Old Growth: The Contribution to Commercial Forests

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What I want to do today, is talk to you about characteristics of natural ecosystems, focusing primarily on old-growth forests. Then, I want to suggest some ways that we can take the new understanding that we have of these ecosystems, and put it to work to try to make commodity landscapes produce more ecological benefits than we seem to be able to do with our forestry practices today.

I tend to be identified as a person who is a tremendous supporter of old-growth forests, and very much concerned with their preservation; and this is true. But the fact of the matter is that battle has moved on to the political arena in the U.S. and is in very good hands. I see today the greater issue of trying to change the practices on our commodity landscapes which Jim Brown of New Mexico has called our "semi-natural matrix." These landscapes are much more amenable, are much more supportive of ecological values, of things like biological diversity than seems to be the case today.

All of you are aware in B.C. that as the settlers came out west, what they encountered on the northwestern coast of North America were probably the finest forests in all the world. Probably 2/3 to 3/4 of these primeval forests they encountered were old-growth forests, of evergreen conifers. Actually, we have historically done very little research on these primeval forests. In the case of the U.S. Forest Service, their primary concern, when they began to cut those forests, was how to cut them down and get new trees regenerated. This is the rather traditional foresters' perspective. So the U.S. Forest Service terminated its research program on old-growth forests in 1958. They knew all they needed to know and moved on to other kinds of forest research activity.

In 1979, a group of scientists at the U.S. Forest Service, with funding from the National Science Foundation, began to do research on natural ecosystems, particularly on old-growth forests. And most of what we know about old growth today is a consequence of National Science Foundation supported activity and research by the Fish and Wildlife Service on selected old-growth forest species, such as the northern spotted owl.

In thinking about old-growth forests, or in fact, any kind of a forest, certainly in terms of natural ecosystems, we can really think of them in three kinds of categories and characteristics, their composition, their function, and their structure.

Composition

When you look at old-growth forests from a plant ecologist's perspective, it can be a little bit discouraging in that our older forests tend to be made up with the same species as younger forests. There are not a whole lot of distinctive kinds of plant species, when you look at higher plants in the old-growth forests. However, when you look at different places in the northwest, and at some of the lesser plants, as well as some of the higher plants, there are some changes that take place with succession; in some cases, species specific, for example, with the development of lichen, such as Lobarium Oreganum, in the case of Oregon forests. And the development of a high cover of western yew, which we find in Oregon's forests, is characteristic of an old-growth state.

In the case of Alaska, we get the rich herbaceous and mixed herbaceous shrubby understory, very important for deer winter browse. We find in the case of animals, the old-growth forests have an extremely high diversity. There are a number of distinctive vertebrate animals. We have developed a list of species: birds, animals and amphibians which vary from place to place; but there are about 15-20 species which have a strong relationship with old growth. In terms of overall diversity, we find that with old-growth forests, the least diversity is at intermediate levels of forest succession, with the greatest diversity actually at the stage immediately following disturbance; such as fire, wind or clearcutting. At this time, we have a big influx of weedy organisms that come in and mix up with residual organisms, because in fact, most of our plants and animals survive these disturbances. So we have a high diversity early in succession. When the tree canopy closes, we have a crash of diversity in terms of the number of species. Then, in the old-growth condition, where things have opened up again, we have an intermediate level of diversity. The distinctive thing about the vertebrates in old-growth forests is they are highly specialized organisms. Things like the northern spotted owl, that don't do very well outside of old-growth forests; that have some kind of need during their life cycle for the old growth.

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We do tend to forget about the invertebrates, and we have done some recent studies; particularly Jim Schowalter and Jack Latten at Oregon State University. We find there is a much higher diversity of invertebrates in old growth, much higher than in adjacent young forests. Furthermore, old-growth invertebrates (insects, etc.) are very heavily weighted toward predators and parasites of other invertebrates. So old-growth forests effectively work as a net source of predators and parasites, on various kinds of herb feeding insects.

In any case, old-growth forests are not biological deserts, a term that was coined by fish and wildlife people who were particularly interested in game organisms. Of course, when you stop and think about it, any system that has been as widespread as old-growth conifer forests, over such a long period, is naturally going to develop a set of organisms which in one degree or another is going to be dependent on them.

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Function

Function is the work the (forest) ecosystem does, and how rapidly it is doing it. There are a variety of different functions; productivity, the capture of the sun's energy and its conversion into carbon products, nutrient cycling, hydrologic cycling and provision of habitat for organisms.

Productivity of old-growth forests has got a "bum rap" from foresters, as being low-productivity systems. In any kind of an ecologist's definition, old-growth forests are, in fact, very highly productive systems. All you have to do is look at the amount of green foliage that is out there in these forests, and you know right away that old growth is highly productive; because they don't keep green leaves that are not producing a net carbon benefit.

Old-growth forests have leaf areas of 10-14 square metres per square metre of ground surface. So obviously, they are producing at very high levels; of course, that's thinking in terms of primary productivity. The reason they have a "bum rap" from foresters, is that even though old growth tends to be very high in terms of its gross production, that is as you have accumulated more living material, the respiration costs of maintaining the forest have gone up, leaving relatively little left; once carbon is available for additional net production, or for additions in terms of wood. What you do find is that old-growth forests are relatively stable, in terms of their biomass (wood fibre). So that in terms of adding wood, they are relatively poor. Hence, the reputation for being low in productivity. the fact of the matter is there have been relatively few long-term studies of old-growth forests.

One of the long-term studies that does exist is in the southern Washington Cascades. I can assure you it is one of the most decadent Douglas fir stands that you can imagine. It is located at Wind River, Washington. Even in the case of this very decadent stand, there is a net balance between growth and mortality. In general, in old-growth forests, there is a very high level of gross production, and a relatively low level of net ecosystem productivity, or additional increments to the mass. In effect, you have a very stable system, in terms of its standing crop.

Of nutrient cycling, there is a lot that can be said, a lot of information about water quality and erosion levels on natural landscapes. What we find is that watersheds occupied by old growth have very low levels of sedimentation. One of the reasons is the incredible root masses that are developed and hold the soil mantle in place. You don't get much in the way of landslides and major channel erosion. There are relatively low inputs of sediments or coarse materials into the stream system. At the same time, there is very little nutrient leaching from the rooting zone, so that groundwater going out of old-growth forest systems tends to be of very high quality and is very, very low in dissolved materials. When combined, the low levels of sediment production, and dissolved solids in these waters, then what you have is very high quality water.

When we, as foresters, talk about being able to improve water quality, we are generally blowing smoke. What we really mean, is that we believe we can do something, without significantly reducing the water quality that is there. It is very, very difficult to improve on water quality from old-growth forest about 99 per cent of the time. When we did our first synthesis of old-growth forests in 1979, we thought for some time about the hydrologic cycle and hydrologic flows; and whether or not an old growth behaved differently than young growth. At the time we wrote the General Technical Report on old-growth forests, we though old growth probably would not behave any differently from new forests. The fact of the matter is that we now recognize at least two situations where an old-growth forest functions differently from a young forest, and certainly differently from a clearcut area.

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First of all, in any situation where you have a major atmospheric influence, in old growth for example, through fog or cloud condensation, the old-growth forest will be uniquely affected by this process. We discovered this in the Bull Run watershed of the city of Portland. We did an experiment, and we thought we knew exactly what was going to happen; we were going to cut the old-growth forest. We know when you cut forests you reduce transpiration losses and consequently, the water yields go up. In this particular case, it was at mid-elevations about 3,000 feet. We cut the forest and the water yields not only did not go up, they began to go down.

In this case, the fog influence was adding an additional 35 inches of precipitation annually on that site from fog drip. What you have to recognize is that in effect, the forest canopy is scavenging the atmosphere in situations like that. Obviously, scavenging condensing water and atmospheric particulates. And, of course, old-growth forests have a higher canopy, a more complex canopy, and more surface area than any other forest stage. This is obviously more effective at scavenging processes than any other forest ecosystem. So where fog and cloud inputs are important, the old-growth forest is going to be effective in bringing that moisture in.

The other aspect of hydrologic functioning where we found old-growth forests played a unique role had to do with snow. Most of the Cascades and the Olympics are in what we call a warm snow zone. What that means is that when a cold front comes in it dumps a lot of snow at mid-elevations, from 1,000 feet to 4,000 feet. What can happen next is that we can have a warm front come in, bringing a lot of rain and that warm air mass can eliminate that snow in a few days or a week. As a result of this combination of a warm air mass and snow pack, we get our most dramatic flood events in the the northwest, which we call a "rain-on-snow event." Old growth is uniquely valuable in reducing both the probability and the intensity of the "rain-on-snow events." This is because old growth reduces the amount of snow that gets into the system, because much of it is held in the canopies and sublimates back into the atmosphere. Then the snow that does get down gets compacted into a regular patchwork; and then when the warm front does come in, the trees protect the snow from the heat of the air mass as well as the impact of the raindrops. This is in direct contrast to a clearcut area where you have a maximum accumulation of snow, and it is laid out there perfectly for a melting process to take place. So you can see old-growth forests can be extremely effective in this part of the hydrologic cycle.

Structure

Structure is of greatest interest to foresters, as this is what we can manipulate. This is what we can create, or can change. What we are talking about is the different structure out there, the trees or the dead wood, and the way it is arranged, and not necessarily what it is doing (just how it is spatially arranged out there, like the furniture in your house). There are lots of structural features that we can talk about with regard to old growth. When we did our first synthesis in 1979, we came to an astounding conclusions, and this is sort of like discovering that water runs downhill. We talked for three days, and then we recognized that four of the things that really distinguished old growth structurally were

- the large old trees;
- the large standing dead trees or snags;
- the large downed logs on the ground;
- the large downed logs in the streams.

In fact, we could attribute many of the distinctive compositional features, as well as the functional features of old-growth forests, as being related to these four kinds of structures.

In our studies, we focused on Douglas fir, although any of the larger long-lived dominants could be substituted, like western red cedar or sitka spruce; for example, in our case, noble fir at higher elevations. The old-growth trees are, of course, food producers, and supreme providers of habitat. The Douglas fir tree provides habitat for perhaps 100 species of cryptograms and perhaps several hundreds of invertebrates. Sites of nitrogen fixation are a consequence of the *Lobaria* lichen; and old growth is a source of large logs and trees. These old-growth trees are very large, complex and individualistic structures. One of the things we find, when we look at them in detail, is they often have decadence associated with them. They often have multiple tops and heart rot. Typically, they have very large branch systems associated with them which, in effect, provide an opportunity for development of a "perched ecosystem" where you actually get very large displays of branches with an organic soil and a complete food web from microbes, all the way up the chain, to the red tree mouse and the spotted owl.

"A typical number of needles is 60 to 70 million for one Douglas fir tree. And the really outstanding thing is there may be as much as an acre of surface area on the needles alone, 4000 square metres of surface area just on the needles, not even counting the twigs and branches."

The surface area associated with these trees is absolutely incredible. A typical number of needles is 60 to 70 million for one Douglas fir tree. And the really outstanding thing is there may be as much as an acre of surface area on the needles alone, 4000 square metres of surface area just on the needles, not even counting the twigs and branches. You can imagine what this is as a scavenger surface, or as habitat for various kinds of organisms. Again, that *Lobaria oreganum*, which is a nitrogen fixer, provides 2-5 kilos/hectare/year, as input in many Douglas fir forests. One of the things we must think about is that these big, old trees provide us with the log, old snags and our big, old, downed logs. There is a tendency to think we can go in and remove these. And if you do, you will eliminate the base of that chain that generates all of these large structures.

I can't talk about forests without talking about coarse, woody debris, the large, standing dead and downed material. Certainly old-growth forests have a lot of that kind of material. One of the things our groups has come to realize more and more is that almost all natural forest ecosystems have large amounts of coarse, wood debris, relatively speaking. This is because natural catastrophes kill trees; but rarely eliminate the wood, either removing it or burning it up. In one study area where fire occurred in the Olympic peninsula, the fire killed the trees but almost none of the wood was consumed. And this becomes a major legacy. This is one of the major elements in the concept we are developing of "biological legacies." This is a carry-over from the predisturbance stand, into the new regenerated ecosystems; and it is a major legacy or gift from that old stand to the new, in organic matter, in structure, in nutrients.

The work that Tom Spies and I have done shows a very clear pattern. The woody debris is important for a tremendous variety of ecological functions. It is important as animal habitat, plant substrate (e.g., nurse logs). They are, in the long term, a source of nutrients and energy, a source of soil organic matter, and a major site of nitrogen fixation (depending on the system and who you want to believe, anywhere from 1 to 10 kilos of nitrogen per hectare per year. They are also extremely important to the aquatic system.

Now, I want to tell you a little bit about animal habitat. Animals have adapted to and used coarse, woody debris for a long, long time. Today, 80-90 per cent of our vertebrates make use of woody debris at some point. I think it was Elton, who said that 1/5 of the forest dwellers in England use coarse wood debris, and was far too conservative. When you factor invertebrates into the situation, probably in the order of 40 to 50 per cent of the invertebrate fauna use woody debris in some forms. Now, snags are extremely important structural components. We learned about them a long time ago from the wildlife people. They serve a tremendous number of wildlife functions, as habitat for cavity nesters; also the loose bark forms roosts for bat habitat.

Downed logs are also very important. Both snags and downed logs are very transient. They don't last forever. On downed logs we have a classification system that looked at how the chemical, biological and physical properties change; from very recent downfall in a Class 1 to a Class 5, with important ecological consequences. Snags are the shortest lived—about 60 to 70 years.

In contrast, a Douglas fir downed log of comparable size would last 3-4 times as long. Our first guess was that downed logs would disappear faster than snags. We obviously were not observing very carefully. In our systems, here on the west coast, where things are very moist and the logs become waterlogged, the logs last much longer than the snags. In either case, you are going to have to manage for snags to perpetuate these structures, if you want them around.

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There are a lot of changes that take place in the understory. There, a great deal of energy is needed in the understory of old-growth forests that is not apparent in younger forests. If foresters had their way, an understory would not be present in younger stands; for example, the development of gaps, which our forests tend to be very slow to fill. We have something which we call "anti-gaps" or areas of very dense understory. And it is interesting in our Douglas fir forest where it is the hemlock canopies which drives the light environment in the understory.

In a 500-year-old Douglas fir old-growth stand, the Douglas firs themselves have very little influence on the light environment of the forest floor. The light environment is determined by the sub-dominant canopy of hemlock and cedar.

Coarse woody debris also plays an important role in streams, rivers and estuaries, performing essential roles as a creator of habitat, a source of energy and nutrients, and a dissipator of erosion, and a creator of sites for nitrogen fixation. In our streams, most nitrogen is produced by organisms living on the surface of wood. It is very important in forming retaining structures, which hold the litter inputs in stream reaches, rather than allowing them to be flushed out.

What Does It All Mean?

How does all this talk about composition, structure and function of old-growth forest have any relevance at all? First of all, what have we been doing in terms of your forestry practices, vis-a-vis natural ecosystems? The point I want to make here is that each stage of succession is doing some very useful things, and sort of optimizing for certain kinds of functions. Certainly, the young forest optimizes for production of additional wood fibre. The old-growth forest optimizes among other things, for provisions of wildlife habitat and high-quality water.

What have we been doing in the management of our forest lands? For the most part we have been simplifying what we have been doing; to effectively homogenize these forests by taking these very complex systems that nature has created over time, and to simplify them to make our job easier, and to make our job more efficient; through from the organism level to the landscape level.

Genetically, we do a whole set of things, some of them on purpose, some of them without even thinking about it, to reduce the genetic complexity of the forest. We don't use very many of the species, and we throw away a number of the plant and animal organisms. Insofar as our selected species are concerned, we reduce the amount of genetic variability sometimes by design in our tree improvement programs; sometimes we do it accidentally.

Just the process of collecting seed and growing it in a nursery, gives you a different genetic selection than nature where it regenerates itself from seed; when that incredible selection process goes from the time of germination, to tree establishment. And so we have been producing simplified forests, with a simplified genetic complement of these species for some very specific objectives, usually short-term objectives. Structurally, one of these things we do is to try to eliminate dead wood. Of course, in our plantations, we want very uniform size material and we tend to like a very geometric kind of spacing; as it is easier for us to move around and for our equipment to move around.

One of the practices we used in the U.S. in the 1970's was the practice YUM and PUM, "yard unmerchantable material" and "pile unmerchantable material", for subsequent burning. Now if there is a single forestry practice that is an unmitigated "bad," it would have to be YUM and PUM. Because, in effect, you are expending lots of energy, dollars and effort, to pull coarse wood debris off the forest slopes and pile it up to let it burn.

One of the changes taking place in management now on U.S. National Forests is a dramatic moving away from removing unmerchantable material which is so important to providing structure. Successionally, we try to truncate the successional stages; and of course, we are not interested in anything beyond maturity, even economic maturity, or maturity as defined by culmination of mean annual increment. In northern Oregon, a typical natural rotation would be 350 years. The first 30 years would probably be spent getting canopy closure, which usually develops relatively slowly in forests here in the west, as opposed to the east. Then young stands occupy the site for about 100 years. Age 80-100 is the approximate age of culmination of mean annual increment.

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While we as foresters considered this to be maturity, it is actually the end of youth and the beginning of maturity. Then we have a stage which we call a mature forest, from about 100-200 years; where you have a great deal more increment of wood taking place. But you are getting a lot more differentiation, a lot more structural variability within the stand. Generally we feel that old-growth conditions are from 200-700 years and go for several hundred years; with normal fire rotation in northern Oregon and southern Washington an average being about 350 years.

Forest managers try to collapse the pre-canopy closure stage to an absolute minimum. Foresters, if they had their way I suspect, would have full canopy closure the year following harvest. An open canopy is considered by foresters to be a tremendous waste of site potential. We do a whole number of things; we plant, we spray herbicides, we try to eliminate competition to shorten the canopy-closure stage. Then we choose some kind of a rotation, the private landowners use an economic rotation of 50-60 years; the Forest Service uses a biological rotation of around 90 years, known as the culmination of mean annual increment. So what foresters are again doing, is simplifying in terms of successional stages.

At the landscape level we are taking a natural system which had a tremendous diversity in terms of its patch sizes, and the complexity within the patches, and in effect we are creating a rather homogeneous landscape condition, as well as creating rather artificial kinds of boundaries.

In a natural Douglas fir forest burn in southern Washington, created in 1902, nature's resulting patches tended to have a tremendous range in size, a lot of heterogeneity within the patch, and the boundaries tended to be very complex. They tended to grade gradually from one another. They tended to be rather convoluted, rather than straight and sharp, such as the boundaries we are creating today were we use the dispersed patch-cutting system. We are now creating a very homogeneous-sized patch and very homogeneous conditions within the patch, and lots of nice straight sharp boundaries.

We have discovered in a number of situations that this checkerboard pattern can create some very important problems, from a managerial sense. Today's system is more or less a mindless application of concepts we have inherited from European forestry. So how can we think about changing our practices? What significance does that kind of simplification have? That kind of simplification has a number of adverse consequences. One is, it does not help us to provide for as many of the elements of biological diversity as we would like. And, we are finding that more and more of our citizenry are concerned that biological diversity is maintained.

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Perhaps an additional concern is that the complexity of a natural ecosystem is very much related to its resilience. By maintaining complexity, and by maintaining diversity, you are able to maintain both ecological options, and more economic options. You have a better chance to better accommodate unexpected changes that are going to take place. One of the things that we are really interested in, on our U.S. timberlands, is making sure we have the resilience to handle these repeated croppings. One of the issues that trying to maintain ecosystem resilience can address is an assurance we can maintain productivity levels. We need to know that we aren't losing ground insofar as the productivity of the forest is concerned.

However, there is even a greater uncertainty facing us which should make us conservative in our practices, and make us want to be sure we retain the greatest amount of resilience. For example, the Harvard Forest of today was agricultural land 150 years ago, and they are hardwood forests today. Our tendency as foresters, and indeed as human beings is to think of forests and forest environments as being immutable — they aren't ever going to change. But there are a number of major changes that are taking place that we are going to have to accommodate, that our forests' ecosystems are going to have to accommodate.

These are the changes associated with global climatic warming. We also have increased pollutant levels. We are going to see altered types of pests and pathogens and we are going to have to deal with them in our ecosystems. Assuming current climate models are anywhere near correct, for the northwest, scientists are predicting 2 to 5 degrees Centigrade increases in mean temperature, with no increase in precipitation, or perhaps a slight decrease. This is the same as effectively moving today's environment at sea level up some 1,000 metres in elevation on the mountainside. That is an incredible change. It will "pop" our cold snow zone, our mountain hemlock zone, right off the top of the mountain. There is not going to be any of it left.

Climate change will cause changes in the various kinds of stresses, the various kinds of disturbances in these ecosystems. We can expect to see much more frequent fires, and we can expect to see much greater periods of drought stress. All of this suggests to me that it makes sense to try to maintain as much resilience in our ecosystems as we possible can, and I believe a great deal of that resilience is associated with complexity, of organisms and structures, that we can retain within our managed landscape. So we are beginning to think today about modified management of our timberlands in order to provide us with more of that resilience, in order to retain more of these options.

Sometimes we call it the new forestry, sometimes we call it altered silvicultural systems. Let me give you an idea of some of the kinds of things we are talking about doing and, in fact, are doing on some of the U.S. National Forest lands. Bear in mind of course, the specifics of what we do to modify forests are going to depend on what you are interested in, and what kind of forest types you are dealing with. One obvious thing is to try to maintain more of the forests' complexity; genetic, structural and spatial.

Early succession tends to be a time of high diversity. There are an awful lot of animal species, especially wildlife species that make use of that state. This is when we get an increment of nitrogen, due to nitrogen-fixing organisms like ceanothus, alder and lupines. It is also a time when we can generate a lot of browse. One possible strategy is to try to maintain that open, pre-canopy closure condition as long as possible, instead of trying to accelerate canopy closure. Interestingly enough, this is one of the things the most intensive-oriented silviculturists in New Zealand are doing in their Monterey pine plantations; where, by year 9, they had thinned their plantations to crop-tree density, and left them that way until the end of the rotation.

The point is that we're planting a lot of seedlings out there on these sites, and spending a lot of money on pre-commercial thinning — talking through our hat about commercial thinning— as almost all of us know that commercial thinnings of all that low-quality small-piece material is not going to be a very economical investment. We are doing all of these expensive things and really not affecting the final yield at all.

What we could alternatively do, is to plant fewer trees, and try to have a low-density stand throughout the entire rotation period. Almost all of the species trials show, in effect, that by going to wide spacings, you don't lose a thing in terms of late-harvest levels at the time of rotation. That's one obvious way of accommodating a number of ecological values and potentially saving ourselves a lot of money at the same time.

The second thing we can do is provide more structural diversity by retaining woody structures; not only retaining them, but ensuring and generating more of them. They are so important to wildlife and for a variety of functions, and they are needed in such large sizes. In order to provide a continuous flow of them — of large woody debris — we are going to have to be creative managers. Generating a continuous supply of standing dead and downed material is a lot more challenging than growing green trees.

One other thing we can do is to preserve existing dead wood, but another thing we are thinking about more and more now is leaving green trees as future sources of snags and downed logs.

We can also provide for mixed stands instead of focusing so heavily on monocultures. We can make a real effort to try to incorporate other kinds of species within the stands. Of course, this is a classic discussion surrounding alder, pro and con, or any of the other nitrogen fixers.

One that I like to think about is cedar. Relatively few people are aware that all of the Cupressaceae are calcium accummulators. They do wonderful things for soils because the litter is so rich in bases and you get development of very good soil conditions. Cedars produce basic soils, high base saturation, high rates of mineralization, and mull-type humus layers. Why don't we simply incorporate more of the Cupressaceae in forest management practices?

"We all know the real problem is the development of structured stands. I never cease to be amazed in forestry. The silviculture textbooks have really short-changed us in our management."

We all know the real problem is the development of structured stands. I never cease to be amazed in forestry. The silviculture text books have really short-changed us in our management. There is a tremendous array of options, from a gradient of possibilities, in determining how many green trees to remove or leave behind. And yet, silvicultural prescriptions are at one end to clearcut, and shelterwood at the other. So you have got clearcuts, and groups of single trees at the other end. **What about that tremendous array of possible cutting systems in between these two extremes?**

One of them we are working at is the idea of retaining large, dominant, green trees in the second rotation in order to provide us with stands that have at least two canopy layers. For example, in a Douglas fir stand of 135-year-old trees, we might leave 10-12 dominants per acre. They are left behind primarily with the idea they are going to survive to the end of the next rotation. Now we have a stand with two different canopy levels. There is a whole set of reasons for doing this — ecological reasons.

As part of any new forest strategy, you have to protect the aquatic environments, retaining streamside strips. In any new strategy, we will be including considerations such as the reservation of areas for things like spotted owls, and corridors for stream side areas. We are talking about a matrix of different kinds of conditions within the commercial forest landscape.

One of the objectives is to manage the commercial forests so there are a lot more opportunities for a flow of materials, a "dialogue," if you will, between the reserved strips and the areas being harvested for timber. And when we think about what might happen with global climatic change, it is very clear a choice between a landscape of strictly preserved areas and scorched earth areas is not a very intelligent decision for society to make. We need to develop more of an over-all concept for managing these landscapes, so that the reserved areas are effectively a part of that commodity landscape. Then it will be possible for groups of organisms to survive.

It is also very clear that preservation, alone, is not going to achieve our objective, because if global change occurs at anything like the scale being talked about, some of the environments and organisms are going to flow right out from under their little patches, their little postage stamps where we intend to preserve them. This problem is particularly going to apply to the small kinds of biological preserves, the small isolated reserves for some kinds of organisms.

There is going to have to be a lot more ecological engineering if we are going to protect options in the face of global climatic change. Management of the U. S. National Forests is changing very rapidly. Not all the old growth is going to be set aside, nor are all the commercial lands going to be managed in what might now be considered to be the most efficient, insofar as wood production is concerned.

Q. What about the issue of reserve size and the issue of forest fragmentation?

A. These days, we are generally saying that an areas of (say) 300 acres is probably not going to be of much value. It depends very much though on what surrounds that reserve. If an area is surrounded by a mature forest, it can be fairly small. But if you are talking about an area of old growth, and everything is cut down around, it has to be larger to be a viable unit.

A 40-acre patch of old growth is all edge, all subjected to external environmental conditions. What we don't want is a strategy that optimizes and maximizes the rapidity in which the forest matrix is reduced from a continuous matrix to tiny patches, isolated from one another. On federal forest lands in the U.S., we are backing away from that. I am not talking about a Weyerhaeuser approach of starting at one end of the drainage and progressively cutting towards the other.

We will never do that on federal lands. What I am talking about is that, at least on an interim basis for the next 5-10 years, instead of dispersing our cuttings we will start aggregating our cuttings, next to each other, so we retain for the longest possible time, our largest islands and patches of remaining old-growth forest.

Where we don't do that, on the federal lands, and we continue to cut at the present rate, probably most of the remaining unreserved old growth on the National Forest lands will be fragmented into these little pieces, 20-to 40-to 60-acre patches that don't have any real viability.

The trade off is, if you are going to aggregate your cuttings, you must have larger cutover areas. The quid-pro-quo is you must leave more structure behind. You are going to have larger cutover areas, but you must have more structure in them, more standing green trees, more snags, more downed trees, more patches of shrubs, etc. That way you don't end up with billiard tables, and so you do end up with large areas that still have structure in them in the next generation. I

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open myself to the conservationists for criticism, by saying that we have to stop dispersing our cuttings and make bigger cuttings. Unfortunately, some foresters hear only "big cuttings"; what I mean is "big, sloppy cuttings". The sloppy concept retains a lot of what we have considered to be chaos and waste, but is in fact essential for protecting diversity.

Q. One of the concepts that seems to be discussed more and more here in B.C. is the idea of a healthy forest. I heard you use that word one or two times. Here in B.C., a healthy forest is considered to be a forest devoid of problem insects and diseases. Now I hear you talk about insects and diseases as decay organisms as part of a fully functioning ecosystem. I would like your definition of a healthy forest.

A. An unhealthy forest is one that is extremely vulnerable to a catastrophe. It might appear healthy, but is extremely vulnerable to stress, pathogens and insect outbreaks. We saw this in the southern pine region where we got insect outbreaks in what should be healthy forests, but they are not. So I would assess health either on current condition or susceptibility. I think a simplified forest would be very susceptible.