects are actually occurring. If at all possible, conducting an independent ground-truthing analysis will provide valuable data for evaluating the site-specific effects of the natural disturbance and the possible site-specific effects of management practices. At this point in the
flow chart, you can move to one of three different options depending on the your assessment of the effects of the natural disturbances.

First, you may be unable to determine whether or not the disturbances are moving the site toward the desired future condition. In these instances, it is important to consider the possible negative consequences of allowing the disturbance to continue. What types of habitat degradation may occur? Are threatened species depending on this habitat? If so, at what threshold will those threatened species lose their ability to survive? When advocating a precautionary approach, we must also consider the cumulative impacts of past management practices when trying to determine whether or not to allow natural processes to continue or whether or not to use silvicultural treatments. If no detrimental consequences are determined, you can move in to the second to last box in the flow chart and consider the social/economic effects. If, however, natural disturbances are not meeting the DFC or if they are detrimental to the management objectives, then management practices can be considered.

Second, if you determine that the natural disturbances are moving the site toward the DFC then you consider the social and economic implications. Finally, the third option is to consider a range of site-appropriate management alternatives. The Bluebird sale was not analyzed according to this flow chart, but it is my assumption that the area was moving toward the DFC as written above. In addition, it is doubtful that the area contains critical habitat for sensitive or endangered species that would be detrimentally impacted if the site were to burn as a result of increased mortality due to insects, disease and low vigor.

Nevertheless, the Forest Service considered several management options for this site. The proposed “treatment” was a series of sixteen two-acre group selection cuts every twenty years for 120 years. This proposal is intended to eventually convert the stand to one dominated by seral species in an open parklike setting, as well as to improve wildlife habitat. According to the first step on the right-hand side of the flow chart, “a range of site-appropriate management alternatives” will be considered if the natural process is not moving the site toward the DFC. The FS proposal considers
only one option—group selection cutting—during four different seasons. Not only is this not a true "range of alternatives," but group selection is inappropriate for the site. First, barely a remnant of the former stand conditions remain since the majority of the dominant emergent trees were high-grade logged. Second, the size of the group selection cuts is far too large and will effectively create a series of small clearcuts within the site. For two-acre cuts to be justified, the average tree height within the stand would need to be 160 feet according to the chart presented on page 83. When average tree height is this high, the trees within the stand are rarely suppressed. If tree height is closer to 80 feet, then an appropriate group selection cut size would be approximately one quarter of an acre. Clearly, the FS needs to consider how they are applying group selection within Hells Canyon NRA and whether or not they are effectively mimicking clearcuts.

In addition, "a range of site-appropriate management alternatives" should include non-silvicultural options. Because HCNRA has a legal mandate to subordinate economic to ecological needs, any human management considered should start with the least adverse-impacting alternatives. For particular concerns about big-game habitat, closing and revegetating access roads may provide greater habitat security than silviculture. Road obliteration and revegetation benefits terrestrial wildlife by reducing habitat fragmentation stream and benefits aquatic species by reducing stream sedimentation. High fuel loading may be reduced through a series of wet-season prescribed fires rather than silviculture. In addition, livestock grazing drastically reduces three things: competition between understory plants and tree seedlings; fine fuel loading; and regeneration because of browsing and trampling seedlings. (Belsky and Blumenin 1995). These effects will change disturbance events in a given area by changing vegetative conditions and fuel loading. Reduced livestock grazing, therefore, can improve forest conditions. The FS can also hold firewood sales to reduce fuel loading on a particular site while benefitting the local human population. The FS is not tied into management by silviculture alone, and within the NRA in particular, they
have the opportunity to take advantage of non-economically driven alternatives that will truly improve the conditions of the land.

Moving on to the next step in the flow chart, you will analyze the ecological effects of each different management alternative. The information and tables presented in Chapter Four list the potential effects of several different types of silvicultural treatments and prescribed fire. The best analysis of these options will consider site specific characteristics including slope, aspect, soil conditions, topography, and vegetation. An on-site analysis will further increase your ability to determine both the beneficial and detrimental effects of the proposed treatment.

Once you have considered the different alternatives, the next step directs you to choose the least adverse-impacting alternative. If management is necessary to protect threatened species or to improve forest conditions, the very least management possible should take place to best allow the forest to return to self-sustainability through natural function. In addition, management should improve conditions not degrade them. Ecological degradation tends to increase with increasing management intensity. Choosing the least-adverse impacting alternative will automatically reduce detrimental effects to a minimum and emphasize ecological recovery and restoration. The human management alternatives under consideration should include options besides logging and the least-impacting option should be chosen. Non-silvicultural management activities can actually reduce impact: They offer an excellent alternative to logging for forest health or habitat improvement.

In the next step, you will determine whether or not this alternative is compatible with the HCNRA Act, the land use regulations (LURs) and the CMP. Each of these legal documents contains specific language regarding the focus of timber activity within the NRA. This is the step at which compatibility is truly determined. Does this project meet not only the ecological requirements on the site, but also the legal requirements? If it does not, then it is necessary to reanalyze the situation and create a different alternative that will meet all of the necessary criteria.
If, on the other hand, it does meet these different criteria, then it’s time to consider the social/economic effects. This is the same step that was mentioned previously, and it is the last step to consider before making your final decision.

Is this sale proposed for an area within the urban wildland interface? If so, private property may be at risk if fuels are allowed to build up as insects or diseases increase tree mortality. High fuel levels may predispose the area to a stand-replacing fire. In this situation, it may be more appropriate to choose the least adverse-impacting silvicultural practice to reduce fire risks rather than to allow natural processes to continue. Additional social and economic considerations may arise. Regardless, for a management disturbance to be chosen over a natural disturbance, it must qualitatively outweigh the natural process in moving the site toward the DFC (regardless of the time frame) or it must clearly outweigh natural disturbances in terms of reasonable social and economic alternatives.

For silviculture to be used in Hells Canyon NRA, the final goal must be ecological, not economic. The following quote from the HCNRA Tepee Butte Fire Recovery Plan depicts how economics can take over under the guise of forest health:

The opportunity is at hand to prescribe sound silvicultural practices that will minimize the potential for insect and disease damage in future stands. By following the recommendations, a healthy pest-resistant stand can be developed and maintained to rotation while fulfilling CMP directives for other amenities, values and benefits. (Emphasis added.)

The Forest Service continues to concern itself within rotation-aged timber and desired future conditions which include maintaining “forests” until the timber reaches rotation age. This maintains an economic rationale behind forest management rather than an ecological rationale. A “healthy, pest-resistant stand,” is not a desired future condition that is in accordance with natural forest processes in the Intermountain West. By utilizing the decision-making flow-chart, the FS can begin to ask larger questions about management practices, natural processes, and how those two different things fit together in the protection of the unique ecosystems (and the processes that created those systems) within Hells Canyon. If the decision is made to log trees in order to...
protect or enhance forest health or wildlife habitat, it is worth considering one final question: Would this decision still be made if the logged trees could not be sold?

Three options are available for the final decision: 1) to allow the natural disturbance to continue; 2) to implement the least-adverse impacting management practice; or 3) to reanalyze the situation. In the case of the Bluebird sale, initially the FS chose to reanalyze the timber sale. By permanently dropping the project they actually are allowing the natural process to continue.

**Salvage Sales**

The National Forest Management Act (NFMA) of 1976 allows salvage sales to recover value from tree mortality through fire, insect and disease attacks, and windstorms. It also allows the harvesting of live trees which are in “imminent” danger of insect or disease attack. Since its designation in 1975, this one regulation has been the focus of most timber harvesting within the HCNRA, and is the focus of the many “forest health” bills proposed during the 1995 Congressional session.

The clause in NFMA that allows the harvesting of trees which are in imminent danger of infestation by insects or disease has resulted in an abundance of green tree salvage logging on public lands. As explained in Chapter Three, tree mortality is a necessary part of a functioning forest. When insect, disease and fire-killed trees are removed from the forest the vital nutrients that they can return to the forest are also removed. When live trees are removed because they may be killed by “pests,” even more of the forest system is disrupted. As discussed in previous chapters, even epidemic infestations were and are a normal part of healthy, functioning ecosystems. The ecological reverberations of past efforts to remove fire from forest systems are still being dealt with. If current managers try to remove insects and disease from forest systems, the ecological reverberations will confound future forest managers in much the same way. Perhaps forest managers can begin to learn from past mistakes.
and offer a more sound recovery for current and future forests and all of the living things that depend on them.

In Hells Canyon NRA in the last ten years, the number of salvage sales as a percentage of total timber sales has risen dramatically (Figure 5.3). In 1988 and 1989, 100% and 99.6% respectively (of total timber harvest) were salvage sales. Salvage sales can be done through any of the harvesting methods explained in the previous chapters, as well as through clear cutting. The purpose of salvage sales is to recover some economic value from the dead and dying trees. Advocates of salvage sales have not considered the long term economic costs of the ecological damage that these sales may cause. Although salvage sales degrade fragile ecosystems, they are often justified in the name of forest health. Before offering salvage sales in Hells Canyon, the FS should consider alternatives as described in the decision-making flow chart.

**Salvage vs. Green Timber Sales in Hells Canyon NRA 1960-1992**

![Graph showing the comparison between salvage and green timber sales from 1960 to 1992.](Barnes 1993)

**Figure 5.3**

Within HCNRA, salvage sales have been justified as treatments for blowdown, tree breakage from heavy snow and icestorms, a variety of insect infestations, diseases, and fire (Magera 1993). Figure 5.4 depicts the percentages of all HCNRA timber sales which were salvage sales between 1976 and 1991. Of the 127.598 million board feet (MMBF) of timber sold from HCNRA between 1976 and 1991, 58.1% was salvage. Is salvage truly necessary on the NRA? To gain a better framework for

Source: Timber Sales in HCNRA since 1976, and telephone interview with Jerry Magara, USFS, 11-22-93

Figure 5.4
answering this question, it is necessary to consider the general conditions which exist on the NRA.

The forested lands of Hells Canyon are located within all of the different management units that the FS has devised for the NRA. The majority of the forests, however, are located within the dispersed recreation/timber management areas. It is in these areas that the FS is most likely to manage for forest health. Most of the lands within this designation are part of either the Snake or Imnaha River watersheds, and therefore terrestrial management practices affect aquatic health and stability of these two key watersheds. Based on the analysis that the FS conducted to comply with Section 7 of the Endangered Species Act (ESA) regarding chinook salmon (USDA 1994b, 1994c), the overall rating of the Imnaha and Snake River watersheds is fair. The terrestrial analysis has been less comprehensive to date. To maintain the already endangered populations of these species, the Forest Service should act to avoid any potential degradation of these watersheds.

HCNRA management must comply with three different regulatory frameworks: the HCNRA Act, the Comprehensive Management Plan, and the land use regulations. (This is in addition to the federal regulatory frameworks (e.g., NFMA, ESA, Clean Water Act) which all national forests/public lands are bound by.) The CMP and the LURs are tiered to the HCNRA Act. Extractive activities which occur on the NRA must be compatible with the protection and preservation of the unique ecosystems of Hells Canyon. The FS has yet to create a framework for determining this compatibility. In the meantime, activities such as timber harvesting and grazing continue. The flow chart explained in this chapter is one tool that the Forest Service can use to determine how to best maintain sustainable forest processes within Hells Canyon National Recreation Area.
Chapter Six
Natural Disturbances vs. Silvicultural Practices:
Comparison and Conclusion

The art of land doctoring is being practiced with vigor, but the science of land health is yet to be born.
Aldo Leopold, A Sand County Almanac

This paper provides a synthesis of the data concerning the ecological effects of natural and anthropogenic disturbances on forests of the Intermountain West. Either forest managers or ordinary citizens can use this information to better understand the effects of natural processes and silvicultural practices on forest conditions. This information can be used to help take political rhetoric out of the "forest health" debate and replace it with scientific knowledge.

Together, silviculture and fire suppression have noticeably changed forest conditions within the Intermountain West, particularly at mid-elevation levels formerly dominated by open stands of ponderosa pine. As pine was removed and fire was suppressed, these sites became dominated by Douglas and true firs, often in stressed and suppressed stands. These vegetative changes provide an increased and continuous supply of host plants for numerous insects and diseases. Insects and diseases, therefore, take over as the major biomass recyclers in the absence of fire. Biomass recycling means tree mortality, and therein lies the "forest health crisis."

The crisis is not an ecological problem, but one of semantics, economics and politics. As trees fall prey to natural recyclers, their economic value decreases. The forest health crisis is a direct response to the short-term economic costs of tree mortality associated with natural disturbances. The real forest health crisis will occur decades or even centuries down the road as contemporary management wipes out future forest resources.

To effectively manage the forests and provide for human needs, decision-makers need an unbiased, scientifically sound definition of forest health. A decision based on the ecological conditions within forest ecosystem will be much more
valuable than one based on tree mortality and human economic and political desires. Human needs are considered by the political decision-makers, ecological needs generally are not.

The crisis mentality that is being attached to forest health in the Intermountain West affects the way decision-makers react to the issues. When managing any type of crisis, common sense is often ignored, while scientific sense rarely even enters the picture. In this case, legislative proposals in the 104th Congress have been calling for most current environmental laws and regulations to be suspended until the forest health crisis is under control. In addition, many legislators are deriding scientific information and analysis. As farsighted scientific studies continue, these legislators create proposals that will undo recent progress toward improving human understanding and management of forest resources. If approved, legislatively mandated timber harvests again will be put in place. These mandated harvests are in direct opposition to sustainable logging and long-term forest integrity. Ironically, these different legislative bills carry ambiguous or even environmentally-conscious sounding names: Senate bill 391 proposed by Larry Craig (R-ID) is entitled the Federal Lands Forest Health Protection and Restoration Act.

The Taylor-Young rider to a budgetary rescissions bill requires the FS to cut 6.2 billion board feet of timber within the next two years. None of the timber cut in association with this bill would have to go through the regular environmental analysis process. Nor would these timber sales have to comply with any existing environmental legislation including the Endangered Species Act, Clean Water Act, Clean Air Act, and National Forest Management Act. These proposed "forest health" bills are intended to increase the cut off federal lands with no regard to current environmental regulations.

If the Congress, the timber industry and the Forest Service utilize an ecological definition of forest health, they may become less concerned with removing the dead and dying timber from the forest. Instead many scientists and politicians advocate immediate and intensive action. For example, Idaho State University forestry professor Jay O'Laughlin (1994 p6) explains: "In the inland west, ecosystem
management is likely to mean more management than previously was practiced." More management implies intensive management. On the other hand, Oregon State University forestry professor David Perry (1995 p510) explains that, "the objective of intensive forest management is to maximize wood production; the cost of this is a loss of habitat complexity."

 Somehow, in the midst of this debate, the ecological issues have been turned inside out. The different "forest health" proposals in Congress, in the Forest Service and in the timber industry make one thing painfully clear: If people kill the trees first, it's ecosystem management, if nature kills them, it's a forest health crisis. This is an overly simplistic view of forest health and ecosystem management, focused almost entirely on short-term economics. Other forest values, including complexity, structure and function, are being ignored in this process.

 The information presented in Chapter Three provides detailed explanations of the many ways natural disturbances maintain complexity, structure and function within the forests of the Intermountain West. In many instances, however, the thinking that went into creating the current legislative proposals is focused on minimizing the likelihood of insects, disease and fire. It is impossible to maintain a tree farm free of natural disturbances within this region, let alone a living, functioning forest. Current proposals are aimed at minimizing insects, disease and fire precisely because they cause tree mortality. Forest systems thrive on this mortality. The information presented throughout this paper reveals the ultimate importance of these disturbances. In addition, the information presented within Chapter Four highlights many of the additional ecological problems associated with silvicultural practices, from soil compaction and road building to the introduction of exotic species. To truly manage for forest health, forest managers might propose several different management options which do not include silviculture, but do include reducing human impacts on the ecosystem through forest restoration. First, vastly increased use of prescribed fire may begin to bring some areas back into sync with the historical vegetation recorded in this region. But this will only begin to restore natural structure, function and complexity if roads are closed throughout the national forests and if grazing is drastically reduced.
As long as fire protection, grazing and road building continue, the ecological integrity of the forests will be threatened and foresters will look to increased logging to solve problems. When forest management switches from an extractive base to a restorative base then the forests will begin to recover. Increased silviculture only creates a need for perpetual forest management.

Although the information presented within this paper focuses on Hells Canyon National Recreation Area in particular, the type of analysis can be adapted in a number of ways to other forests and other land resource activities. The methods for determining ecological compatibility can be applied to other extractive practices (e.g., mining, livestock grazing, industrial tourism) that occur on national forest land. For example, people concerned with the effects of livestock grazing on grasslands can create similar tables listing its ecological benefits and drawbacks. The compatibility flow chart can then be adapted for certain livestock grazing decision-making processes and the two can be put together to help understand whether these activities are compatible or incompatible with maintaining the health of the grasslands. Since the information presented within this paper is a synthesis of other scientific work, the same can be done for other extractive activities.

Many national forest managers propose "forest health" timber sales on their forests. Although the specific legal framework may not be the same for protecting other national forest lands, the tables within this paper can be adapted to other regions to understand whether or not proposed sales will actually improve forest health. People have some ability to hold the Forest Service accountable for their actions, and this is one tool to help people do that. If the Forest Service really wants to improve forest health, let's make sure their proposals are appropriate. It is inappropriate to allow the ecological integrity of the forests to degrade, especially in the name of forest health improvements.

Many ecological terms or concepts have been taken and turned around to justify exactly the opposite of what they say. Although the concept of forest health has been abused recently to satisfy political and economic desires, concerned citizens and scientists have the ability to take the definition back. The myth of the forest
health crisis has been created to justify ever-increasing logging activities. With a look at the real importance of the disturbances that are responsible for the "crisis" we can begin to understand natural systems in the Intermountain West in a more comprehensive way, and can perhaps manage (with humility) to enhance the effects of these disturbances, rather than suppress them.

In addition, we can consider how best to manage our remaining resources to maintain threatened and endangered plant and animal populations. The management practices that we put in place are not confined to the two, twenty, forty or four thousand acres that we directly treat. Terrestrial practices affect aquatic and atmospheric resources. To maintain all systems, a precautionary approach to management is necessary. But this must be combined with an understanding of the degradation our past practices have caused. In certain instances, the cumulative effects of past management practices in conjunction with current natural disturbances can cause significant stress to threatened or endangered wildlife or plant populations. In instances where populations—or the habitat they depend on—are already severely stressed, some human management may be necessary to reduce increased stress from natural disturbances.

**Conclusion**

The Hells Canyon National Recreation Area Act, passed in 1975, retrained forest service management, but altered the agency's standard multiple use mandate for the NRA. In particular, it subordinated extractive uses to protective uses. The HCNRA Act provides a legal mandate for the protection of the unique environmental values that exist within Hells Canyon. In this special place the Forest Service has the opportunity to utilize an ecological definition of forest health regardless of the economic interests. This gives the FS the opportunity to utilize the precautionary principle in forest management.

If the Forest Service can set aside some land that has had fire suppressed and been cut over, they can observe how nature manages that land and how the vegetation
evolves. From these observations then, perhaps they can mimic nature elsewhere. At this point in time the 104th Congress, the Forest Service and even the timber industry should be advocating caution when dealing with these human-caused problems. Instead, by proposing highly intensive, aggressive management, they create an unending situation of perpetual forest management, asserting that without human intervention the forests will fall back into poor health.

Should the aim be to manage continually all national forest lands at all levels; to manage only national forest designated timberlands at an intensive level; or to relieve all national forest lands, including designated timberlands, from human management and to restore degraded lands to a condition where they are self-sustaining and ecologically sound? Leaving some lands in our nation out of forest health prescriptions in order to act as a control on grand forestry experiments will benefit not only the natural systems and the wildlife that depend on them, but it also will benefit the Forest Service and the American people, as we leave a forest legacy for future study and understanding. Perhaps Hells Canyon can act as one of these many necessary control areas. It is already legislatively protected, it has been partially logged, and fire has been suppressed. Let us see where nature takes this place in the next millennium.
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