THE CONTRIBUTION OF OLD GROWTH TO THE NEW FORESTRY

Jerry F. Franklin

Professor of Ecosystem Analysis
College of Forest Resources, University of Washington

and

Former Chief Plant Ecologist, USDA Forest Service
(retired 1992)
Pacific Northwest Research Station
Seattle, Washington

Lecturer

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This paper contains Jerry F. Franklin's major public address given on 4 April 1990.

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Dr. Franklin has travelled widely and is internationally renowned. We are pleased that he agreed to include the University of Alberta among his destinations.

JERRY F. FRANKLIN

Dr. Jerry F. Franklin was a research scientist for USDA Forest Service Pacific Northwest Research Station for over 30 years. He is currently Professor of ecosystem analysis in the College of Forest Resources, University of Washington.

Dr. Franklin received his B.Sc. degree in forest management from Oregon State University in 1959, his M.Sc. degree in forest management from Oregon State University in 1961, and his Ph.D. degree in Botany with a minor in soils from Washington State University in 1966. During 1973-75, he was loaned to the National Science Foundation to serve as Director of the Ecosystems Study program.

He has worked in four major areas of technical specialization. These include the structure and functionä of natural ecosystems, especially old growth forests; successional processes following catastrophic disturbances; effects of changing environmental conditions on forest processes; and silvicultural systems for forest treatment. He has published over 250 other papers. Among other professional activities, he has served on the Board of Governors of the Nature Conservancy since 1978; is currently now President ofä for the Ecological Society of America; and is on the editorial boards of Applied Ecology and Ecological Applications. He is Chairman of the Long-Term Ecological Research (LTER) Coordinating Committee and is a Councillor of the International Association of Landscape Ecologists.

THE CONTRIBUTION OF OLD GROWTH TO THE NEW FORESTRY

ABSTRACT

Research on old-growth and other natural forests during the last two decades has provided a wealth of new information and perspectives on forest ecosystems and how they function. Among the findings are a greatly enhanced appreciation of the complexity of natural forest ecosystems, mechanisms for ecosystem recovery following natural disturbances, and the necessity to consider larger spatial scales. Natural forests have a richness of organisms and processes, much of which is linked to their characteristic structural complexity. Recent research on natural disturbances has increasingly clarified the importance of biological legacies of living organisms and organically-derived structures, such as snags and down logs, in providing for perpetuation of complex natural ecosystems. The importance of large-scale or landscape perspectives has been clarified by research on issues such as cumulative effects and forest fragmentation.

There are strong indications that alternative approaches to forest management are needed. These should reflect the need to base stewardship on the most current scientific information; and to incorporate society's increasing concern with sustained productivity. The objective in New Forestry is development of forest management systems which better integrate commodity production with maintenance of ecological values. At the stand level the basic principle of New Forestry is maintenance of structurally complex managed forest systems; this contrasts with the structural and compositional simplification that is characteristic of current intensive forest management practices. At the landscape level the basic principle of New Forestry is to consider effects of management practices over large spatial and temporal scales. This includes such issues as the arrangement of different patch types and sizes, and integration of reserved areas with commodity lands to produce a diversified landscape.

Based on a talk given on January 19, 1990 at "Forests Wild and Managed: Differences and Consequences", a symposium at the University of British Columbia and ecological values, including biological diversity. "New Forestry" is a concept which attempts to do this.

INTRODUCTION

I appreciate being here and having this opportunity to talk to you about old-growth forests as well as some different ways of looking at our managed forests. I want to begin by simply reminding you that here on the northwestern coast of North America, we share the most incredible temperate forests in the world, bar none. They really do not take a back seat even to the tropical forests in terms of their complexity and richness. This Pacific coastal region supports the most massive and among the most productive forests that exist anywhere in the world. They represent the largest organic accumulations of any of the world's ecosystems. The trees species composing the forest are both the largest and longest-lived representatives of their general and are further noteworthy because of their ability to sustain significant growth for several centuries.

The use of these forests has become increasingly controversial. Indeed, what we're looking at, in forestry and in forest resources management is a revolution. This is not very surprising when you reflect upon it, because the practices that we're using today were, in their fundamentals, laid down many decades ago—in the late 1940's on national forest lands in **Oregon and Washington.**

So much has happened in the last few decades—in terms of increased knowledge about these forests and changes in our societal objectives—that a reassessment of forest practices is long overdue. We need to step back and take a fresh look at what we're doing and why we're doing it.

I think that most parties to the controversies recognize the need to develop some practices which do a better job of accommodating ecological values at the same time that we're trying to provide for some level of commodity production; to create what I've sometimes called a "kinder and gentler" forestry or, as it is popularly known, a "New Forestry".

Tonight I want to talk about old-growth, some of the controversies, and the potential role of New Forestry.

SCIENTIFIC UNDERPINNINGS OF NEW FORESTRY

The scientific knowledge that is both driving the need, and providing the basis, for some changes in our forestry practices is a good place to begin. I emphasize the scientific underpinning because there are people on both sides of the issue who suggest that new forestry is a facade—smoke and mirrors—lacking scientific substance. In fact, it is most emphatically based on peer-reviewed scientific research, particularly research during the last 20 years on natural forest ecosystems and how they work.

It is only very recently that we examined these forests as ecosystems. Indeed, serious ecosystem research on natural forests in the Pacific Northwest began just a little over two decades ago, with National Science Foundation Support of the International Biological Program's Coniferous Forest Biome project in 1969 (Edmonds 1982). This project and other ecosystem research programs have yielded a tremendous wealth of new knowledge. I will present some of it here under three topical headings: (1) ecosystem complexity; (2) "biological legacies" or aspects of ecosystem regeneration following catastrophic disturbances; and (3) landscape ecology perspectives. While these subject areas are not new, I think that the richness of the scientific information base and its relevance to forest management issues really is new.

Ecosystem Complexity

We have discovered from our research that natural forests are very complex. More complex than we could have imagined, as Chris Maser is fond of saying.

To begin with, these natural forests contain a richness of species. We can take mammalian species as one example. Diversity of mammal species varies with successional stage in Douglas-fir forests (Fig.1)[1]. This pattern exhibits high levels of diversity (many species) in the open ecosystem prior to tree canopy closure. This diversity is a mixture of both forest species and weedy pioneer species. Diversity collapses to much lower species numbers when the forest canopy closes and then recovers to intermediate levels of diversity in the mature and old-growth stages. This is a very common pattern; it is similar for many other groups of organisms including birds, fishes and many types of invertebrates.

A critical point is that, although the early successional (pre-canopy closure) stage has more total species, many of the species found in the mature and the old-growth forests have specialized habitat requirements. They often require conditions that are only found in older stages of forest succession and, hence, are found primarily in those kinds of forests. The northern spotted owl is a good example of that kind of organism.

Equally or perhaps more important, and as yet largely unrecognized, are the incredible levels of invisible or "hidden" diversity which exist in natural forests, diversity which is critical to the functioning of these forests. The diversity of invertebrates, for example, and of fungal species, groups of organisms that we really don't think much about, let alone catalog and study. For example, old-growth forests, to the degree that they have been studied, appear to be very rich in invertebrate species. Schowalter (1988) found 61 species of arthropods in canopies of old-growth forests and only 16 species in adjacent young, managed stands. Furthermore, most of the old-growth invertebrates were species that prey upon or parasitize other kinds of invertebrates—insects that kill bark beetles or aphids, for example. This is a very much healthier situation than in the young stands where invertebrate communities were dominated by organisms that prey on plants, such as the aphids. So, there is not only a richness of species in these natural forests, but many that do specialized and very important kinds of "work".

The studies of species richness boil down to the simple recognition that mature and old-growth forests are biologically diverse ecosystems and not biological deserts. They never were

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[1] Not available at time of print

deserts; they only seemed to be, as viewed from such narrow perspectives as production of some game species.

We also see in natural forests a great richness of process. Sources of nitrogen for the forest ecosystem provides a good illustration. Thirty years ago, we had few ideas about how nitrogen was brought into these systems; as you know, the air is full of elemental nitrogen but a few organisms can convert or "fix" it into biologically useful forms. In recent years ecosystem scientists have identified numerous pathways by which nature provides for nitrogen additions to the ecosystem. An important early discovery in IBP was the role of foliose lichens, large leafy lichens, which live in the canopies of old-growth Douglas-fir trees, in nitrogen cycling. These lichens are estimated to fix five to nine kg/ha/yr of nitrogen, a significant addition to these forest systems. Other routes for nitrogen additions include fixation by microbes living in rotting logs and in the rhizosphere or regions immediately around the tree roots.

Scientists have also discovered that the mature and old forests are very productive by any kind of ecological or biological definition. It really couldn't be any other way given the amount of "green" or chlorophyll that's out there in those old-growth forests. Trees do not retain leaves that lack a net benefit in terms of photosynthesis. And there are a lot of leaves out there, as any-one can see! So the older forests are, in ecological terms, as productive as most young forests. The difference is that in older forests a lot of the productivity is being used in respiration—to maintain the incredible accumulated biomass—rather than for production of additional wood. Hence, from a forester's perspective, older forests are viewed as unproductive forests because they are not growing many additional "boards". Much of the tree growth is offset by tree mortality. To the degree it has been studied, however, older forests are very stable in terms of wood volumes and many even continue to gradually accumulate additional merchantable wood (DeBell and Franklin 198__)[2]; virtually all of these old forests continue to have net accumulations of organic matter (stored carbon).

Another thing that we see increasingly are the incredible linkages that exist in these forest ecosystems; the richness of webs of various kinds, of functional relationships. One very fine example is the part of the forest that exists below ground. Although the below ground sub-system makes up only twenty percent of the biomass of the forest, it has such high rates of turnover that as much as fifty to seventy percent of the photosynthate produced by the forest may be required for its maintenance. This certainly underlines the importance of trees as energy sources fuelling the soil subsystem. Dave Perry identifies the tree roots as "white holes" providing the very lifeblood of soils by pumping energy into them. And, of course, there are the mycorrhizae and mycorrhizal relationships which are increasingly recognized as critical linkages not just between trees and their soil environment but also between trees and between plants in the overstorey and in the understorey. Through fungi and other organisms the soil subsystem is, in fact, a highly interlinked living system.

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[2] Not available at time of print

The extremely high-quality water yielded by old-growth forest systems is a consequence of the complexity and richness of the below-ground system. Tight biological linkages reduce nutrient leaching and, hence, levels of dissolved materials in these water. The extensive root mass helps reduce levels of various kinds of erosional events thereby reducing sediment levels in surface waters.

The forest canopy is a second subsystem that is exciting because of its richness and complexity. The canopies in old-growth Douglas-fir forests represent truly immense surface areas which are interfaces between the forest and the atmosphere. We can imagine the canopy as a giant atmospheric scavenger which condenses large amounts of moisture from the atmosphere and precipitates dust and other atmospheric particulates, bringing these materials into the ecosystem. Of course, these canopies also provide large and diverse areas of habitat for various kind of organisms.

Imagine the volume of space that is occupied by one of these ecosystems where the canopy extends seventy or eight metres into the atmosphere. A single old-growth Douglas-fir tree, has around an acre of foliar surface area! So you can imagine the canopy surface area of a whole forest of these trees. That is one reason that these forests are so effective at scavenging the atmosphere. In some of our forests condensation from fog and low clouds adds very significantly—a net of 882 mm/yr in one case (Harr 1982)—to the moisture inputs into old-growth dominated watersheds and, consequently, to the level of streamflow.

Riparian areas provide a third example of a highly interlinked and ecologically rich subsystem which previously we had not adequately appreciated. The linkages between forests and streams are proving numerous, complex, and critical to stream functioning. For example, we started 20 years ago by thinking about forests primarily in terms of their influence on temperature regimes of streams. More recently we have recognized that forests also provide the critical structural features for streams (e.g., in the form of woody debris) and diverse allochthonous inputs (litter and other organic materials) that are the streams' energy and nutrient base.

Structural complexity or diversity in natural forests is recognizably the key to much of the richness of organisms, of habitat, and of processes. Some of this structural complexity can be defined in terms of individual structural features, as has been done in many current definitions of old-growth forests. These individual structures include large old-growth trees, large snags or standing dead trees, and large downed logs.

Coarse woody debris—standing dead trees and downed logs—is an important element of structure. In reflecting on my career as a forester I find it difficult to understand why it took me so long to appreciate the contribution that dead wood structures make to ecological functioning in a forest. Those contributions range all the way from geomorphic functions, such as in influencing erosional processes; to biological diversity, such as in providing habitat for a broad array of vertebrate and invertebrate organisms; and to providing long-term sources of energy and nutrients for these systems. From an evolutionary point of view we need to remember that large, woody structures have been around for a long time and that there has been a lot of animal and microbial evolution in association with these kinds of habitats.

Big pieces of wood are at least as important to streams as to forest ecosystems. Wood is a major element in creation of stepped structures in these systems and moderates various erosional processes. Woody debris is important in the larger rivers and estuaries, as well as in small streams although it plays different roles; your fisheries people can provide you with detailed information.

One of the keys to the overall structure, the "gestalt" of the old-growth forest, is the spatial heterogeneity that is present. Large trees, large snags, and large downed logs are important individual structural components of old-growth forests, but we also have to recognize that the forest as a whole has some structural attributes. It is not just the sum of a few individual pieces. For example, there are gaps in the natural forest—places where light levels are higher and there is rich development of the understorey. And areas that are the reverse of the gap ("anti-gaps")—very heavily shaded locales where a dense overstorey of hemlock and cedar prevent the establishment of almost any green plant on the forest floor. This variability in light conditions helps create the incredible complexity and richness of the understorey in these forests. The importance of diverse and well-developed understories is illustrated by the critical relation between old-growth forest structures and Sitka black tailed deer in the coastal forests of the Tongass National Forest. Research by Paul Alaback and others has also shown that the development and maintenance of these diverse understorey plant communities is complicated—not just a matter of allowing more light, for example.

What can we conclude with regards to forest complexity? The essence is that most (all?) of the parts of a forest ecosystem have value—fulfil some functional role; that complexity has value. The inference is that simplification should be approached with considerable caution. Research has also shown us that old-growth forests have intrinsic value; that they perform many functions, including many which are of direct interest to human beings. Old-growth forests are neither biological deserts nor cellulose cemeteries; rather, they are rich and diverse ecosystems that fulfil many ecological functions very well.

Biological Legacies

"Biological legacies" is a short-hand identification of the second scientific concept that I want to discuss. It relates to the way ecosystems recover from disturbances. Mount St. Helens provided a unique object lesson to scientists, one that presumably won't be repeated in my lifetime; a lesson in the way that nature perpetuates complexity, for richness, in the regenerating ecosystems which develop following a catastrophic disturbance.

As we looked at our TV sets on May 18, 1980 we thought that Mount St. Helens had provided us with a moonscape to study. "Oh, boy, we get to watch succession start from scratch! It's got to start all over again." However, from our first minutes on the ground in the devastated zone ten days later, we encountered incredible legacies of living organisms, survivors of the eruption. As I took my first steps from a helicopter I encountered hundreds of fireweed sprouts, ants scurrying about, the excavations of pocket gophers, etc.

We discovered that many kinds of organisms had survived within the devastated Mount St. Helens landscape utilizing a wide variety of strategies. Essentially the only organisms that had been lost were the birds and the large mammals that lived above ground. Anything which was living below ground or could regenerate from parts protected below ground or was buried in a snow bank or in the mud at the bottom of a lake, or in any of a number of other environments, was able to survive. From seeds to spores to full-size organisms, an important key to early recovery at Mount St. Helens was survivors. In addition to that living legacy, there was also an immense legacy of organic matter and, most importantly, biologically-derived structures—snags and downed logs, large soil aggregates, etc., in the landscape.

The importance of biological legacies, both living and dead, stimulated us to rethink ecosystem responses to other catastrophic events. "Now what does happen following a fire? What happens following a windstorm? What happens following clear-cutting?" Our review quickly reminded us that while natural catastrophes typically kill trees and other organisms, they leave behind most of the wood, most of those structures or dead legacies, as well as many living organisms.

In most cases natural forest systems do not really start from scratch at all; biological legacies provide them with a running start at richness and complexity. Hence, we see young natural forests with substantial structural and compositional diversity. For example, a 70-year-old Douglas-fir stand at Mount Rainier National Park, developed following a wildfire, has large standing dead trees, many large downed logs, and some large and old green trees which survived the fire, as well as an abundance of young trees.

The concept of biological legacies really isn't new, but it has been nearly ignored in our textbooks. We have emphasized the need for migration and re-establishment of individuals in barren areas. Although we knew about biological legacies we really did not appreciate their significance. (Perhaps one reason is the historical emphasis on old-field succession in ecological research; such environments probably offer minimum levels of legacies compared with other types of secondary succession, e.g., those that follow fire.) And so one of the things that we have tended to do in talking about forestry practices is to persist in representing practices like clear-cutting and broadcast slash burning as being similar to natural processes. This is clearly not an accurate portrayal. It is not generally the way that nature does it and never was. Although clear-cutting is often a very effective way of accomplishing some of our objectives, it is not the way that nature perpetuates ecosystems.

Landscape Perspectives

The landscape perspective is the third scientific topic that I want to discuss. This refers to the need to consider larger spatial and temporal scales than has traditionally been the case in forestry. It means thinking beyond the individual stands or patches to drainages and to mosaics of patches and to long-term changes in these mosaics. Here in coastal northwestern North America we can recognize immediately that the kinds of landscapes that nature created were mosaics of large heterogeneous patches. We can also recognize, as in the Washington Cascade Range, that the landscapes often had complex attenuated boundaries between patches. This contrasts starkly with the landscape pattern that we have been creating through our management practices on National Forest lands in Oregon and Washington—small homogeneous patches with sharp, straight boundaries.

We resource managers first began to consider landscapes seriously in dealing with management of large animals—ungulates, such as elk, or wide ranging predators, such as the grizzly bear. I suspect that this was the first widespread recognition that, "Oh, yeah, we've got to think about more than just 25 or 40 acres. We've got to think about large areas."

That got us into landscape ecology. Unfortunately, we've learned more about landscape ecology from dysfunctional landscapes, landscapes that are not working well, than we have by studying really healthy landscapes. One example is in the southeastern United States where we have created extensive pine monocultures that are outstanding opportunities for outbreaks of the southern pine bark beetle.

Closer to home, the cumulative effects issue has exposed us to another class of dysfunctional landscapes. Many of our cumulative effects are a consequence of the fact that, after you clearcut an area, there is a period of time where you have increased potential for certain kinds of undesirable hydrologic or geomorphic events, such as landslides or more intense rain-on-snow flood events.

Rain-on-snow events are an interesting phenomenon. They are a consequence of the fact that along the Pacific northwestern coast much of the mountain landscape is part of a "warm snow zone". This is an area where snowpacks develop during cold fronts; then a warm front may bring in warm air and rain which melts the snow pack. High flows result from the combined run-off of the melted snowpack plus the additional rainfall. Essentially all significant flood events in northwestern North America are rain-on-snow events, from Alaska to northern California.

Looking at the hydrology of these events we find that old-growth forests have a low potential for contributing to rain-on-snow events compared to cutovers or young forests. Several factors are involved. For one thing those huge canopies with their stiff branches intercept a lot of the snow which then evaporates or sublimates back into the atmosphere. Much more of it melts, drips to the ground, and enters the soil. Some snow does form a snowpack on the forest floor, of course. As any of you who've been in an old-growth forest after a wet snow knows, it gets in there in big blobs, and sets up in irregular hard snowpacks in the understorey. So there is less snow and the old growth forest cover protects it from both the warm air and rains that cutovers are exposed to. Hence, the contributions of old-growth forests to rain-on-snow flood events are typically much lower than those from recently cut areas.

In clearcuts, snow accumulates to maximal depths because none of it is intercepted. And it is exposed to the warm air and rains which melt it and convert it to runoff. Consequently, you can dramatically exacerbate flood events if you do not pay close attention to how much of your landscape is in a freshly cutover state at any point in time.

Fragmentation is another example of landscape dysfunction and a stimulus to think at larger spatial scales. Fragmentation results when forest cover is broken into small pieces or patches that cannot function effectively in providing interior forest environments. This has been a particular problem for us on federal lands in Oregon and Washington where we have used a dispersed clearcutting system, as I will point out later. Please note, that if you create large continuous clearcuts, as has been done in much of coastal British Columbia, there is no problem with fragmentation. You have to leave some forest behind in order to have a concern with fragmentation!

One element of the problem is that when you break forests down into small patches, surrounded by cutovers, the patches are effectively all edge. For example, using dispersed patch clearcuts as adopted by the U.S. Forest Service the forest is quickly converted to small patches; the landscape may still be half covered with forest but it's all in patches of 10 to 15 ha. This is a problem because a 15 ha patch is all edge environment. From studies of forest edges we have found that you must move two to four tree heights into a forest from its boundary with a clearcut before the microclimate returns to the conditions found in a large intact forest patch; this can be as much as 400 to 500 m in extreme cases. Hence, a landscape of small forest patches interspersed with cutovers effectively lacks interior forest conditions; no habitat remains suitable for species requiring interior forest environments.

This problem is a very serious one if you have an interest in retaining interior forest conditions, such as for some wildlife. The fragmented landscape is also very vulnerable to windthrow.

Summary of Scientific Underpinnings

We have now considered scientific findings in ecosystem complexity, biological legacies and the landscape perspective. There is obviously a large and rapidly-growing body of knowledge which is substantial, quantitative and provides some fundamental principles that we might use in creating some alternative forestry practices.

We are beginning to appreciate the complexity of the natural forest ecosystem. Furthermore, as each piece and process is identified and studied we can recognize that essentially all play significant, often essential, roles. None can be discarded without consequences. Hence, forest simplification should be approached with caution and humility.

We can see that nature provides for the rapid re-creation of ecologically complex young forests through the mechanism of biological legacies. These carryovers of live and dead organic materials help insure that natural young forests are structurally and compositionally diverse. In effect, nature perpetuates ecosystems rather than simply regenerating trees.

We can see that much larger land areas—landscapes—and time periods must be considered in forest planning. Without these grander perspectives we almost certainly will create undesirable cumulative impacts on forest resources.

Have we foresters been incorporating this knowledge into our philosophy and recommended practices? In general, no; at least not to appropriate degrees. Some concepts have been picked up by some foresters, such as providing for coarse woody debris. But we foresters have resisted the notion that major problems exist with traditional practices.

Traditional forest practices are based on principles of simplification, homogenization. They seemed satisfactory to us until fairly recently. I was taught, and I think most foresters have been taught, that good forest stewardship is simply regenerating new trees that can grow freely and rapidly and produce boards. And we really felt—and based upon the science that we've had up until fairly recently—that was a reasonable assumption. A healthy forest was one that was growing lots of wood. What would be good for wood production would be good for other forest values! This clearly "just ain't so!" But, not knowing otherwise we developed our current practices such as clear-cutting, broadcast slash burning, disposal of large woody debris (at very substantial costs, in the case of the U.S. Forest Service), and establishment of even-aged monocultures. At least we've made an effort to establish those monocultures even though we haven't always succeeded. (Fortunately, nature hasn't always allowed us to do everything we thought that we wanted to do.) And we've been applying these practices on a very large scale.

Now, although I'm a forester I think foresters need to acknowledge that they have been slow to recognize problems with current practices. We really have been reluctant to acknowledge that a lot of ecological values are being sacrificed using traditional forest practices and to accept the principle that what is good for the production of wood fibre is not necessarily good for other resource values.

NEW FORESTRY

In the United States, foresters have discovered that they no longer have a choice about dealing with these issues. Some concerns, like biological diversity, have risen up and "bitten" the resource managers. The options left for organizations like the U.S. Forest Service, given current inclinations in the United States Congress, are considerably fewer than they once were. Effectively, foresters must either change or will be changed. This has created a tremendous incentive to think about using ecological perspectives to create alternative forestry systems.

I do want to point out that we're not going to throw out our old tools. A lot of foresters react to New Forestry by assuming it throws out everything that has been done before, assuming that these practices were wrong. That isn't the idea. Rather, we're trying to add some new knowledge and techniques to our existing "tool kits".

I also want to acknowledge that many of these "new" approaches have been around a long time. Take partial retention. Partial retention cutting was something the Europeans were doing 100 years ago (although for very different reasons than we have). But we North Americans looked at some of these techniques and rejected many of them, partially because there really wasn't a scientific rationale for using more complicated systems. Our objectives did not require the more complex silvicultural systems nor did our scientific understanding of the forests support the need for such practices. That has changed.

Management systems are needed at both the stand and landscape levels which incorporate both the new knowledge and the added societal objectives for forest lands. This is the New Forestry concept, management systems which better integrate maintenance of ecological values with commodity production. I am going to divide this discussion of New Forestry into the stand and the landscape level.

New Forestry at the Stand Level

At the level of the stand or individual patch, there is a general principle—to create and maintain managed stands that are structurally and compositionally diverse. Rather than attempting to simplify forests, try to retain higher levels of structural diversity. Maintenance of processes and species should follow from the structural diversity. Keep this general principle in mind so that you do not hang up on specific concepts, i.e., mentally arguing that "I don't think it'll work in my area, etc." The exact set of silvicultural practices, the treatments that you develop to create or maintain structural diversity, are going to vary. They will depend on forest type and condition, the environment, and on specific management objectives.

Providing a continuing supply of coarse, woody debris—large standing dead and downed material—is an obvious stand-level practice to maintain higher levels of structural diversity. Again, how can anyone look at these structures—their size and abundance—and not understand intuitively that they have ecological value in a forest, that they are doing something?! Retaining large standing dead trees and downed logs is a practice that is now extensively applied on federal, state, and private forest lands in Oregon and Washington. Note that this objective is not best achieved by simply leaving behind a heterogenous sea of slash.

Management of young stands provides another set of opportunities to modify practices for ecological values. To begin with we could aggressively create stands of mixed composition—mixtures, for example, of conifers and hardwoods. You can do a lot for species diversity, for example, by providing an occasional big leaf maple within an otherwise conifer-dominated landscape. And, of course, there are the nitrogen-fixers like alder. But we also need to think about mixtures of conifers. Cedars are great soil-building species in addition to providing valuable products. All Cupressaceae are foliar calcium accumulators. Consequently they produce very high quality litter which increases base saturation, reduces acidity, and encourages high rates of nitrogen mineralization in soils. We need to be thinking much more about mixtures as we design our forests. We also need to be thinking about creating young forests of mixed structure, but I'll come back to that momentarily.

Delaying the process of canopy closure can also be of value in some young stands. Intensive forest management has traditionally sought rapid canopy closure, full reoccupancy of the site by commercial trees. In fact, I've suggested that foresters would have instant canopy closure if they could get it—full forest occupancy of a site one year following broadcast burning! But there are a lot of ecological values associated with that early period of succession prior to tree canopy closure. This stage is rich in plant and animal species as I pointed out earlier, and many of these are organisms of interest to humans. For example, many game species use the pre-canopy closure stage and nitrogen-fixing species are often abundant at that time. Canopy closure is probably the most dramatic and, in terms of some processes, traumatic single event in the whole life of the stand, other than its ultimate destruction by some catastrophe. Many things change very rapidly and significantly at the time of closure. So, we can consider using wider spacings to delay canopy closure in order to obtain more of the values associated with early successional conditions. And, based on spacing studies, we can probably do that with little or no sacrifice in commercial wood volume production. We can also think about related practices, such as pruning, in order to produce higher-quality wood. Interestingly, the approach of very wide early spacings and pruning resembles the intensive Monterey pine forestry carried out by the New Zealanders.

Retention of large green trees on cutover areas is another practice which creates greater levels of structural diversity in managed stands. Of course this can't be done everywhere. You can not do it with some species, some topographic situations, and certain kinds of soils, for example. But there are many places where we could leave large green trees behind.

I have to be careful in talking about green tree retention because I am enthusiastic about it and people could go away thinking, "Ah, new forestry at the stand level is just leaving green trees behind." It is not! It is just one of many techniques that we can use to enhance structural diversity of managed stands. But green tree retention is an important approach and one that has been largely ignored. Beliefs notwithstanding, nowhere is it written in stone tablets that we must clean-cut—cut down all of the trees—not even in the Douglas-fir region. On many (most?) sites we could choose to leave green trees behind.

Why would we leave merchantable green trees behind? Well, there are many things that can be accomplished by such practices. So many that it boggles the mind. Green trees are, of course, sources of coarse woody debris, of snags and downed logs, especially where safety concerns do not allow for retention of snags. In fact, the first green tree retention cutting that I laid out was done with the idea of providing green trees as sources of snags.

Retaining large green trees can accomplish other goals. They are potential wildlife trees. We can retain them in order to grow high-quality wood fibre during the next rotation. For example, 80-year-old Douglas-fir trees continue to grow very well for the next century of their life and are producing much higher quality wood during that time.

Another potentially important value of green trees on cutovers is as refugia and inocula for much of that hidden diversity. This concept greatly intrigues me. Many species of that rich invertebrate fauna found in the old-growth forests do not disperse well; they are species that either fly poorly or not at all. Hence, they do not recolonize areas well after being eliminated by clearcutting. We can provide refugia for some of those organisms by leaving behind host trees. This also provides an inoculum or a "seed source" of these organisms for the new stand. The same phenomenon is true with many mycorrhizal fungi. Some of those fungi really can disappear very quickly if you eliminate their hosts. By leaving some of their hosts behind, the fungal communities can be conserved and become a source of inoculum for the young stands.

This is the flip side of the foresters' lament about green tree retention, which is—"Well, we can't leave those trees! They've got mistletoe, they're sources of diseases and insects!" Well, some of those invertebrates and some of those fungi are organisms we want, and green tree retention may be a useful tool for preserving that biological diversity.

Green tree retention also alters the microenvironment of the cutover area. That is what shelterwood cutting is about. By leaving an overstorey we moderate climate, allowing regeneration of trees where clearcutting would be too severe. An area with green trees has a mellower environment; frost and insolation problems are ameliorated. Guess what—if it works for trees, it may work for other organisms as well; in other words, other components of forest ecosystems will almost certainly be able to survive on cutover areas with green trees that would not be able to survive on a clearcut. Many other organisms will be able to move through a cutover landscape with green trees that would not be able to move through a clean-cut landscape, again, because of ameliorated environments and protective cover. Perhaps the whole landscape can be made more porous, the cutovers less of a sterile environment that isolates organisms and forest patches, by leaving green trees.

Obviously, there are many things that could be accomplished by green tree retention. Perhaps it could even be utilized to mitigate the potential for rain-on-snow events or to retain sufficient root strength to reduce erosional failures on cutovers.

Partial cut stands contrast markedly with traditional even-aged management even where just one age class is retained (Fig. 2)[3]. At each cutting cycle when you enter the stand for harvest, you would leave behind some larger trees. The structural diversity that is generated is obvious. It contrasts sharply with what is done using even-aged intensive management practices.

Green tree retention has immediate relevance in Oregon and Washington with regard to the northern spotted owl issue. Most disturbances, whether fire or wind, do leave behind a significant component of green trees (Fig. 3)[3]. Even though the old-growth condition doesn't occur until about age 200 years, we find that many of these stands begin to provide habitat for northern spotted owls at around seventy or eighty years. On the Olympic Peninsula, for example, there's a large area called the "21 Blow" which blew down in 1921. Today it is dominantly a 70-year-old hemlock stand, but it contains large residual old-growth trees and snags and downed logs. And portions of the 21 Blow are providing viable northern spotted owl habitat. There are many other examples of dominantly young but structurally diverse (because of legacies) forests that provide owl habitat in the Pacific Northwest.

We can think, then, about the possibility of creating similar mixed-structure forests on rotations of, for example, 120 years. This would provide 40 to 50 years of suitable habitat for some of the old-growth related species, and very much resembles some kinds of stands that nature created. It appears to be a real alternative to either total preservation of stands to provide habitat for old-growth related species or, alternatively, rotations of 250 or 300 years which would be necessary to recreate old-growth-like conditions following clean-cutting.

Green tree or partial retention cutting can take a wide variety of forms depending upon stand conditions and objectives. For example, the density and type of leave trees some stands will resemble a shelterwood-cutting (although it is not a shelterwood-cutting in the traditional sense because the over-story remains until the next rotation). In other cases, it may be better to leave groups of trees rather than individuals. Plum Creek Timber Co. is doing substantial experimentation in leaving small patches, groups, and corridors so as to retain green trees while minimizing added logging costs and safety problems.

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[3] Not available at time of print

I want to emphasize that green retention is not selection cutting, although selection systems also will have a significant place in New Forestry. However, in selection forestry individual trees or small groups of trees are removed, stands are entered on a relatively frequent cycle of ten or fifteen years, and an uneven-age stand is the objective rather than just a two- or three-aged stand. This is very different than what I envision with partial retention, which would have only one entry per rotation and during which the majority of the stand would be removed. We foresters currently don't even have a general term for this silvicultural approach. But partial retention is distinct; it is not clear-cutting, it is not shelterwood-cutting, it is not even-aged management and it is not selection cutting and uneven-aged management. It has its own identity, whatever we choose to call it.

New Forestry at the Landscape Level

New Forestry at the landscape level has its own general principle-individual activities must be planned and integrated at larger spatial and longer temporal scales. We must think about how mosaics of patches work rather than just about individual patches; how to allocate lands and treatments at the landscape level so as to maintain the numbers and distribution of patch types (in terms of sizes and conditions) needed to achieve management objectives. Including, of course, the objective of avoiding undesirable cumulative effects, like accentuated rain-on-snow events and accelerated and excessive erosional activity.

An important landscape consideration on the commodity lands is providing for reserved areas. Some people interpret New Forestry as meaning we don't need any reserved areas. But we do if we are going to achieve ecological objectives such as maintenance of biological diversity. Unfortunately the emphasis has been on the large reserved areas, areas that are set apart from everything else including the commodity lands. We must think more about designing reserved areas into the commodity landscape, about the various kinds of reserved and semi-reserved forest areas that must be built into and be a part of a commodity landscape. And we need to plan the reserves as a network of areas rather than as isolated units.

In National Forest landscapes we already have designated or planned many set-asides or reserved areas of various types-streamside corridors, spotted owl management areas, unstable soil areas, regeneration-problem areas, etc. But until the spotted owl came along, these had never been examined as a network with consideration of their geographic distribution and linkages.

Hence, part of New Forestry at the landscape level is the creation of an appropriate network of areas reserved from intensive forestry practices. The critical elements here are viewing set asides as a network and as a part of the commodity landscape rather than apart from it.

Appropriate patch sizes are another landscape issue. Solutions are going to vary with the landscape, the forest type, and the organisms which you are managing. On federal lands in Oregon and Washington, we originally selected a system which dispersed small clearcuts; this approach maximized the amount of edge and the degree of fragmentation in the landscape. You couldn't design a system that does do a better job of breaking a forest matrix into small pieces.

This approach—dispersed clearcutting with a patch size of 10 to 15 h—does not fit the Douglas-fir ecosystem or many of the resident organisms. Hence, one practice that we are considering is creation of larger cutover areas or aggregating some of our cutover areas so that the patch sizes of both our reserved and cutover areas are larger—perhaps up to 100 ha or more in size. This would reduce the amount of edge and create forest patches that provide for interior forest environments. One approach to aggregated cutting is called "minimum fragmentation".

A critical element in enlarged cutover patch sizes is the need to retain much higher levels of structural heterogeneity on cutover areas in order to protect ecological values. I am definitely not advocating great big clean-cuts; I am talking about large cutover areas on which there are high levels of standing dead and downed material, green trees, patches of regeneration, etc. This will provide organisms with thermal and hiding cover, provide refugia and inocula for the new stands, and avoid creating large blocks of sterile environment.

I am not going to suggest that you need larger cut-over areas up here in British Columbia! Anyone that's flown over Vancouver Island can see that your problem is just the reverse. You do not have any problems with fragmentation because you rarely leave any forest patches behind! And your large cutovers are clearcuts which do not provide the desirable levels of structural diversity.

Given what I know about B.C. landscapes, I think that one of the most important things needed is the inclusion of reserves within the commodity landscape so as to reduce the extent of extremely homogeneous and relatively sterile cutover tracts. Further, I think that much more structural heterogeneity needs to be built into your cut-over areas. In any case, bigger and structurally cleaner cutovers are clearly not the desirable thing for B.C. ecologically. You do need to look at your mix of reserved and commodity lands and the level of legacies that are being left on those cutover areas.

There are other concerns at the landscape level. Connectivity among reserved areas and within the landscape as a whole is a critical issue. Green tree retention may be one way of improving the "permeability" of the commodity land matrix; i.e., cutovers with some cover may be easier for organisms to move through than clean-cuts. Another issue is the need to recognize that all portions of the landscape are of equal value. Although this seems obvious, foresters sometimes forget this fact. For example, problems have arisen on the Tongass National Forest because the productive alluvial Sitka spruce-western hemlock forests are critical habitat for Sitka blacktailed deer, anadromous fish, and grizzly bear as well as the highest volume timber stands; hence, these forests cannot just be allocated to timber production while other resource are accommodated on the less productive lands.

CONCLUSIONS

These, then, are some of the practices that I identify with a New Forestry. My vision is one of a very different kind of landscape pattern and of a different dominant cutting pattern on commodity lands with partial retention replacing clear-cutting as the dominant practice on the federal lands in the Pacific Northwest.

The stand-and-landscape-level principles do have a broad application. Maintaining structural diversity in managed forests and analyzing effects at larger spatial and temporal scales are important everywhere. These concepts are not just relevant to old-growth issues or to the forests of the Pacific Northwest.

Modified practices are being used now. Changes are occurring very, very rapidly in what we are doing in Oregon and Washington on the federal, state, and private lands.

For example, on National Forest lands the guidelines for FY 1991 timber sales are very different than for previous years. Some changes anticipate listing of the spotted owl as a threatened species. Others simply reflect the commitment that the U.S. Forest Service has now made to New Forestry practices (which they refer to as New Perspectives in Forestry) and to the idea of integrating ecological values with commodity production.

There's certainly going to be a lot of learning along the way because many practices are conceptual at this point. We have a lot to learn. And it's certainly going to be traumatic because allowable cuts are unquestionably going to decline. Maintaining ecological values means reinvesting some of the productivity—including wood—back into the ecosystem.

In conclusion, I think that in the interests of maintaining options for future generations, in the interests of sustainable productivity, in the interests of biological diversity, and, fundamentally, in terms of responsible global stewardship, we need to take a fresh look at natural resource management. We foresters need to reconsider our practices with increased respect for the complexity of these forest systems and with a humility that reflects our true level of knowledge about those systems and how they work.

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