Managing Ecosystems for Forest Health: An Approach and the Effects on Uses and Values

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ABSTRACT. Forest health is most appropriately based on the scientific paradigm of dynamic, constantly changing forest ecosystems. Many forests in the Inland West now support high levels of insect infestations, disease epidemics, fire susceptibilities, and imbalances in stand structures and habitats because of natural processes and past management practices. Impending, potentially cata-

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strophic fires can be avoided or modified through proactive forest health management–protecting, creating, and maintaining stand structures, processes, and species populations at viable levels across substantial landscapes. Proactive management will be less costly than fire fighting and associated rehabilitation, especially if done jointly with environmentally sound production of commodities. Management to achieve a fluctuating balance of patterns, processes, and species can begin while better information-based tools and scientific knowledge are being developed. A wider array of silvicultural and other management tools will be required for forest health management than has traditionally been used for commodity management. Specific changes that will allow forest health management include: recognizing the extent and consequences of present imbalances, decentralizing management decisions, adopting management techniques, coordinating with various landowners through incentives, funding forest health management activities, and supporting appropriate research.

INTRODUCTION

The "constant change" ecological theory (Botkin and Sobel 1975; Stephens 1990; Oliver 1992a,b) fits forest ecosystem processes in the Inland West better than the "steady state" theory. Disturbances of all types, climate changes, and species migrations have strongly influenced the constantly changing structure, composition, and function of these ecosystems (Johnson et al. 1993).

Many Inland West forests presently contain or soon will have high levels of biomass as well as large insect and disease infestations (Hessburg 1993). The result will be catastrophic fires and–perhaps even more destructive–reburns of the dead trees created by the first fire (Wellner 1973). These fires will be expensive to fight and recover from and will result in erosion, loss of property (and probably human life), and imbalances of habitats.

These catastrophic fires can be avoided, or their adverse impacts reduced, by using management practices to mimic, avoid, and regulate natural disturbances. For example, thinning an overly dense ponderosa pine forest would begin to return a "park-like" condition, common before fire control, by removing excess stems. The thinning would also reduce the remaining trees' susceptibility to insects, diseases, and fires, thus reducing the potential for catastrophic fires (Oliver et al. 1994). If desired, controlled surface fires could then be reintroduced into these thinned stands. This management would approximate the historical range of disturbances but would apply the disturbances at scales, intensities, and frequencies which would maintain all habitats and species within a landscape area (Everett et al. 1993b).

National Parks and Wildernesses are presently being managed with prescribed natural fires or manager-ignited fires to perpetuate fire-dependent ecosystems on a landscape scale within the historical range of variability. Outside of Parks and Wildernesses, forests can be managed both to sustain healthy ecosystems and to produce such other amenities as wildlife habitat, recreation, timber, fish, and water.

This paper will describe how forests can be managed to restore and maintain forest health. Conditions creating the problems and what specific targets can be managed for will be addressed first, followed by a description of the available tools of management. A discussion of ways of reducing the cost of management and of dealing with uncertainty and a description of present barriers to managing for forest health and ways to overcome them are also included.

THE PROBLEM

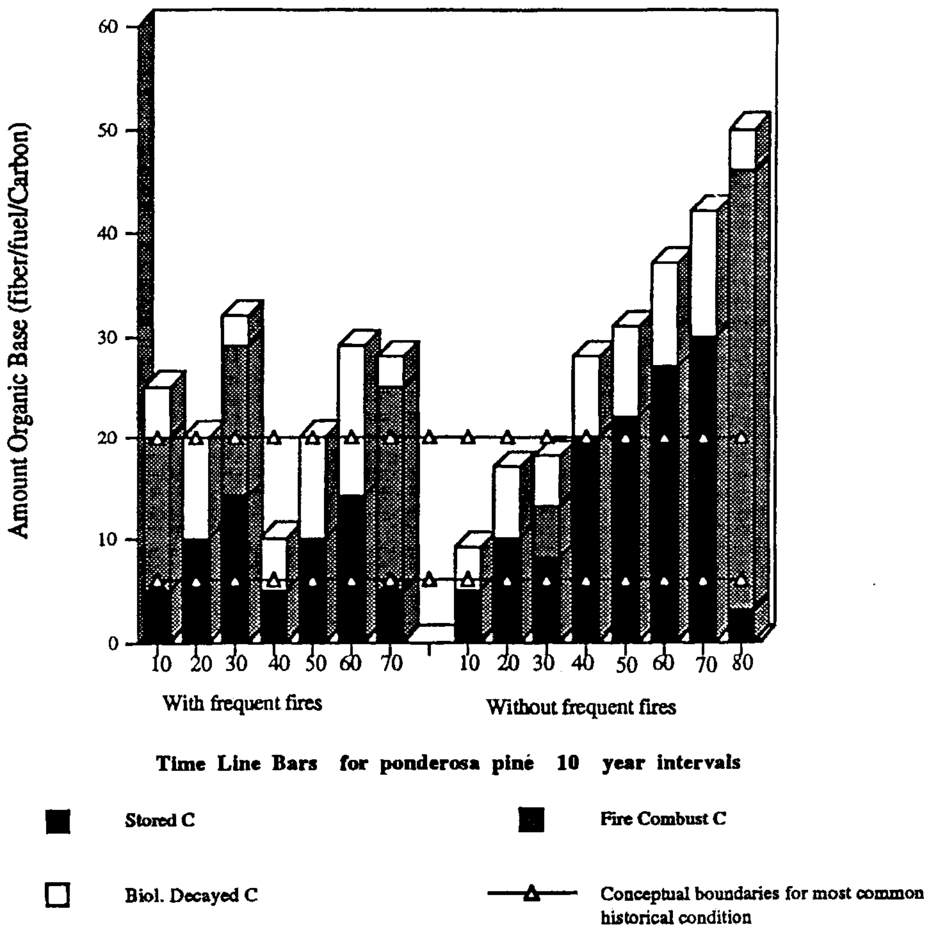
Forests fluctuate in their amount of biomass and their structure. Extreme conditions of biomass–too much or too little–or extreme amounts of a single structure can create problems in forest health, as will be described below.

Biomass–"Carbon"–Fluctuations

Forest biomass (organic matter) is primarily composed of carbon, hydrogen, oxygen and (to a lesser extent) other elements. For this paper, fixation of carbon will be used to refer to accumulations of all elements in biomass. Carbon accumulation, movement, and loss are unique to and indicative of the general condition (health) of forest ecosystems and of the balance between fire and biological decomposition. This balance is an especially important characteristic of forests in the Inland West (Harvey 1994; Harvey et al. 1979, 1987, 1994). Forests exist as a balance between the fixation of carbon through photosynthesis and the release of carbon through respiration (biological decomposition) and oxidation (fire) (Harvey 1994; Harvey et al. 1979, 1994) (Figures 1a,b).

Forests in humid areas such as the tropics often maintain a balance of carbon by rapidly releasing it through rotting of dead trees (biological decomposition). In the Inland West, however, dead material does not decompose rapidly (Edmonds 1991) because moisture and warm temperatures are not simultaneously available to promote rotting. Consequently,

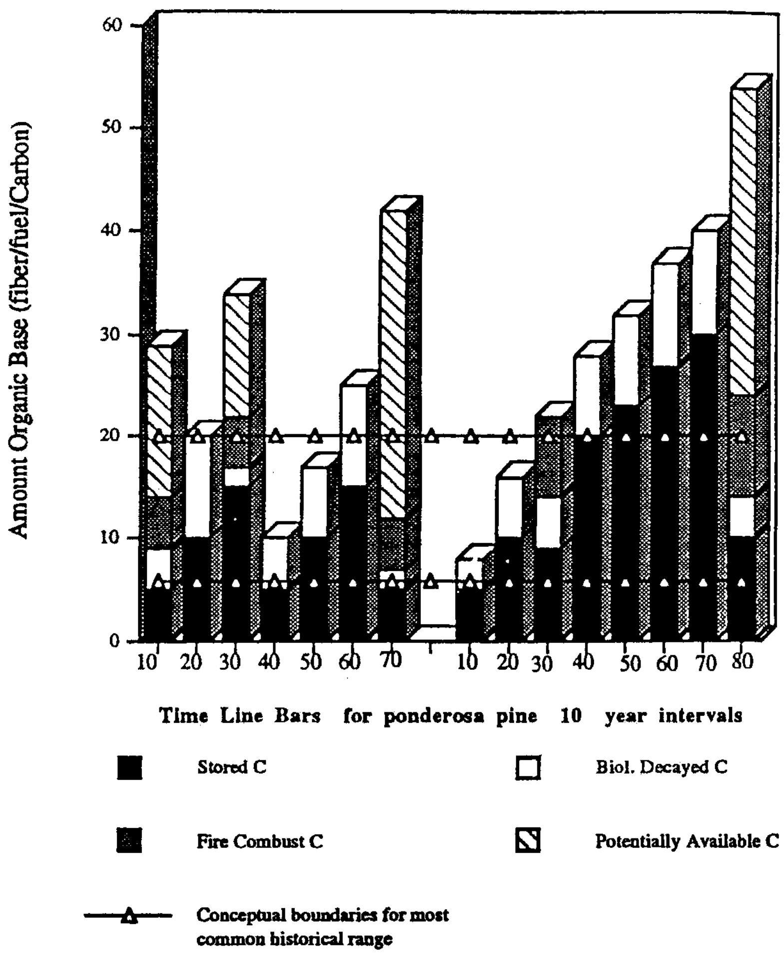
FIGURE 1a. Schematic depiction of carbon stored and lost through combustion and biological decay in forest development in a frequent fire environment (left) and in an environment of naturally or artificially infrequent fires (right). Successive bars to the right represent 10-year time intervals for ponderosa pine, 25-year intervals for Douglas-fir, and 100-year intervals for cedar/hemlock forests.



carbon fixation exceeds decomposition in virtually all ecosystems in the Inland West (Olsen 1963). Carbon is a useful indicator of forest health since forests with high carbon accumulations are at risk from insect and disease activities and from high intensity fires.

Accumulations of carbon in excess of biological decomposition either are stored as peat, coal, or similar products or are released by fire. Forests

FIGURE 1b. Timely removal of "potentially available" carbon from these forests preserves both the cycle and the fire regime, including soil organic reserves. Removal also allows sequestration of carbon in long-lived timber products that help offset the cost of removal. Bars represent 10-year time intervals for ponderosa pine. For different species the time interval would vary.



in the Inland West generally release the carbon through fires. The fires can be frequent and of low intensity if little flammable biomass is allowed to build up, but they can be infrequent and catastrophic if much biomass has accumulated (Habeck and Mutch 1973). Extreme wildfire events can produce excessive loss of carbon from the site and create excessive erosion and slow regrowth of vegetation (Harvey et al. 1989; Jurgensen et al. 1990).

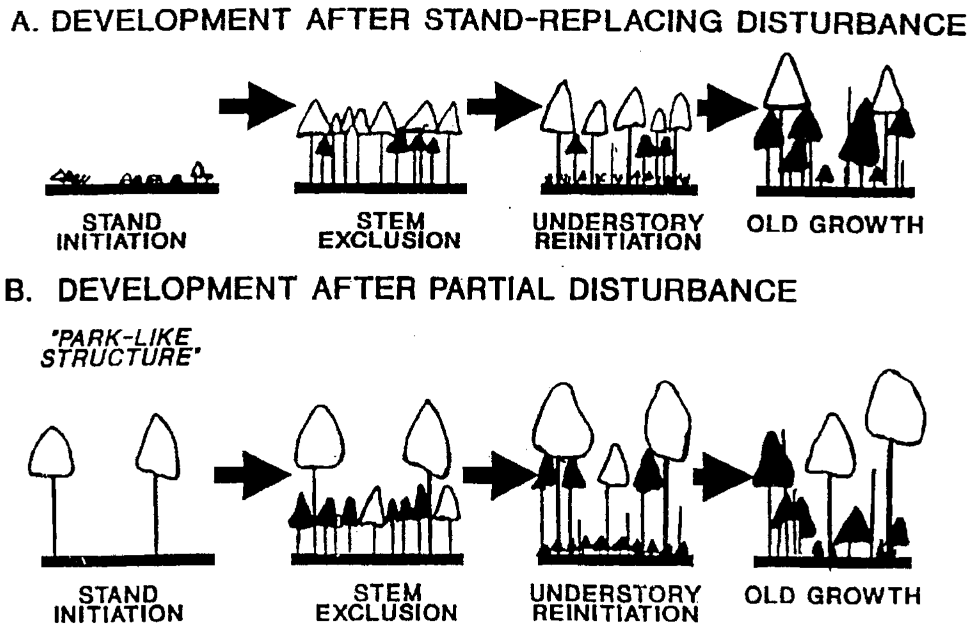
Stand Structures

Accumulation of carbon is a characteristic of stand structures, depending on local conditions of soil, climate, disturbance,and other factors (Oliver and Larson 1990) (Figure 2).

These structures change with time and disturbances and eventually become susceptible to insects, diseases, fires, and other agents (Harvey 1994). Following disturbances and the associated release of carbon, the forests regrow through similar or different structures, again depending on local conditions.

Historically, these disturbances often covered large areas, but left "refuges" of "old growth" and other closed forest habitats where plants and animals requiring these structures survived. Plants and animals requiring open areas increased in numbers and avoided genetic inbreeding by out-

FIGURE 2. Stands in the Inland Western United States develop after both stand-replacing and partial disturbances. They change through a variety of structures as they grow. Each structure is suitable for some species and not others. White tree crowns represent shade intolerant species (e.g., pines and larch); dark crowns represent shade tolerant species (e.g., Douglas-fir and true firs). From Johnsen et al. 1993.



breeding during times of abundant habitat immediately after disturbances. With forest regrowth, "open" (stand initiation) areas became more isolated and eventually became refuges where small populations of "open" species survived. Concomitantly, the "closed" forest increased, as did the ability of closed forest species to outbreed. This fluctuation may have been beneficial both to avoid genetic inbreeding of open and closed species and to allow genetic drift during times of isolation.

PRESENT CONDITIONS

Most forests in the Inland West now have large excesses of carbon and an excess of closed forests (especially the "stem exclusion" stage), thus setting the stage for widespread, catastrophic fires. They may be lacking "open" structures–creating shortages of species which utilize open areas (e.g., butterflies [Young 1992], goshawks [Reynolds 1992], bighorn sheep, lynx, *Penstemon lemhiensis*, *Penstemon attenuatus* var. militaris, *Cirsium subniveum*, and *Juncus hallii* [USDA Forest Service 1990]). The presently volatile condition is the result of natural processes in some places and past management in others.

Many forest ecosystems in the northern Rocky Mountains and Cascade Range developed naturally to high levels of insect infestation and then burned through catastrophic fires (Wellner 1973) at about 100 year intervals (Johnsen et al. 1993; Oliver et al. 1993). Many of these forests burned about 100 years ago; their present extreme insect and fire susceptibilities are probably within the natural range, although not necessarily desired by people.

Other forest ecosystems–such as the ponderosa pine forests of the southern Inland West, the Sierra Nevada Range, and low elevations of the Cascades and northern Rockies–historically had relatively benign, low intensity surface fires which kept the stands in open, park-like structures (Figure 2) (Wellner 1973; Covington and Moore 1994; Johnsen et al. 1993). Many decades of fire exclusion have allowed these fire-adapted ecosystems to grow from open, park-like structures to overly crowded stands with high levels of biomass and insect infestations. These conditions are not within the historical range of variability of these stands and will probably result in catastrophic, stand-replacing fires and reburns–which are also not part of the historical condition of these stands (Mutch et al. 1993).

If the fires occur naturally, they will probably be on such extreme scales that they will reduce the amount of closed forest habitat enough to threaten or extirpate species which need these conditions, as well as endanger people, property, and the future productivity of affected forests.

OPPORTUNITIES TO IMPROVE FOREST HEALTH THROUGH MANAGEMENT

Forest health management can prevent extremely severe fires over large areas by removing excess carbon. The carbon which is removed can be utilized as timber products, thus both substituting for more polluting products and keeping the carbon from being released to the atmosphere as carbon dioxide. This approach can incorporate a wide range of tradeoffs (Figure 1b).

To manage for forest health, the various stand structures, levels of carbon accumulation, and populations of plants and animals would be allowed to fluctuate across each landscape, but minimum amounts of each structure and process would be maintained within a target range. Even with unlimited funds, it will not be possible to engineer forest landscape patterns in great detail because of natural and management-induced variations in stand structures, disturbances, soils, and climate. Across a broad area, management of different landscapes could be roughly coordinated to maintain the fluctuations of stand structures out of synchrony. For example, when one landscape area had large amounts of "old growth" and minimum amounts of "open" areas, a contiguous landscape area could have large amounts of "open" areas and minimum amounts of "old growth."

The appropriate range of variability for structures, processes, and populations can be described for each ecosystem. The historical range of variability would be used as a reference to judge appropriate ranges; however, it may sometimes be appropriate to manage outside the historical range of variability to protect endangered species or valuable properties, to emphasize other values, or to account for changes in climate or species. When outside this historical range of variability, scientific recognition of the departure and recognition of the possible consequences are important. Research can help refine reference ranges of variability.

Exact target amounts of each structure, process, and population will not be necessary to begin management. The information which can be gathered about forests is infinite, and delaying management until more information is gathered can create long delays, during which time catastrophic wildfires of hundreds of thousands of acres will probably have occurred. Delaying operations can also cause equipment owners and skilled labor and professionals to leave the region, so that operations can no longer be performed even if a decision is made to do them. Much management can be done with existing knowledge, since there has been a legacy of over 50 years of intensive research on forests (Baker 1934; Toumey and Korstian 1937; Lutz and Chandler 1946; Smith 1962 and 1986; Daniel et al. 1979; Spurr and Barnes 1980; Kimmins 1987; Hunter 1990; Oliver and Larson 1990).

Management of ecosystems for forest health, like other biological processes, never did or will achieve precise conditions because of the variability of biological and logistic factors. Neither human nor natural disturbance (or other processes) ever provided perfectly predictable structures or patterns in ecosystems; consequently, all forest species are adaptive in their requirements. It will probably be most effective for managers to proceed with trying to maintain or create conditions where all species, patterns, and processes are maintained across the landscape while improving these targets through interacting with the scientific community and through adaptive management (Walters 1986; Everett et al. 1993a).

TOOLS FOR MANAGING FOR FOREST HEALTH

Many tools exist or are rapidly being developed to allow management to create and maintain a targeted variety of forest conditions across the landscape and over time. Some tools are new, and others are modifications of well known practices. Analytical tools are used to determine what silvicultural operations to apply in each stand within a landscape to achieve and maintain the desired balance of conditions. Specific silvicultural operations are needed to achieve these desired structures.

Landscape Management Tools

Analytic tools are rapidly being developed which allow the projection of different stand structures and landscape patterns through time across landscape areas. These tools integrate traditional inventory systems, satellite imagery, geographic information systems, stand projection models, and silvicultural decision keys (Boyce 1985; Oliver et al. 1992; O'Hara and Oliver 1991). They allow rapid visualization of consequences of various management alternatives. They will be very efficient both at determining costs and tradeoffs of various alternatives and implementing desired management directions once the costs and tradeoff decisions have been made.

These tools are not yet readily accessible; however, management can proceed while these tools are being developed. The local manager can subdivide forests into landscape management units along topographic boundaries. On each landscape management unit, the manager can then begin doing operations in those structures which are in extreme excess to create more of those structures which are in extreme shortage. This initial management is highly unlikely to interfere with the more detailed plans developed through the landscape tools, since both objectives will be to reduce the extremes of structures. The initial management will also give local managers understanding and ability to contribute to developing the landscape tools. As the tools become more refined, the ability to determine appropriate ranges of structures can be refined to account for differences in geomorphologic origin, climate, species ranges, and other factors.

Silvicultural Operations

Specific silvicultural operations can be used to create the desired stand structures and biomass accumulations within each stand. These operations include:

- control of tree density and species composition;
- salvage of dead or dying trees to reduce the amount of carbon on the site–and so reduce the potential for unplanned fires or reburns;
- regeneration to achieve the targeted mixture of tree, shrub, and herb species and genotypes at the desired time and place;
- site preparation to reduce undesired fuel, soil, or vegetation conditions;–competition control to encourage targeted species and avoid excesses or non-targeted species (e.g., introduced weeds);
- grazing with domestic or wild animals to obtain and maintain appropriate tree, shrub, and herb mixtures. Silvicultural regimes can also be designed either to encourage or discourage animal grazing;
- fires to reduce carbon buildup in dry fuels or living trees, to control species compositions, and to recycle nutrients;
- productivity enhancement through fertilization, which may also increase tree resistances to insects and diseases;
- gene management for trees, shrubs, and herbs to develop races which are resistant to introduced pests;
- evolving operations to achieve new targets; such operations include creating snags for cavity nesting birds, and creating down logs in appropriate conditions for mushroom production.

These and other silvicultural operations can be used to alter stand structures and landscape patterns. They can be used to enhance wildlife habitat, fish and riparian habitat, forest health, recreation, timber production, and other values as needed.

Integrated Management of Wildlife, Fish, and Pests

Wildlife, fish, and pest management can utilize both silvicultural operations and other techniques to control habitats and population sizes of target, predator, and prey species. This integrated management is most advanced in pest control through "integrated pest management." Through this technique, insect and disease populations are controlled, but not eliminated, using an integration of pest management tactics in a systems approach based on anticipated consequences of the pest behavior.

Maintaining forest health will often require more intensive management than is needed for single commodity production. It is pro-active management. Various portions of the ecosystem will need to be accessed to thin stands. Where roads are undesirable, too expensive, or liable to cause too much stream sedimentation, other forms of transport could be used. Helicopters or balloons may be an alternative. Like other management operations, the cost of a transport system may need to be justified through the joint production of commodity and non-commodity values, including forest health.

OFFSETTING THE COST OF FOREST HEALTH MANAGEMENT

The various operations needed to maintain forest health will create employment but may represent a cost, although probably not as high a cost as fighting and recovering from uncontrolled fires and pest epidemics. The removed trees can be manufactured into timber products to help offset the cost of removing the trees. Timber products are also an environmentally sound substitute for energy-intensive steel, aluminum, plastic, and concrete (Kershaw et al. 1993), or for timber removed from other places (and other countries) with fewer environmental safeguards.

Managing for forest health while jointly producing other values such as timber can be more cost-efficient than managing for forest health alone (Lippke and Oliver 1993a,b; Oliver et al. 1994). The cost of joint production, however, will often be higher than the cost of managing for a single product such as timber. Forest health management would sometimes mean that a forest area would forego maximum timber production to maintain certain uneconomical (for timber production) structures so the landscape maintains all desired patterns and processes.

Where forest health, wildlife habitat, recreation, or other values are high, these values can help pay the cost of creating and maintaining the structures which are uneconomical solely from a timber production perspective. The joint production of two or more values reduces the cost of producing either value individually. Such joint production practices have been considered as "below-cost" timber sales when values other than timber were not considered to benefit from the operation.

OVERCOMING BARRIERS TO FOREST HEALTH MANAGEMENT

Various institutional barriers have inadvertently developed which impede forest health management. These barriers include organizational structures, conflicting laws, funding, and research needs.

Organizational Structure

Organizational Structure and Management–Forest management can be more responsive to local or impending forest health conditions if local managers have the authority and responsibility to plan and implement management over local areas–a bottom-up management approach. This management approach allows improved knowledge to be incorporated efficiently in the diverse forest areas through a "flexible systems" approach (Reich 1983). Upper levels of management are useful in a bottom-up approach to coordinate information, direction, resources, and effort to allow local managers to do their job more efficiently.

This flexible systems (bottom-up) approach allows rapid incorporation of new knowledge into management; it allows specific prescriptions to be applied to local circumstances; it allows rapid response to changes induced by unexpected perturbations; and it allows rapid implementation so that skilled labor is not lost and biological opportunities are not foregone during a planning period.

Although the U.S. Forest Service was initially organized to allow local flexibility, many existing laws and practices discourage this "bottom-up" approach. For example, the long time required to change a forest plan means local managers are either operating under outdated plans or are doing no operations until the plans are completed–both of which can be counterproductive. NEPA (National Environmental Protection Act) guides and sets standards, rather than allowing local managers to respond to local conditions. State Forest Practice laws controlling private lands also generally set uniform regulations which do not allow adjustment to local condibe extremely inefficient by the collapse of the Soviet Union. "Top-down" planning relies on the creativity of a few planners, who simply cannot anticipate all conditions. Consequently, others in the system use much of their creativity to circumvent inefficiencies created by central planning.

A bottom-up management style could be effective in forest management through utilizing elements of the U.S. income tax system and medical system. Similar to the payment of income taxes, each local manager would be responsible for managing for the common goal of forest health, but could solicit advice from technical and scientific experts. Line officers would be evaluated and rewarded on their contributions to managing for forest health. Resource specialists in recreation, wildlife, timber production, and other functions would be evaluated and rewarded on how well they used their special knowledge to contribute to the overall objective of forest health, rather than on how well they defended their functional specialty.

A group of "auditors" would occasionally inspect various local management systems, both to offer constructive criticism and to stop any willful deviations from primary objectives. The U.S. medical doctors similarly prescribe treatments on a case-by-case basis, rather than through uniform standards. The doctor is, however, responsible and accountable for using up-to-date scientific and technical knowledge.

Organizational Structure and the Public–Part of the public has lost confidence in the technical ability of foresters. Their credibility needs to be regained through an organizational system which encourages management decisions supported on a scientific basis, a commitment to managing forests using techniques that achieve historical ranges of variability, and a commitment to full public participation in forest management decision making.

Problems in management organization and training of public and private forest management entities have led to failure to communicate with the public and between hierarchial levels of organizations. This "dysfunction" has not allowed different levels of management or the public to realize or understand either the change in ecological theory from the "steady state" to "constant change" or the change in management paradigm from primarily commodity production to primarily forest health maintenance.

An organizational approach which reduces dysfunction was first developed in the United States in the 1930s (Feigenbaum 1951) and expanded in Japan under such names as "statistical process control" and "total quality control" (Deming 1982). It is recently being adopted by many organizations in the United States.

As the concept of forest health management is being developed, these organization and management techniques can help with public coordination, with empowerment of local managers through bottom-up management processes, and with applying adaptive management.

Conflicting Laws

A strong role for politicians and upper level managers will be to ensure that local public and private managers are not encumbered by directives and federal, state, and local government rules and laws which work at cross-purposes. It may require a public decision to identify forest values as a "target" segment of the U.S. economy, followed by detailed examination and rewriting of pertinent legislation, to create the most favorable climate for management of forests for biodiversity. Such targeting and rewriting could produce extremely favorable results for maintenance of biodiversity, other commodity and non-commodity values, and employment under economically efficient conditions.

Specific laws could include incentives for managing for forest health on private lands, air quality regulations relative to controlled burning, and anti-trust laws requiring private landowners to coordinate harvest activities in order to maintain stand structure balances within a landscape of multiple ownerships.

Incentives for Managing for Forest Health on Private Lands–Forest health management on private lands will require more intensive silviculture (and more costs) than traditional commodity management. Except for prevention of pest outbreaks and fires, the public–not the landowner–derives most of the other forest health benefits such as species diversity. The private landowner, therefore, is asked to provide a public value. Mandating the providing of this value through regulations forces the landowner to spend more money on management than is otherwise efficient, which means the cost of timber increases. This raised cost shifts consumption to wood extracted from areas of fewer environmental safeguards or to non-wood substitutes (Perez-Garcia 1993) which are less environmentally sound (Kershaw et al. 1993).

Incentives would reward landowners for providing the public values, rather than punish them as regulations do (Lippke and Oliver 1993a,b). Incentives could be efficiently handled through a free market bidding of the contract to produce certain forest health values (e.g., a needed stand structure) within a landscape area. The landowner who could produce the value at the lowest cost through joint production with timber management and other values would be rewarded by receiving the bid.

Air Quality Regulations and Prescribed Burning–Scientists will need to describe–and regulatory agencies and the public will need to adjust to–the tradeoffs between smoke from increased prescribed fires to avoid wildfires, smoke from the otherwise inevitable wildfires, and ecosystem health requirements which include the presence of fires. There may need to be changes in regulations or basic laws to allow these adjustments.

Anti-Trust Laws and Managing Landscapes with Multiple Owners–Forest health management will require coordination of timber harvesting among private landowners in some areas. The landowners become liable for violation of the Sherman Anti-Trust Act if such practices are done in a cooperative manner. The competitive bidding described above can avoid this liability. Another approach is to require each landowner to maintain certain proportions of each structure and/or species populations on their lands, but with the ability to trade (buy/sell) acres of structure and numbers of animals with other landowners within a landscape unit (Oliver 1992b). This system is similar to the "tradeable pollution quotas" of the 1990 Clean Air Act. Such systems would be less subject to anti-trust violations if state laws mandate them.

Funding Allocations

Forest health management in the Inland West must also focus on the monetary means to achieve it. Special appropriations will probably be needed to do the extra forest operations necessary to maintain forest health. The degree to which the balance can be maintained will be directly related to both the efficiency of management and the funding available.

Management will be most efficient if funds are directed toward ecosystem health, rather than toward traditional functional targets such as timber, wildlife, recreation, grazing, or similar single values. The funds will also be most efficiently used if forest health management is done jointly with production of commodities, as discussed earlier.

Several sources of public funds have been described by Lippke and Oliver (1993b). Since forest health management would reduce the costs of fighting otherwise inevitable wildfires, it may be appropriate to fund forest health management from the same source that pays for very large forest fires.

Research Needs

It is important that some research and development be targeted to ongoing specific problem areas related to ecosystems and forest health. For example:

- Specific areas where basic information is needed to improve management can be identified by local managers;

- Incorporating research scientists into the adaptive management process will then increase the scientific accuracy and statistical soundness of monitoring and analysis;
- Continued research on forest patterns, disturbance processes, and populations will help maintain critical features, provided the research concentrates equally on all seral stages, species, and habitats;
- Research and development on information systems, management tools, and equipment will increase the efficiency of planning and implementing management at the landscape and stand levels;
- Research into commodities such as wood products that increase their ease of management or usefulness (and value) to society will reduce the cost (and increase the incentives) for a landowner to grow forests for forest health through the joint production process, as discussed earlier.

A SYSTEMATIC APPROACH TO ACHIEVING FOREST HEALTH

The above principles can be incorporated into a systematic process to manage for forest health. For example, an eight-step process is described below. All steps can begin simultaneously and be improved reiteratively in an "adaptive management" process to avoid further delays in improving forest health.

Step 1. Describe a historical range of variability of such elements as disturbance regimes, stand densities, species, and vegetation structures using all available information. Knowledge of this variability provides a reference for assessing the current condition and the range of desired conditions of the landscape–although historical ranges are references, not recipes (Everett et al. 1993).

Step 2. Assess possible current departures from historical ranges of variability to determine whether present trends are within or outside of these ranges.

Step 3. Involve scientists, the public, managers, and all landowners in determining an acceptable range of variability using this historical range as a reference.

Step 4. Involve all partners in developing strategies on a landscape scale to return trajectories within bounds of acceptable variation. To involve the public meaningfully, the process must do more than ask the public to ratify foregone conclusions and must be more than the compromises among well-represented interest groups (Hanrahan 1993).

Step 5. Use large areas to feature alternative forest health management strategies. The large areas and alternative strategies ensure that opportunities to promote forest health are not lost because they do not follow the prevalent theory (Walters 1986).

Step 6. Practice adaptive management techniques to be in a position to modify actions and prescriptions as new feedback information becomes available.

Step 7. Highlight consequences of alternative management actions so that various publics appreciate the effects of different alternative courses of action.

Step 8. Conduct education and awareness programs at all levels, both internally and externally, so that people understand the application of forest health management principles.

CONCLUSIONS

The serious decline of forest health in the Inland West can be attributed both to natural conditions and to management actions that did not fully recognize the role of disturbances in sustaining forest health. Diseases, insects, and fires have periodically occurred within the Inland West with different ranges of variability for different areas. The effective exclusion of fire over the past six to seven decades has changed the structure, species composition, and diversity of many forests. Other forests are naturally returning to conditions where they are susceptible to insects, diseases, and catastrophic fires. People, their property, and natural resources are at risk.

The solution to this forest health problem seems straightforward, but it has some significant barriers. The techniques, costs, and values of forest health management are different from timber extraction, fire fighting, or individual endangered species preservation. The difference is a shift toward proactive management to prevent excessive fires and insect epidemics and species declines, and away from reactive management to recover from them. The solution could start with thinning and harvesting to reduce the density of overcrowded stands. Where large quantities of standing dead trees are present, salvage logging could be encouraged to remove accumulations of fuels and to obtain wood products. Diverse silvicultural operations applied systematically within a landscape area can maintain biodiversity and reduce insect and fire hazards by creating a diversity of stand structures and levels of biomass. The silvicultural operations can include thinning, regenerating, selection and even-age harvesting, using prescribed fire, and creating snags, among others. Integrated management of pests, wildlife, and fish will help ensure their balance as well.

Successful management for forest health in the Inland West will depend on how well internal and external barriers can be overcome to allow the management to be done on a large enough scale to make a difference. Embarking on a major paradigm shift toward forest health management will also require a significant paradigm shift toward the public perceiving ecosystems as dynamic and changing. Placing the priority on valuing the health of entire ecosystems will require increased scientific understanding on the part of natural resource specialists and managers, as well as on the part of the general public, politicians, and regulatory agencies.

REFERENCES

Baker, F.S. 1934. Theory and practice of silviculture. McGraw-Hill New York. 502 p.

Botkin, D.B. and M.T. Sobel. 1975. Stability in time-varying ecosystems. *The American Naturalist* 109 (970): 625-646.

Boyce, S.G. 1985. Forestry decisions. USDA Forest Service General Technical Report SE-35. 318 p.

Covington, W.W. and M.M. Moore. 1994. Postsettlement changes in natural fire regimes and forest structure: Ecological restoration of old-growth ponderosa pine forests. In: pp. 153-181. Sampson, R.L. and D.L. Adams (Eds.). Assessing Forest Ecosystem Health in the Inland West. Proceedings of the American Forests scientific workshop, November 14-20, 1993, Sun Valley, ID. The Haworth Press, Inc. New York.

Daniel, T.W., J. Helms and F.S. Baker. 1979. Principles of silviculture. 2nd edition. McGraw-Hill. New York. 500 p.

Deming, W.E. 1982. Out of the crisis. Massachusetts Institute of Technology, Center for Advanced Engineering Study. Cambridge. 507 p.

Edmonds, R.L. 1991. Organic matter decomposition in Western United States forests. In: pp. 90-194. Harvey, A.E. and L.F. Neuenschwander (Comps.) Proceedings-Management and productivity of western montane forest soils. USDA Forest Service, Intermountain Research Station. Ogden, UT.

Everett, R., C. Oliver, J. Saveland, P. Hessburg, N.Diaz, and L. Irwin. 1993. Adaptive ecosystem management. In: pp. 361-375. M.E. Jensen and P.S. Bourgeron (Eds.). Eastside forest ecosystem health assessment, Volume II. Ecosystem Management: Principles and Applications. USDA Forest Service, National Forest System, Forest Service Research. Wenatchee, WA.

Everett, R., P.F. Hessburg, M. Jensen, and B. Bormann. 1993. Eastside forest ecosystem health assessment, Volume I. Executive Summary. USDA Forest Service, National Forest System, Forest Service Research. Wenatchee, WA. 57 p.

Feigenbaum, A.V. 1951. Total quality control. McGraw-Hill, Inc. New York. 851 p.

Habeck, J.R. and R.W. Mutch. 1973. Fire-dependent forests in the northern Rocky Mountains. *Quaternary Research* 3: 408-424.

Hanrahan, T.P. 1993. Soft systems analysis and public lands planning. Unpublished Masters of Science thesis. Washington State University, Department of Natural Resource Sciences. Pullman. 98 p.

Harvey, A.E. 1994. Integrated roles for insects, diseases and decomposers in fire dominated forests of the Inland Western United States: Past, present, and future forest health. In: pp. 211-220. Sampson, R.L. and D.L. Adams (Eds.). Assessing Forest Ecosystem Health in the Inland West. Proceedings of the American Forests scientific workshop, November 14-20, 1993, Sun Valley, ID. The Haworth Press, Inc. New York.

Harvey, A.E., M.F. Jurgensen and R.T. Graham. 1989. Fire-soil interactions governing site productivity in the Northern Rocky Mountains. In: pp. 9-18. Baumgartner, D.M. et al. (Comps.). Prescribed fire in the Intermountain Region, Symposium Proceedings, Washington State University, Cooperative Extension. Pullman, WA.

Harvey, A.E., M.F. Jurgensen, M.J. Larsen and R.T. Graham. 1987. Decaying organic materials and soil quality in the Inland Northwest: a management opportunity. General Technical Report INT-225. USDA Forest Service, Intermountain Research Station. Ogden, UT. 15 p.

Harvey, A.E., M.J. Larsen and M.F. Jurgensen. 1979. Fire-decay: interactive roles regulating wood accumulation and soil development in the Northern Rocky Mountains. Research Note INT-263. USDA Forest Service, Intermountain Forest and Range Experiment Station. Ogden, UT. 4 p.

Harvey, A.E., G.I. McDonald, M.F. Jurgensen and M.J. Larsen. 1994. Microbes: drivers of long-term ecological processes in fire-influenced cedar-hemlock-white pine forests in the Inland Northwest. In: Baumgartner, D.A. (Comp.). Interior cedar-hemlock-white pine forests: Ecology and Management. March 2-4, 1993. Spokane, WA. Washington State University, Cooperative Extension. Pullman, WA. In press.

Hessburg, P.F. 1993. Eastside Forest Ecosystem Health Assessment. Volume III. Assessment. USDA Forest Service, National Forest System, Forest Service Research. Wenatchee, WA. 750 p.

Hunter, M.L., Jr. 1990. Wildlife, forests, and forestry. Regents/Prentice Hall. Englewood Cliffs, NJ. 370 p.

Johnsen, C.G., R.R. Clausnitzer, P.J. Mehringer, and C.D. Oliver. 1993. Biotic and abiotic processes of eastside ecosystems: the effects of management on plant and community ecology, and on stand and landscape vegetation dynamics. In:

pp. 36-100. Hessburg, P.F. (Ed.). Eastside Forest Ecosystem Health Assessment. Volume III. Assessment. USDA Forest Service, National Forest System, Forest Service Research. Wenatchee, WA.

Jurgensen, M.F., A.E. Harvey, R.T. Graham, M.J. Larsen, J.R. Tonn and D.S. Dumroesse. 1990. Soil organic matter, timber harvesting, and forest productivity in the Inland Northwest. In: pp. 392-415. Gessel, S.P. et al. (Eds.). Sustained productivity of forest soils. Proceedings of the 7th North American Forest Soils Conference. University of British Columbia, Faculty of Forestry Publication. Vancouver.

Kershaw, J.A. Jr., C.D. Oliver and T.M. Hinckley. 1993. Effect of harvest of old growth Douglas-fir stands and subsequent management on carbon dioxide levels in the atmosphere. *Journal of Sustainable Forestry* 1(1): 61-67.

Kimmins, J.P. 1987. Forest ecology. Macmillan. New York. 531 p.

Lippke, B. and C.D. Oliver. 1993a. An economic tradeoff system for ecosystem management. In: pp. 337-345. Jensen, M.E. and P.S. Bourgeron (Eds.). Eastside forest ecosystem health assessment, Volume II. Ecosystem Management: Principles and Applications. USDA Forest Service, National Forest System, Forest Service Research. Wenatchee, WA.

Lippke, B. and C.D. Oliver. 1993b. Managing for multiple values. *Journal of Forestry* 91: 14-18.

Lutz, H.J. and R.F. Chandler, Jr. 1946. Forest soils. John Wiley & Sons. New York. 514 pp.

Mutch, R.W., S.F. Arno, J.K. Brown, C.E. Carlson, R.D. Ottmar and J.L. Peterson. 1993. Forest health in the Blue Mountains: a management strategy for fire-adapted ecosystems. USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-310. 14 p.

O'Hara, K.L. and C.D. Oliver. 1991. Silviculture: achieving new objectives through stand and landscape management. *Western wildlands* 17: 28-33.

Oliver, C.D. 1992a. Enhancing biodiversity and economic productivity through a systems approach to silviculture. In: pp. 287-293. The Silviculture Conference. Forestry Canada. Ottawa, Ontario.

Oliver, C.D. 1992b. A landscape approach: achieving biodiversity and economic productivity. *Journal of Forestry* 90: 20-25.

Oliver, C.D., D.R. Berg, D.R. Larsen, and K.L. O'Hara. 1992. Integrating management tools, ecological knowledge, and silviculture. In: Naiman, R. (Ed.). New perspectives for watershed management. Springer-Verlag. New York.

Oliver, C.D. and B.C. Larson. 1990. Forest Stand Dynamics. McGraw-Hill. New York. 467 p.

Oliver, C.D., L.L. Irwin and W.H. Knapp. 1993. Eastside forest management practices: Historical overview, extent of their application, and their effects on sustainability of ecosystems. In: pp. 216-288. Hessburg, P.F. (Ed.). Eastside Forest Ecosystem Health Assessment. Volume III. Assessment. USDA Forest Service, National Forest System, Forest Service Research. Wenatchee, WA.

Oliver, C.D., C. Harrington, M. Bickford, R. Gara, W. Knapp and G.Lightner. 1994. Maintaining and creating old growth structural features in previously disturbed stands typical of the eastern Washington Cascades. In: pp. 353-387. Sampson, R.L. and D.L. Adams (Eds.). Assessing forest ecosystem health in the Inland West. Proceedings of the American Forests scientific workshop, November 14-20, 1993, Sun Valley, ID. The Haworth Press, Inc. New York.

Olsen, J.S. 1963. Energy storage and balance of producers and decomposers in ecological systems. *Ecology* 44: 322-331.

Perez-Garcia, J.M. 1993. Global forestry impacts of reducing softwood supplies from North America. CINTRAFOR Working Paper 43. University of Washington College of Forest Resources Center for International Trade in Forest Products. 35 p.

Reich, R.B. 1983. The next American frontier. The New York Times Book Co. New York. 324 p.

Reynolds, R.T. 1992. Quoted from Seattle Post-Intelligencer Newspaper, p. A-1 & A-6. November 9, 1992. Mr. Reynolds is a research wildlife biologist, USDA Forest Service, Rocky Mountain Station. Fort Collins, CO.

Smith, D.M. 1962. The practice of silviculture. 7th edition. John Wiley & Sons. New York. 578 p.

Smith, D.M. 1986. The practice of silviculture. 8th edition. John Wiley & Sons. New York. 527 p.

Spurr, S.H. and B.V. Barnes. 1980. Forest Ecology. 3rd Edition. John Wiley & Sons. New York. 687 p.

Stevens, W.K. 1990. New eye on nature: the real constant is eternal turmoil. New York Times. Science article. Tuesday, July 31, 1990. B5-B6.

Toumey, J.W, and C.F. Korstian. 1937. Foundations of silviculture upon an ecological basis. John Wiley & Sons. New York. 456 p.

USDA Forest Service. 1990. Final environmental impact statement. Trail Creek Timber Sale, Beaverhead National Forest. Dillon, MT. 122 p.

Walters, C. 1986. Adaptive management of renewable resources. Macmillan Publishing Company. New York. 374 p.

Wellner, C.A. 1973. Fire history in the northern Rocky Mountains. In: pp. 42-64. The role of fire in the Intermountain West: Proceedings of the Intermountain Fire Research Council. October 27-29, 1970. University of Montana. Missoula.

Young, M.R. 1992. Conserving insect communities in mixed woodlands. In: pp. 277-296. Cannell, M.G.R., D.C. Malcolm, and P.A. Robertson (Eds.). The Ecology of Mixed-Species Stands of Trees. Blackwell Scientific Publications. Boston, MA.