Biodiversity:
Toward Operational Definitions

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Malcolm Hunter ▲ Hamish Kimmins

The 1995 Plum Creek Lectures
Nick Baker, Editor

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The School of Forestry at The University of Montana-Missoula is a comprehensive natural resource education and research institution offering Bachelor's, Master's and Doctoral programs in forest and range resource management, wildlife biology, natural resource recreation, and natural resource conservation. The School's Montana Forest and Conservation Experiment Station, institutes, and centers administer its research and outreach programs.

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The Lectures

Hal Salwasser
Regional Forester, USDA Forest Service Region One
Conserving Biodiversity: Sustaining the Parts and Processes of Healthy Ecosystems 1

Jack Ward Thomas
Chief, USDA Forest Service
Biodiversity and the Land Manager: Where Do We Go From Here? 15

Alan Randall
Department of Agricultural Economics, The Ohio State University, Columbus, Ohio
Biodiversity: Reasons And Values 27

F. Henry Lickers
Mohawk Council of the Akwesasne, Cornwall, Ontario, Canada
Can't See the Forest for the Trees: A Native American's Perspective 39

Malcolm Hunter
Professor of Wildlife Biology, University of Maine
Biodiversity: Buzz-word or Fundamental Concept? 55

J.P. (Hamish) Kimmins
Department of Forest Sciences, University of British Columbia, Faculty of Forestry, Vancouver, British Columbia, Canada
Respect for Nature: An Essential Foundation for Sustainable Forest Management 69
Introduction

Thank you, Perry. It is a real privilege to be with you today. It is a privilege to have an opportunity to open the Plum Creek Lecture series and it is a joy to be back on campus here. It is a bit less stressful than my job across the river, and I have enjoyed having a day to spend with students and faculty.

My task with this presentation is to give you an overview of the concept of biological diversity, to try to weave a middle ground between something that nonscientific people can understand and that scientifically-oriented people might find is a satisfactory coverage of the topic. This is not going to be a highly scientific, theoretical treatment of the subject.

I will start by giving you an image of biological diversity. Biological diversity is the variety of life and all of the processes of life that occur in ecosystems from very small places to very large places in this place we call earth. Sustaining the parts and processes of these ecosystems is vital to our future and obviously to the future to all other forms of life.
I will provide a road map for the presentation, and I might say that I have designed this presentation to give you a foundation on which the remaining presentations in the series will build. I will treat each subject a little bit and none in great detail. We will start with some definitions, talk about values and uses of biological diversity, factors that affect the integrity of biological diversity, some ways that we conserve it, and some priorities for the challenges that we face in the near future.

I will start with a definition. I have been talking about biological diversity for well over ten years now, and I still encounter people who say, "Well, if we only knew what it meant." Well, this is what it means:

**Biological diversity** is the variety of life and all the processes that keep life functioning. No more, no less. It includes:

- The genetic variation in species that is the basis for all adaptation and evolutionary processes
- The richness and variety of species
- The processes by which populations function
- The aggregations of species that we call biological communities and all the interactions that occur among species in biological communities
- The linkages of all living organisms with their physical and chemical environment
- The processes that we would consider to be characteristic functions of an ecosystem.

Biological diversity has genetic, species, community, and ecosystem attributes.

It is a lot of stuff, folks. Far more than we can comprehend. There are an estimated 1.4 million species of plants, animals and other forms of life that have been identified and cataloged. That is just a portion of what is probably out there. Ed Wilson, a distinguished professor at Harvard, estimates that there are somewhere between 10 and 100 million different species. Most of them are not the vascular plants and the vertebrates that we would typically identify with. They are not the charismatic megafauna or megafauna like grizzly bears and big redwood trees. They are the little things. Many of them are insects. Many of them are organisms that occur in soils, in the bottoms of lakes and oceans and in places where we will probably never, if ever, see them. Biological diversity includes things beyond the species, as well as all the different variations within species. It includes the races, the ecotypes and all the pathways and processes that these species use to interact with one another. You can see it is quite a complex of life.

What are the values and uses of biological diversity? Here are five categories:

**Ecological Values**

Biological diversity drives ecological processes and provides environmental services. These include:

- Maintaining the health and productivity of the ecosystems upon which we depend
- Preserving the resilience and renewability that enables those ecosystems to respond to disturbance by rebuilding the plant and animal communities that were there before
Conserving Biological Diversity: Sustaining... Healthy Ecosystems

- Protecting the ability to maintain water quality, air quality, and the long-term productivity of soils
- Sustaining ecosystems' capacity to run their nutrient and biogeochemical cycles.

**Economic Values**
Products of biological diversity have economic value. These include
- Products that we can use "as is," straight from the land (e.g. huckleberries and elk)
- Raw materials for manufactured products (Wood is a prime example.)
- Botanical "blueprints," which we use to build some of our medicines
- A quality of life that may not be measured in financial terms but certainly has value to people
- Future products that we haven't figured out yet.

**Subsistence Values**
Biological diversity is a subsistence resource for many people.
- Many people throughout the world—including many of us here in Montana—enjoy biological diversity for its subsistence values. We use plants and animals for food, shelter, clothing, medicine, and even tools.

**Cultural and Spiritual Values**
Biological diversity supports many cultural and spiritual conditions worldwide that have a direct tie to elements of biological diversity:
- Animal stories entertain and teach our children about complex ecological relationships
- Diverse environments are sources of recreation
- Some religions are based on aspects of biological diversity
- There are many symbolic values (Think of a soaring eagle and the symbolism that has.).

**Knowledge Values**
Biological diversity provides us with knowledge of the living world.
- Learning about biological diversity helps us understand how life and the world we depend on work.
So biological diversity has many values.

OK, we have an idea of what biological diversity is and what some of its values and uses are. The question is, "Why all the fuss?" Why is there so much attention focused on biological diversity, and why does it generate so much controversy and misunderstanding.

I propose to boil the answer down to a series of if/then questions:
If humans, with our growing population, use more and more space and resources of the planet,
then it is inevitable that there will be less space and resources for the other things that we share the planet with.

If some of those other things disappear as a result,
then the complexity and resilience of our ecosystems are likely to decline.

If our ecosystems lose the complexity of their structures, functions and processes,
then ecological services and potential resources for us and for other living things decline.

That is essentially what has been happening for the last 300 years. Human populations have increased almost exponentially. The world has not gotten any bigger, so the amount of earth available per person has declined by about 90 percent, crowding more people into the finite spaces and, in many cases, crowding the other things off the place.

But humans are not always a negative factor. There can be both pluses and minuses for biological diversity as a result of human activities. Certainly the use of more space and more habitat by people has a negative effect on some species. It doesn’t seem to bother cockroaches, mice, English sparrows and starlings, but many species are negatively affected by humans using more space. Overuse of resources has caused species to disappear locally. Many have disappeared altogether.

You probably are all familiar with the passenger pigeon story and know that the passenger pigeon is gone entirely from the face of North America. You are probably not so familiar with the stories of the many species that are currently thriving (including some here in Montana) but are now absent from places where they once were common. Elk and bison, for example, once ranged much of the Midwest.

Alterations to ecosystems can have both negative and a positive effects. We have demonstrated that we can restore many of the beneficial characteristics of ecosystems we have previously destroyed. Our technology enables us to change landscapes dramatically, which can have a negative effect on some elements of biological diversity. But technology can also be beneficial in restoration and resource management. Technology that is viewed by some people as being a negative for biological diversity can, in the long haul, be positive, because without resource management to produce the wood, food, water and minerals that we need (with as many people as we have running around all over the place, consuming whatever they can consume) we would have far greater negative effects on the native diversity of life.

But overall, the net result of human population growth and the use of resources has forced many species to the brink of extinction. The cumulative effect has been the loss of habitats, principally through conversion from wildlands to other uses—primarily agriculture. The kinds of places that have suffered most from this are native grasslands and—some of our most threatened native wild ecosystems—estuaries, marshlands, wild rivers, and forests.

There have also been hidden changes in habitats. While they still may look like forests or grasslands they are not quite as diverse as they once were, due to structural changes in species composition, fragmentation, and isolation of small parcels of habitats, and populations that were once well connected.

I mentioned overuse and overpopulation by people. This is typically more prevalent in developing economies, and has not been as significant a problem in North America since scientific management came into being. But it has had an effect, and continues to have an effect in many parts of the world. Pollutants and toxins are certainly helping push biological diversity to the brink.
In the human dimension, population growth is potentially the most powerful negative force on biodiversity, but improved literacy rates, changes in personal habits, and adoption of a land ethic by people in their daily activities can have positive effects. Diversifying our economy so we are not as dependent upon single resources, providing incentives, training people, and increasing our productivity so that the things we need come from smaller areas of land all have the potential to allow us to retain much of our biological diversity while our population and economy continue to develop. The challenge is to find a balance between protection of the environment and development of economies that support people’s aspirations for well being.

The creation of that balance requires that we develop a strategy, a conservation strategy that does not exist in this country at this time. We have a de facto strategy for biological diversity and it is essentially what results from implementing the Endangered Species Act, the Clean Water Act, the Clean Air Act, the National Forest Management Act, state Best Management Practices, and so on. There is not a comprehensive strategy for biological diversity, and there has not been an active policy debate that has involved the citizenry of this country in trying to decide what we want to do about it. Without such a strategy, as we have learned, we are at the mercy of the implementation of individual pieces of legislation that have not been well coordinated. If we were to develop a strategy then we would establish a policy, we would identify the desired results, we would assign rights and responsibilities for carrying out that policy, we would provide incentives for people to operate on the policy, we would carry out actions to achieve the goals, we would reward success, and we would probably penalize negligence.

Several years ago, the principal federal land and resource agencies, together with private sector institutions, resource industries, and non-governmental conservation groups asked the Keystone Center, a consensus dialog group out of Colorado, to convene a national policy dialog to basically do a “what if:” What if we were to have a national policy for conserving biological diversity, what would we like it to be?

This is an adaptation of what came from that Keystone dialog:

*It would be the policy of this country to conserve the diversity of life and its processes, to promote desired environmental economic and social conditions (principally to provide for human well-being), to perpetuate healthy ecosystems, and to provide an evolutionary course for all life.*

I want you to keep in mind that where I am going now is kind of a “What if?” This doesn’t exist yet.

What would be the desired conditions for biological diversity in a world or a nation that has as many people with as high a material standard of living as we do? How can we sustain, restore, and enhance ecosystems ranging in size from small sites to large geographic regions? How do we preserve the diversity of
biological communities, and the functional integrity of ecosystems and resources for human well being? How do we accomplish the various goals we have for different places? How can we maintain the viability and productivity of native species (and perhaps some desired introduced species)? How do we maintain species integrity where natural influences cause variation?

This might be a way that we would identify some desired future conditions from a biological diversity policy, recognizing that there will not be a one-size-fits-all solution, and that the goals and desired conditions of biological diversity will be very different in the Bob Marshall Wilderness complex than they might be in the Missoula Valley.

I would like to introduce you to some key concepts. If you participate in the remainder of this series you will be exposed to quite a bit of detail on several of these.

Genetic Variability is one of the key concepts. Species Viability is another. You will hear of species area curves and island biogeography and fragmentation. You will hear about edge effects and patch dynamics, coarse filters and fine filters, biological legacies, succession, disturbance regimes, ranges of variability, reserves, conservation areas, multiple use zones, linkage zones, corridors, and adaptive management.

I am going to give you just a little background on a few of these.

Genetic Variability is important for human beings because (among other things) so many of our crop species depend upon having access to the variability that allows us to continue to enhance productivity, and deal with susceptibility to diseases and pathogens.

Species Viability is a very simple concept, but is extraordinarily difficult to put into practice in either the theoretical or the management sense. The central concept is that the more individuals of a species you have, and the more widely distributed they are, the more likely it is that they will survive into the future, and the longer they can be expected to persist. So at very low populations, species are very vulnerable to extinction. At very high populations, they have quite a bit of insurance—if you will—against the vagaries of natural and environmental variation.

Island Biogeography is the notion that if small patches or islands of things are surrounded by environments that are uninhabitable (to, say, terrestrial plants and animals), then the larger the islands are, and the closer they are to the mainlands, the richer in plant and animal diversity they are likely to be. The smaller those islands are, the smaller the populations are likely to be. Small populations, remember, have a higher vulnerability to extinction. You are also likely to have fewer species because smaller places simply do not have the variety of habitats that fosters a larger variety of species. The island biogeography concept extends to terrestrial systems and the concept of habitat patches.

Fragmentation is the division of a continuous landscape into smaller disconnected areas, limiting plants' and animals' ability to move from area to area. Fragmentation tends to reduce the total area available to endemic species, isolate habitat fragments, and increase edge effects. The principle causes of habitat fragmenta-
Conserving Biological Diversity: Sustaining Healthy Ecosystems

In North America are agriculture, residential development, Interstate Highways, and the systems of dams and reservoirs that we have created on our waterways.

There are differences of opinion on the best approach to conserving biodiversity: Some favor a species (or fine filter) approach, others an ecosystem (or coarse filter) approach. Let me give you a little background on those. In a species focus, known as a fine filter, you look at a particular species, like a spotted owl or grizzly bear or Furbish louse wart, and you try to meet its critical needs. It is a good idea to pick wide-ranging species to serve as an umbrella for other species, because the wide-ranging species tend to require a variety of habitats, large open spaces, and a diversity of flora and fauna. Examples of those that we use here in Montana are the grizzly bear, anadromous fish, migratory birds and mammals, elk, and waterfowl. They serve as good umbrella species to maintain quite a bit of diversity while we focus on the individual species. Sometimes it is good to focus on a highly specialized species, such as the water howelia up in the Seeley and Swan Valley areas, in order to meet very specific local needs.

The weakness in using the species approach is that there are too many of them and you can't address them all. You won't get there if you try to address the specific needs of several hundred species, let alone a million or so. We don't have enough time to figure it out, we don't have enough finances, we don't have enough patience, we don't know enough. Besides, many of the species move around over time making it very difficult to conserve them, and, perhaps more fundamentally, most species are hidden from view and we will never know about them.

On the other hand, the ecosystem approach to conserving biodiversity addresses the needs of a whole bunch of species at one time. It is a coarse filter. By maintaining a variety of ecosystems and habitats we can preserve many, many species. By addressing ecological functions we address many processes and the natural dynamics of the landscape. Dealing with short terms and long terms, small sites and large regions, we can catch some of the hidden diversity and maintain natural dynamics and variability.

There are several weaknesses in an ecosystem approach, however. First, because it is general rather than specific, the diversity preserved may not meet the needs of some critical species. Further, there is not a generally accepted taxonomy of ecosystems. We cannot identify ecosystems with the same level of precision that we can identify bald eagles, bull trout, or West Slope cutthroat trout. There are no valid universal rules for determining how large ecosystems ought to be, or how many we should address across a landscape in order to conserve all the parts and processes within them. Furthermore, we may not even be capable of identifying the processes that are most important.

So this species vs. ecosystem dialog that you may encounter is really a false dichotomy. It is not an either/or, nor is the notion that we must choose between nature and culture. The ecological reality is that all aspects of biological diversity are important, and that nature and human culture have been evolving for at least two million years and we hope will continue to do so for a long time to come.

I want to mention some other concepts at this point:
Biological legacies are things like dead trees that are left in the forest to provide habitat for woodpeckers, squirrels, bats, bugs, etc. Some trees are left to fall and rot into the forest floor. While they rot, they provide habitats for many organisms that wouldn’t otherwise exist, and ultimately their nutrients leach back into the soil to feed other organisms.

Ecological succession is the expression of ecosystems’ dynamic energy. We need to work with the notion that these ecosystems are going to change and they are going to change in ways that are going to make them dramatically different over time.

So we need a multifactor approach to the conservation of biological diversity. We have to blend a species approach when that makes sense (or, as often happens, it is required by the Endangered Species Act) with an ecosystem approach, and we also have to integrate human goals at different scales because most of our ecosystems now have people either living in them or dependent upon them.

Sensitive or keystone species and ecosystems can be identified. We need to also identify and consider critical or keystone economic and social conditions that are important to human goals and traditions. We need to use adaptive management and property rights as positive forces in conserving critical elements of ecosystems. Think of the fire triangle we learned about in elementary school: To sustain a fire, you need heat, fuel, and oxygen. To sustain healthy ecosystems that include humans, our strategies must be economically feasible, politically and socially desirable, and ecologically sound. There is a role for science, a role for economics, and a role for communities and social processes. If a conservation strategy, whatever its intended goal, doesn’t balance these three things, then it simply will not persist. It will not be durable.

This hypothetical policy I am describing must also identify rights and responsibilities. We currently focus too much on government’s rights and responsibilities. We need to start focusing on the individual citizen’s rights and responsibilities. The job of conservation belongs to everyone, and it starts with each of us as a citizen.

We certainly need to identify a positive role for property owners in preserving biodiversity. It will not work to penalize property owners if a critical element of biological diversity is discovered on their land: They need to be rewarded, and certainly government agencies have a role here. The incentives that we should build into conservation policy include information services and technical assistance: Education is always beneficial. Recognition and rewards can motivate some people to take appropriate action, others may respond to tax incentives or regulatory waivers, and cash or other economic benefits will appeal to still others.

I mention rules and penalties last. That is where they belong, not at the top of the list as they have been in our recent policies. Conservation actions need to be bold. It is not likely that we will slow population growth no matter how desirable that goal is to some people. Our best strategy is to temper the undesirable impacts of population growth and resource depletion through education, by making sure that communities have economic vitality, by ensuring that they aren’t forced into a subsistence mode of living (except for recreational, spiritual and traditional purposes), and by investing in research and education for new knowledge.

Here I will mention property rights and responsibilities again. We need to be
stronger in using markets and property rights to achieve biological conservation, and we must be quick to incorporate information and knowledge that we acquire from monitoring our progress. The current concept promoted by federal agencies, conservation groups, and many industries is called the ecosystem approach. Terminology notwithstanding—and I recognize there is some baggage to this—what we are trying to find is a way to meet basic human needs, to reduce human impacts on land, water and biota, to integrate environmental and social goals, to maintain the cultural diversity that is a vital part of the health of our communities and economies, to build a land ethic into people’s thinking, and to diversify the uses and values of our resources.

What gives us hope that we can do some of this? I think history gives us hope. Think for a minute about how things were in this country 100 years ago, when our policies were to dispose of land and to exploit resources. The notion of conservation was not even into its teenage years yet.

We had extremely diminished wildlife resources, and many species that are common today were on the brink of extinction. Today we have helped many of those species to recover. While we certainly still have species concerns we have, by and large been increasingly successful in the management and conservation of wildlife.

One hundred years ago our forests were heavily depleted. Every year we harvested and burned more forest than we regenerated. Parks, wilderness areas and nature reserves did not even exist. That story started to turn around after 1920, and since 1950 we have been on the upswing with regard to forested area and the productivity of forests, and we have the most comprehensive park, wilderness and reserve systems of any developed country in the world today. Our agencies have professional managers as their stewards, and we have educational and research institutions to supply the knowledge and training those managers need.

Waterfowl populations were decimated around the turn of the century, largely by plume and market hunting. We recognized the problem, addressed it, and our efforts have successfully restored waterfowl populations—certainly not to pre-settlement levels—but to healthy and productive numbers. Policies are in place right now to make sure that we don’t again extinguish species.

The trend in cropland and forest land in this country has stabilized since 1920, during a time when we boosted agricultural production without converting additional forest land to farm land. One third of the terrestrial surface of this country is in federal public lands, mostly in the West, and largely intended for the conservation of natural resources. Some of it is highly protected, some developed under multiple use concepts. So what are our current challenges?

These are some of the priorities we face today:

- Endangered and migratory wildlife are certainly a high priority because the growing human population has a tendency to spread out into rural environments. Fragmentation of these environments is creating some problems for animals that need to move around during the course of the year. Large carnivores are especially at risk.
Hal Salwasser

▲ Old growth and xeric forests are at risk.
▲ Agricultural ecosystems are at risk, especially the native agriculture systems and the native cultivars of our crop species.
▲ Native grasslands are one of the most endangered ecosystem types in the world.
▲ Wetlands and estuaries are still under great pressure.
▲ Fisheries, rivers, and riparian ecosystems still are high priorities.
▲ Human cultural diversity is a high priority. In many parts of the world—Europe especially—human cultural diversity has been eliminated. In parts of Asia, South America and (I hope) here in North America we still have a high priority on maintaining the cultural diversity of native peoples and of immigrants.
▲ We will have to learn how to manage for biological diversity in the working landscapes of this country. We do not have enough wilderness areas to provide for all native species' needs, they are not in the right places nor at the right elevations. They are not large enough. Nor are National Parks sufficiently large to conserve all of the elements of our native flora and fauna. If we double their size it would still not be enough.
▲ We will have to manage landscapes both public and private.
▲ We will have to focus on the genetic variation in managed species so they will maintain their productivity and resistance to diseases and stress.
▲ We will have to learn to manage native species at least for viable populations and many of them for continued productivity.
▲ We will have to focus on maintaining structurally and compositionally rich communities, maintain ecosystems that have diversity in their parts, processes and patterns, and manage the natural resources that we depend upon for our entire well being so that they maintain higher productivity and resilience.

This is possible and I want to leave you with the thought that biological diversity is not just something that is off in the wilderness somewhere: It is in your backyard. It is in the places where you work and play.

Questions from the audience:

Do you see the GAP analysis helping to achieve some of the goals you have outlined?

The GAP analysis is a nationwide effort using satellite imagery to map and determine the abundance and distribution of different habitat types, and to overlay that with what we know about the distribution of different species. Then we can identify what you might call hot spots—places where there are unique combinations of species and habitats that create especially high priorities. GAP analysis is an essential step in learning what we have and where it is. Once we know that, we need to develop preservation priorities and figure out the best mechanism to actually achieve conservation goals. In some cases we may decide to protect an area in a natural state. In others we may want to continue current management strategies: After all, that is probably why the species are still around. The GAP analysis project is a critical step toward a national inventory.

Are industrial forestry land managers trying to tone down the application of biodiversity and
ecosystem management principles because they feel accepting those approaches could lead to government interference with private property rights?

Boy, I don’t know if I have a good answer to that. I work with people in industrial forestry and the professional forestry association, the Society of American Foresters and I haven’t encountered an overt attempt to do away with ecosystem management approaches or efforts to preserve biological diversity.

I think there is some frustration and confusion over what ecosystem management means, and when it is presented in a way that suggests government regulation of private property those people get really nervous. But when you talk about the principles and the approaches I have mentioned this afternoon, people don’t have a problem. As long as we respect property rights, and respect the fact that people managing private lands need to make a living on those lands, and need to contribute to the economic well-being of their community and the nation, private land owners and managers can feel comfortable with maintaining biological diversity. We recognize that as a key part to the whole picture. In my experience, people who oppose the concepts of biological diversity and ecosystem management do so out of fear, rather than understanding.

What lessons could you pass on to us from your experience with the Forest Service New Perspectives program?

The New Perspectives effort went from 1990 through 1992 and its goal was to stimulate people at the field level, the local level, to try new ideas on the ground. Those new ideas could come from the sciences, from sociology, from political science or any other discipline. We came out of that experience with some fairly basic principles that I think are extremely important today. In fact, they are the framework for ecosystem management.

One of the most important is to get the people who are affected by government agencies’ decisions to actively participate in shaping those decisions—“Collaborative decision making,” and “participatory democracy” are some of the buzz words. Without that kind of involvement, people tend to sit back and use government agencies as whipping boys when a pet special interest hasn’t been served.

Another is to strengthen the link between scientists and land managers in crafting and carrying out resource management activities. We will never know all that we would like to know, and we are always going to get blindsided by surprises. The normal link-up is for scientists to do their thing, publish their research, and five or ten years later somebody will pick it up and figure out how to put it into practice. Well, the whole world will have changed by then. Tightening the linkage and cutting lead time is critical to getting science into the field in a timely manner.

A great example of how that can work is a project that spun out of the New Perspectives work. In the Bitterroot Ecosystem Management Research Project just down the road here, university scientists and government agencies are working closely with land managers and actively involving citizens in shaping management approaches. An open decision-making process, tighter linkage between science and management, and a larger role for community members in shaping the decisions that affect them are some approaches that we learned are effective. These are fairly dramatic changes from how natural resource management was carried
You touched on the positive relationship between economic development and conservation of biodiversity. Could you describe how that works in developing countries?

At any level, from community to country, from local to national there must be a certain sense of affluence and well being to believe that resources can be expended to take care of the environment. That has been well illustrated in the United States. We are affluent enough that we tax ourselves, so to speak, with environmental laws that mitigate the potentially devastating effect of our life-styles on the quality of our water, air and soil. I have traveled in India and Mexico and I have seen clearly that very poor economies cannot afford to take care of the environment. After I delivered a lecture on conservation ethics to a group in India, a forester came up and said, “You need to understand that conservation ethics come after breakfast.”

So I think there is a linkage. That is not to say that we have to have an economic engine running wild. It is just that we need a certain level of well being before people can perceive the need to invest in the future.

Are there some specific actions that can help foster ecosystem management cooperation across land ownerships?

Yes, there are. The key to cooperation across land ownerships—especially when you are talking about private lands—is the need to have incentives and enforceable property rights. I am not familiar with all the legislation currently being introduced, but the Kempthorne Bill on endangered species, for example, is taking a stab at providing economic incentives for private land owners who preserve biological diversity as mandated by the Endangered Species Act. This has generated considerable interest, but it is not national policy yet, although it is certainly being tried at the local, private level. The program in which the Defenders of Wildlife compensate landowners for raising a litter of wolves is a good example of a private incentive: It is not a government program. I think we are seeing some definite trends in that direction and it is only a matter of time before it shows up in national policy, because it is the only way that coordination across land ownership will occur. Government regulation will not be effective on the private lands. Landowners would find ways to subvert it.

How does forest health fit into all of this? Will our definition of forest health change?

It is wide open for debate and we are going to see a pretty active dialogue on that in the next several years. The Columbia River Basin Project will deliver some information. It is going to make a strong pitch for forest health as one of the driving factors. They are going to differentiate among conditions in a healthy forest in a wilderness area vs. a healthy forest in a production area. In the next session of Congress we might have legislation on forest health, and I think it will force the debate. If you accept that people live in ecosystems, and your definition of ecosystem health includes individual well being, the state of communities, and things like crime rates, employment rates, and general sense of quality of life as well as water quality, air quality, and endangered species, then I think it will be a real exciting
Conserving Biological Diversity: Sustaining Healthy Ecosystems

dialogue for people to participate in.
The ringer in this definition is that people's values and attitudes change over time, too. One of the things that we are not adequately paying attention to right now is that the population of the United States is growing by 33 percent over the next three or four decades. I don't think people are comprehending that it is going to be a different kind of population. It is not going to be the demographic makeup that we have right now. We are looking at a much greater shift in the ethnic diversity of our population than we have seen to date, and that is going to change attitudes and values in ways that we can't predict.

*How does improved genetic stock fit in with what you have been talking about?*

I guess I tend to believe that if we can improve the productivity, and the resilience, and the disease-resistance of the commercially valuable species that we manage for crop resources—trees, food, fiber—that will allow us to meet our needs on less land. That allows us to manage some of the other landscapes for other values. So if we can do an effective job at stimulating productivity and get the resources that we need from the same or a smaller land base, that is a positive contribution to biological diversity. I think that tree farms in the South, for example, are a net positive contribution to the biological diversity of this nation because they keep us from having to cut trees everywhere in the west. It may not be quite so good for some people in the south, but every place has a role to play.

*Does it fit your definition that we can have a lesser percentage, say 20 percent improved stock, to maintain diversity?*

I think that is a possibility. I think we have learned that diversity in the forest is desirable. It doesn't always pay to come back in with a single species of tree. But, for example, the Douglas fir and red alder story out in the Northwest, where you run a crop of red alders first and it puts nitrogen back into the soil, and then you come in with the firs and you harvest both of them and you end up getting more biomass and productivity then if you would have just tried to grow the Douglas fir in the first place. I think that is the sort of thing that would make sense.

*Missoula, Montana, October 10, 1995*
Biodiversity and the Land Manager: Where Do We Go From Here?

Jack Ward Thomas
Chief, USDA Forest Service

Introduction

Perry Brown, School of Forestry Dean

Welcome to the 1995 Plum Creek Lectures. Today we have the pleasure of hosting the chief of the United States Forest Service, Jack Ward Thomas.

Jack is a professional and a leader who inspires hope for the future of our National Forests and our American heritage. He is a man of vision and action who brings practicality and integrity to natural resource discussions. Listen carefully to what he says so you can fully appreciate what he has to share.

Jack has degrees from Texas A&M, West Virginia University, and the University of Massachusetts. In his 38-year career he has worked for the Texas Game and Fish Commission and the USDA Forest Service. For 21 years he was the chief research wildlife biologist and project leader at LeGrande, Oregon, where he did pioneering work in integrated natural resource management, and led teams of scientists dealing with very, very politically, socially, and scientifically difficult Pacific Northwest natural resource issues.

In fall, 1993 Jack was appointed the 13th chief of the USDA Forest Service, bringing tremendous intellect, insight, practical inclinations, and leadership to that organization.

Today Jack will share with us some ideas on biodiversity and public land management agencies. Please join with me in welcoming Jack Ward Thomas.

I am pleased to participate today in the Plum Creek lecture series dealing with biodiversity.

Where do we go from here in dealing with biodiversity in management? An answer requires knowing the state of knowledge, and the level of professional and public understanding of biodiversity. Based on the experience of the last few years, I have a mental image that, for many, trying preserve biodiversity is like eating Jell-O with chopsticks: The intent is clear but much remains to be worked
out in practice.

As a first step it seems essential to describe biodiversity. The definition seems simple enough—to scientists. Biodiversity can be described as the sum of extant life forms, with diversity concerns ranging from alleles, to individuals, to populations, to communities, to ecosystems, and the inherent processes at each level of concern. And, it becomes clear that the most prudent path to the salvation thought to reside in sustainability is to retain as much biodiversity as possible over the long term. What is there in this objective of the conservation of biodiversity whereby biodiversity retention emerges as a Holy Grail?

This emergence of preserving biodiversity as a unifying management concept is the present point along a trail that reaches back to Darwin’s underlying theory of evolution. The most inclusive possible preservation of biodiversity retains the optimum cultural medium in which the ongoing process of evolution can best thrive. Preservation of biodiversity allows biologists of all ilks a way to heed the voices of the prophets who cried out in the intellectual wilderness. Aldo Leopold’s pleas to be careful, when tinkering with the earth, to save all the “cogs and wheels” is a foremost example.

The concept of retaining biodiversity has many attributes of a worthy Grail: It is bright, shiny, and new. It is mysterious, potentially unifying, and sufficiently complex to inspire an almost infinite number of quests. Yet the concept is familiar enough to allow some reassurance that the quest is a worthy one. This seems significant, for as T.S. Eliot observed in “Little Gidding:”

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.  

So we have arrived, after a long journey, back at the seminal concept in biology of evolution, and the preservation of the cultural medium that allows that process, that unifying concept, its fullest potential. Some biologists and natural resources management professionals begin again on a course of exploration and adventure. Somewhere in the backs of the minds of many of those folks is the feeling or suspicion that the retention of biodiversity is somehow central to the long-run welfare of the earth and its inhabitants—and, most assuredly, humans.

Several years ago, the Endangered Species Committee (the “God Squad”) was convened by then-Secretary of the Interior Manuel Lujan at the request of Cy Jamison, director of the Bureau of Land Management (BLM). The purpose of their deliberation was to determine if 44 timber sales proposed by the BLM, and which the US Fish and Wildlife Service determined would jeopardize the welfare of the northern spotted owl (a threatened subspecies), should be allowed to proceed to prevent the anticipated negative economic impacts of preserving the owl. During that hearing, the attorney representing the timber interests announced to the press that, in the course of the hearing, he would “defrock the high priest of the cult of biology.” Several biologists spent a day or so each on the witness stand in the course of that action. Whether or not they were defrocked, tracked, or other-
wise folded, mutilated, and spindled is not the point. The point is that they were attacked on the very basis of biological theory that underlaid the accepted conservation strategy with the intent to establish that there is a “cult” of biology that is a threat to people and their welfare.

This may well have been a precursor of actions to come and provides the biological community with a view of the future. It may be well at this point to take time to see ourselves as others see us. It is not my intent to blaspheme, but let me describe what runs through my head as this issue unfolds.

The holy tablets that Charles Darwin brought back from his pilgrimage to the Galapagos Islands described the theory of evolution that now underlies all fields of biology. After the proponents of that concept had wandered a while in the intellectual wilderness, the theory of evolution became the foundation of biology and the “cult” of biology emerged. Many sub-priests of the cult came forth to serve the evolution credo—geneticists, ecologists, taxonomists, botanists, zoologists, etc.—to devote themselves to developing knowledge and theory, and to publishing the sermons of their faith in peer reviewed journals and other scholarly treatises.

From this base, crusaders developed and spread this knowledge to encourage the manipulation of the earth for human benefit. Among these crusaders were agronomists, foresters, aquaculturists, wildlife biologists, and many others.

This reductionist approach, both in the development of basic knowledge and in application in management, became accepted modus operandi for most of the 20th Century. Each of these disciplines raised their towers of understanding, of knowledge, of practice, one upon or next to the others. And, each tower was different in some way from the others. With time, the structure of the tower and the sounds emanating from each of the towers became more different still. For those striving to discern some coherence and some means of integrating science, from whatever source, for management of renewable natural resources—including retention of biodiversity—it was indeed, collectively, a Tower of Babel.

Then the science of ecology began its slow development at the end of the first third of the 20th century. Ecology came to be called, “the subversive science” in that it revealed that, as Barry Commoner put it, everything is connected to everything else and there is no free lunch.

This meant that some new integrative approaches of applying scientifically derived information were required to augment, if not replace, the tribal rites of the separate orders of knowledge and practice. From this intellectual ferment an idea that is coming to fruition—the extension of ethics beyond the confines of human relationships to the relationships between humans and the land itself. It is at this confluence of the merging streams of ecology and ethics that we find ourselves today. In these newly mingling streams lies much promise and much danger.

We must look for some unifying mechanism to bring useful order out of seeming chaos. To do so requires a focus on a worthy objective and new universal language, an Esperanto, to facilitate communication.

The unifying concept that has emerged has been biodiversity and its preservation, and a new applicable Esperanto could be contained in the concepts and approaches evolving in the fabricated field of conservation biology. These may,
together, constitute a viable means of providing a unification of ideas and knowledge from myriad disciplinary orders, and an emerging land ethic in search of a new vision and a new mission.

But again, in the spirit of stepping back and seeing ourselves as others see us, let me describe some additional impressions. The new order in the evolution of biological disciplines is developing a new language where comprehension separates the washed from the unwashed. Meetings on biodiversity have been complete with a Latin service—"in situ, ex situ, alpha, beta, and gamma, amen." I have attended meeting after meeting, and seen transparency after transparency projected that reveal hieroglyphics and other mysterious writings worthy of ancient tombs of the Pharaohs—boxes and arrows and "black boxes" of great wonderment.

High priests swoop in from afar (no doubt on great silver-winged birds) to impart wisdom, guidance, and insights, then quickly depart to spread the word elsewhere. They talk of world institutes concerned with biodiversity, of national institutes, and of unifying and coordinating infrastructures with appropriate staff and resources that transcended boundaries of land ownerships, states, and even nations. There are intimations of new covenants between humans and the earth. They even try to impart a vision—a necessary thing—for without vision the people perish.

I am left feeling empathy for those who struggle in the trenches of natural resource management forming themselves into "cargo cults" that daily scan the sky for the return of the great silver birds bearing wisdom, institutes, and resources. Indeed, the big silver birds may return, heavily laden with goodies. Or—much more likely—not.

I have watched the faces of the foot soldiers in the ragtag army that deals with natural resource management day in and day out. I have visited with the grunts as they watch and listen and evaluate the chants of biodiversity conservation. They, in general, have not been encouraged by what they hear. They are concerned about unnecessary complexity, unintelligible presentations and worry about the institutes and mandates to come. They fear the likely extreme political resistance and barriers preventing achievement of any biodiversity retention. This is reminiscent of the scene in the Wizard of Oz in which Dorothy, Toto, Scarecrow, Tin Woodman, and Cowardly Lion are deep in the Enchanted Forest. The further they go into the gloomy wood, the more frightened they become. They begin to chant together, softly at first, "Lions and tigers and bears," and then, louder, "Lions and tigers and bears!!" and then, louder, "Lions and tigers and bears!!" This continues until they are paralyzed by fear.

The goals and concepts for the retention of biodiversity that emanated from the Tower of Babel seemed increasingly complex and convoluted. I vaguely remember that some philosopher said (as reported by columnist George Wills) that roadblocks to achievement could be divided into messes and problems. Messes, he said, were too difficult, given present circumstances, to clean up. Messes were to be endured. Problems, on the other hand, were different. Problems can be defined, addressed, and solved.
I suggest that the foot soldiers in natural resource management leave the messes to the gurus and high priests that come and go on the big silver birds and contemplate and concentrate on the solution of problems with the tools and resources at hand. Forget about the pomp and ceremony of the full Latin service and return to the folk mass suitable for the instruments and voices that are available. Start thinking and being concerned about biodiversity at an appropriate intellectual and philosophical level.

Is, intuitively, the preservation of biodiversity a good guide for a general conservation strategy? The answer that emerges again and again is “yes.” Why? It makes good sense for a number of reasons. Then we can ask the question, “What can the individual or agency do, here and now to come to grips with the ‘problem’ of this place and time?” It really doesn’t take super-sophisticated science nor does it require the blessing of the Cardinals to address such problems at the local or regional level.

The word biodiversity now regularly appears in the press and in conversations with Congress and even in presidential politics. That’s the good news. The bad news is that it is quite clear that the use of the word is far more prevalent than an understanding of the concept. You know there is a long way to go in education of the nation’s leaders when a congressman asks you if a certain action is apt to be “good for the biodiversity.”

If natural resource managers are convinced that retention of biodiversity is a worthy goal, there is no need to wait for the high priests and gurus to point out the way. Do the best you can with what you have at your disposal. Don’t wait, start now. Don’t be intimidated. More big picture thinking will be forthcoming as “biodiversity retention,” “ecosystem management,” “new forestry,” “landscape scale management,” “new perspectives in forestry,” etc., meld and move from concept to concept. But, in the meantime, natural resource managers need to be aware and do what they can.

There are repeated calls for inventory and monitoring to a degree that boggles my mind. I am, admittedly, not enamored with overly intensive inventory and monitoring as an expenditure of scarce resources. This is not because the information would not be valuable, but because experience tells me that such efforts have, historically, fared badly both in terms of maintaining adequate funding and agency commitment, and in making good use of the information gathered.

This reservation goes hand in hand with the repeated calls for getting our "stuff" together, from the top down. Well, certainly that is quite important over the longer term. At any rate, such things are more the purview of those who walk the halls of power, compose and put through legislation, ply the skies in the big silver birds, and appear to us all on our TV screens and in the press. Messes and their resolution are their purview. Bless them all. For the rest of the natural resource management professionals, we can respond when called upon but our immediate best contribution is dealing with problems.

At this moment in the United States, concerns with the retention of biodiversity seem to be subsumed into the attention to the activities occurring in the name of the Endangered Species Act. The controversy swirling around the plans for the
conservation of the northern spotted owl, red-cockaded woodpecker, grizzly bear, and the various runs of races of salmon disguises the fact that these are really issues that serve as surrogates for the real question—the retention of biodiversity. To cast these issues in sound bites such as “jobs vs. owls” trivializes the real underlying issue—the retention of biodiversity. There is a need to move beyond the Endangered Species Act to a broader concept.

I heard two definitions concerning the utility of conservation biology at the conference on biodiversity held in July 1992 in Sacramento, California. It is well to dwell on those descriptions. They are very different and quite apt to yield different results as our concerns over biodiversity manifest themselves in management applications, laws and regulations, and legal action.

The first of these descriptions was made by Hal Salwasser as follows:

*The long term utility of conservation biology depends on its validity as an objective synthesis of different scientific disciplines and how it applies ecological theory and empirical facts to the practical resolution of complex and difficult choices in conservation policy, not on how it mingles scientific theory with the value system of its practitioners or aids in the political agenda of particular interest groups.*

Contrast that to this statement by Michael Soule:

Conservation biology is the mission-oriented servant of radical movements in the cause to save biological diversity.

Which matches your view? There is a big difference.

In ending, I want to emphasize that people, too, are part of ecosystems. People—their numbers and their actions—more than any other factor will influence the degree of biodiversity that will be retained over the next centuries. Satisfying human needs or controlling human demands or both is certainly one key to preservation of biodiversity. I noted a quote in the paper during the 1992 presidential election that emphasizes the point. The sometime presidential candidate, Ross Perot, asked about the controversy that swirls around the economic and social costs of instituting the conservation plan for the northern spotted owl commented, “If our children are hungry, we will cut every last tree. And, we won't worry about spotted owls except maybe to eat them.” Believe me, it doesn’t take sophisticated science nor an intricate mathematical model to surface that truth.

It is imperative that it be recognized that a national policy on preservation of biodiversity on public lands has simply evolved over the past 20 years. This has come about through the interactions of various laws—particularly the National Forest Management and the Endangered Species acts—the regulations issued pursuant to those laws, the accumulation of case law, and the policy of absorbing the brunt of the Endangered Species Act on public lands to the extent possible.

This unannounced, unproclaimed, and little recognized *de facto* policy is that the preservation of biodiversity has become the overriding objective of public land management. It is this *de facto* policy that is, in my opinion, the crux of the debate that rages today over the appropriate management of the public’s lands.

This evolution of circumstances to produce such a *de facto* policy of such
significance begs attention from the Administration and Congress. An answer to the question of the validity of that de facto policy is sorely needed if public land management is to ever be less acrimonious than at present.

So, how do we protect biodiversity and assure the goods and services required from the public’s lands? It seems likely that both objectives must be achieved if sustainable natural resource management is to be a reality—they cannot be achieved independently.

My point is that we must start on that journey, and our managers cannot and should not wait for the grand strategy to begin actively working to maintain biodiversity. Do the simple things. Do the obvious things. It is not so complex and so daunting as the theorists might make it seem. But it must be kept in mind that it is always human beings who will, in the end, determine the results of that quest. Those human beings, their cultures, their needs, and their support—or at least acquiescence—are essential to success.

The chances for the sustenance of biological diversity is obviously best where there are public lands to serve as the anchors and building blocks for management. These lands, considered in combination with all other lands, are the medium—each with an important but perhaps different role—that will assure biodiversity. Those public lands are critical—I repeat critical—to the achievement of that worthy and, perhaps, essential goal.

**Questions from the audience**

*How can land managers execute biodiversity if, as you suggest, they use science alone (and not ethical considerations) as a basis for management decisions?*

My point was: Can science alone to support this operation, or should we use a combination of science and human need, understanding, and ethics in the decision-making process? Biodiversity is a human concept and cannot be “executed” solely within the realm of “science.” That is what I meant.

In Ross Perot’s “eating owls” statement, people are an obvious part of the equation. I call for considering ethics along with science in our treatment of natural resources and of the land. Those two things obviously must go together. All decisions we make come through the filters of human experience and training.

*Don’t you think land management decisions should be based primarily on ethical and philosophical considerations?*

No, I don’t. It is the role of science and scientists to make the appropriate risk assessments, understand what is possible, and determine the associated costs and likely benefits. Once those parameters are established, it is the role of philosophy and ethics to establish how much risk, how much investment, how much return forgone are acceptable.

*What is salvage logging’s role in preserving biodiversity?*

Some salvage operations are related to forest health, and sometimes a cigar is just a cigar—that is, the salvage sale is made primarily to capture the opportunity to put wood on the market. There is wood to be harvested, with acceptable (or with
what we consider to be acceptable) risk. That provides wood for the part of the ecosystem equation that provides housing and other wood products. We expect that salvage logging will be done in a manner that does no harm, provides wood to the market, and will allow the ecosystem to recover.

**If you had sweeping powers, how would you maintain the ecological process in National Forests?**

The approach I would take would not be much different from what we are currently doing. I would try to achieve the best balance among preservation, intensive management, extensive management and human use, and to build an underlying objective of protection of biodiversity while maintaining the production of goods and services that people require.

Our proposed forest planning regulations state our objective as the preservation of ecosystems, perpetuation of ecosystems, the restoration of damaged ecosystems, and the production of goods and services at a level compatible with ecosystem health. One comment on those regulations claimed they exceeded our legal mandate, and that the Organic Act (passed before 1900) directs us to produce timber. My response was, there are two other requirements in that Act: the first is protect the forest, and the second is provide clean water of adequate amount. Our regulations say the same thing, but in 1990 language rather than 1890 language.

**Do you believe in the difference between political and scientific definitions of biodiversity and, if so, what is that difference?**

I don't believe in such a difference.

**Given the fact that biodiversity is both relative and site-dependent, how do you monitor it across landscapes?**

Quite obviously we have to devise national-scale monitoring systems (which are being devised) and a national grid that would be both large-scale and relatively site-specific. In some cases we may need more site-specific information than provided by the grid. In those cases, we would collect that information as required. All of that, of course, depends on adequate budget and personnel.

**Do you have any professional opinions or concerns about proposals to privatize public lands?**

Yes. That is the one thing (outside of my family) that I am willing to fall on my sword over. Congress asked me if we should sell off our public lands and I answered in two ways: as Forest Service chief and as a private citizen.

As chief, I said I would use Pinchot's arguments, which are still relevant today. One Congressman expressed the opinion that the fact that some state's selling price for timber was one-fourth of the Forest Service's indicated that we weren't operating our lands efficiently. I pointed out that the only reason the state could offer low-price timber was that they piggy-backed off of the road systems that the Forest Service built, and let the Forest Service bear the legal costs of answering protests and challenges. Further, most states operate under much less restrictive laws and operate under "forest responsibility doctrine" to maximize profits. If the state paid a fair share of those costs, and operated under the same rules, their
prices would be equivalent to the Forest Service's. It was a comparison of pears and pumpkins.

As a private citizen, I said I was raised in a state that had almost no public land. As a kid, I loved everything that I love now—hunting, fishing and roving around in the woods—but I was never able to do those things without begging permission, paying a fee, or sneaking. (I was good at all of them.) I went to Texas A & M, they gave me a degree, and I went to work for the state game department. We developed an absolutely marvelous system for producing big game animals and other wildlife on private land. We made it more lucrative for the landowners than the livestock business, but I still could not hunt without paying a fee or begging permission. Nothing had changed much.

When I was 32 years old, I went to work for the Forest Service, and for the first time in my life set foot on a National Forest—land that we all own in common. There was not a “No Trespassing” sign there, and I didn’t have to ask permission: I just went. (Thirty years later, I still look over my shoulder to see if somebody is coming to get me.)

That free and open land is a precious American heritage that no other people on earth possess, and it is extremely dear to me. I asked my sons what they thought about that question, and their opinion is the same. I would have asked my grandchildren, but they don’t talk very well yet. Of course, their kids—who will be born in 25 or 30 years—can’t comment either. We need to speak for them. So I said, Congressman, speaking strictly as an individual, the answer is not no, but HELL NO!

Ninety percent of the wealth of this nation is held by 10 percent of the population is that not enough? For me, those lands are so precious, so much a part of my heritage and inheritance that they are not for development, and they are not for sale for a mess of pottage. They belong to the citizens of the United States of America, and I personally choose to keep it that way.

We can argue about the management of those lands. There is a broad spectrum of management possibilities and that is a worthy subject for debate. But again, speaking for myself, I can’t imagine Montana without its National Forests; I can’t imagine Idaho, Oregon, and Washington without their National Forests. I admit that that is a very emotional response. To me it is an issue that is so close to my gut that I can’t say it any other way. It may be that I have been in the Forest Service so long that I am too much a part of the culture, and that I have been too tightly tied to that land for 30 years—but I don’t think so.

**What would I tell a district biologist if she asked me how I manage for biodiversity?**

The first thing I’ll tell you is that you, alone, sure as heck will not be able to manage for biodiversity and satisfy the various human desires and needs. I suggest that you and your colleagues start by looking for the obvious.

What unique things do we have here that need to be considered? What are the attributes of biodiversity and how are they distributed on our district and on our forest? What is the rate and scale of change? What do the people in the local community think about it, what part does this play in their culture, and what are
their needs? What does the law require? It is complicated, but it is where I would start. First and foremost, however, it has to be a cooperative effort with other professionals, constituency groups, the public, and the people that live there. Without that collaboration there is no chance of success, except in a very limited, temporary sense.

If ecosystems are to be the bases of land management and preservation of biodiversity, why (as recently reported in the press) is the Department of Agriculture suggesting rearranging the Forest Service’s regions so that the forests of northern Idaho will be in the same region as the very different ecosystems of the Great Basin, Southern Idaho, Utah, and Wyoming?

Newspapers are not usually the best source of information. I think you are talking about the Columbia Basin Assessment. That assessment merely recognizes that those lands shed water into the Columbia River—it doesn’t put them in a mixmaster. The Columbia River system contains a considerable number of species and strains of fish that must be considered within the context of the entire system. The high desert and northern Nevada are a bit different from the Idaho panhandle, and I don’t think that the assessment implies that they should be managed alike—it just recognizes that all of them shed water into the Columbia. That is a rational basis for an overall assessment.

How much attention do you pay to the dismal science of economics?

A bunch. Some people have suggested that we should not have goals, targets, or objectives, but that we just send out money into the field and they do what they do, and everybody’s happy. Not quite. The economists have a lot to say about this. In particular, they want to know what you are going to do with the money, what are you going to get out of it, why should we spend the money to do this, what are the benefits, what are the cost, and what are the probabilities? That applies to biodiversity just as it applies to the production of timber, or enhancement of an elk herd.

How can land managers integrate the Endangered Species Act into their planning efforts?

First, we have to move beyond the fascination with individual species. Preservation of the Northern Spotted Owl, for example, is not the issue. The issue is preservation of the ecosystem upon which the owl (or any threatened species) depends. That is the objective of the act. As long as we deal with species as the question, we will hoist ourselves on that petard. The right approach is to look at systems and communities.

Would you comment on the forces behind privatization?

Yes, but don’t take my comments too seriously. I don’t know much more about it than anyone else, but I see it this way: There is a lot of valuable land out there and some people might like to own it and profit from it. Once the land is devolved, fragmented and developed it is a whole lot easier to either influence its management for private gain or to put it into whatever hands will accomplish that end.

That might be part of it, but it seems more likely that people are frustrated by the perception that our management is not particularly efficient, that we have
created an incredible hodgepodge of laws, processes, appeals, lawsuits, changes in the law, and quick fixes. We have redone some timber sales five times and the results weren’t 2% different from the first time.

How many of these efforts are deadly serious, and how many are shots across our bow, is another question—but I take it seriously. I think examining the issue is the issue. We need to struggle with the frustrations that produce the issue and we need to resolve some of those frustrations soon or they will become more and more validated.

I think many of those frustrations are legitimate, and I don’t think they should be addressed by throwing up our hands and giving up on all those things we, as a nation, wanted and passed laws to bring about and support. But I do think it’s time to sit down, examine these things in terms of their consequences, decide—as a nation—what we want from these lands, and determine how can we most effectively and efficiently achieve those objectives.

It is extremely frustrating for everybody—including me—that we are currently not very effective or efficient. Someone asked how I feel about this, and I said I feel like Gulliver, tied down by a million threads. When the chief of the Forest Service spends more time working with lawyers than he does with national resource management professionals, something is wrong. I don’t want to—nor can I—give up, but we need to move on from the acrimony that resides in the tails of that bell-shaped curve of public opinion because neither extreme has the solution. That will be found several standard deviations in from those tails.

Missoula, Montana; October 17, 1995
Biodiversity: Reasons And Values

Alan Randall
Department of Agricultural Economics
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Introduction
Don Potts, Associate Dean, School of Forestry

Dean Perry Brown gave me the honor of introducing Professor Alan Randall, today’s speaker in our 1995 Plum Creek Lecture series.

Professor Randall received his Bachelor’s and Master’s degrees in agricultural economics from the University of Sydney (Australia). You will notice when he speaks that he has lost most of his accent. That’s because he has been in the United States since 1968 when he came to Oregon State University to earn his Doctorate, which he received in 1970.

He served briefly as an assistant professor at New Mexico State University, then moved to the University of Kentucky where he spent 12 years teaching agricultural economics. Since that time he has been Professor of Agricultural Economics at The Ohio State University.

While his two years in Oregon wouldn’t qualify as time the northern Rockies Professor Randall is no stranger to this area. He has done a considerable amount of contract work over here and is currently working with the Coeur d’Alene Indians on a lawsuit seeking remedies for the environmental degradation of the Coeur d’Alene River basin.

Professor Randall is quick to point out that he has very little to do with agriculture, and a lot to do with multi-resource economics and choices in the values that we all share. While the title of his talk is “Biodiversity: Reasons and Values,” you will find that he is not going to speak exclusively about the economics of biodiversity but rather the choices we make. Please help me welcome Professor Alan Randall.

Humans ask what care and concern we should have for biodiversity, and what limits we should place on this care and concern. We want to know whether the value we attribute to biodiversity justifies sacrifice in order to preserve it; whether we have a duty to preserve biodiversity; or whether right action requires preservation of biodiversity. The questions we ask as we approach the issue reveal a lot about our philosophical framework(s). This is the subject matter
today's lecture.

While the definition of biodiversity is controversial, many definitions suit my purpose so the precise definition we use is not crucial. The concept of biodiversity that I am using focuses on the richness of life forms and the idea of "wild things sustaining themselves in (reasonably) wild places."

Often-heard reasons for preserving biodiversity concern its actual and potential usefulness to people. Biotic resources frequently prove valuable to people and taken together, the total value of these services is enormous. Obvious examples include food and fiber from domesticated plants and animals that were selectively bred from wild ancestors, and chemical and pharmaceutical products with biotic origins.

The majority of species on earth have not been catalogued and have unknown commercial potential. But, since many known species are useful, it is reasonable to expect that many unknown or poorly understood species will also prove useful (Bishop 1978), and that new uses will be discovered for known species not currently thought useful. Given the usefulness of known species under present technologies, it is statistically probable that virtually any species, known or unknown, will eventually prove useful. Thus, we should presume that any species has positive value for humans and is, by that standard, worthy of preservation.

The assertion that species store genetic information for future use has been extended to include the ethno-biological knowledge of indigenous human cultures. If ecosystems and humans have coevolved harmoniously, then disruption of indigenous cultures by colonization can destroy not only the ecosystem but also the folk knowledge that enhances its value (Southgate 1988, Norgaard 1984, 1988).

In the 1970s, environmental economics established that people have demand for natural systems as sources of raw materials and also as amenities. Amenity values include existence value—human satisfaction in knowing that some desirable thing or state of affairs exists—and use values—aesthetic and recreation potential. (Travel is now the fastest growing industry worldwide and adventure travel is the fastest growing segment of the travel industry.)

Another rationale for preserving biodiversity is ecosystem support services. Natural ecosystems affect water and air quality and serve as effective assimilators of wastes: Wetlands help purify water, and forests assimilate greenhouse gases and help restore oxygen to the atmosphere.

Ecosystems are complex and fragile, and it is a tenet of ecology that everything has its place in the broader scheme of things. There is a presumption that species are not only directly useful, but also indirectly contribute to ecosystem support. Species that have no conceivable raw materials or amenities value (if there are any) can still be valued for ecosystem support services they provide to species that are more directly valued. While it is clear that there is considerable redundancy built into the biosystem, the Erlichs (1981) caution against piecemeal sacrifice of biodiversity for modest gain.

These considerations add up to a substantial argument that a society of rational human beings pursuing homocentric goals should preserve biodiversity. At the very least, biotic resources should be carefully allocated rather than squandered
or wasted. They should be valued for their amenity services as well as their usefulness, and, beyond their commercial values, their ecosystem and environmental support services should be recognized as well. Statistical arguments can demonstrate positive expected values that are not otherwise obvious.

These reasons for valuing biodiversity—which have broad currency among conservationists, ecologists, and social scientists—focus on value (rather than duty or respect for rights) to justify the sacrifice required to preserve biodiversity. Humans are the valuers, and value is determined from a human perspective of the services biodiversity performs and the satisfactions it provides. Value is instrumental, consequentialist, and prudential.

This account is entirely consistent with standard economic thinking about the benefits of biodiversity. After all, mainstream economics is all of the above: homocentric, instrumentalist, consequentialist, and prudential; all that economics adds is a utilitarian perspective on valuing consequences. In economics, however, benefits are weighed against costs, including opportunity costs. To recognize that biodiversity is beneficial does not, by itself, clinch the economic case (or any consequentialist case) for protecting biodiversity. If costs outweigh benefits—always possible in benefit/cost analysis—such an economic evaluation would not promote the case for biodiversity.

In Search of a Fail-safe Case for Conservation

I suspect Ehrenfeld (1988) speaks for many preservationists who "would like to see [conservation] find a sound footing outside the slick terrain of the economists and their philosophical allies" (p. 215). These preservationists find the homocentric, instrumentalist and utilitarian rationale for conservation slick terrain because it can place a negative value on biodiversity. They would prefer a rationale for preserving biodiversity that does not depend on human preferences (which may well be fickle), nor on instrumental arguments (which might be rendered moot by emerging technologies). In fact, Ehrenfeld objects to the very idea of valuing biodiversity in comparison to other good things to meet society's desire for production and consumption.

If the standard economic approach yields only slick terrain for conservation, it is interesting to consider whether alternative philosophical approaches provide a more secure footing.

Consequentialist Approaches. Homocentric, utilitarian approaches are a subset of a broader group of consequentialist theories that claim, loosely speaking, that the rightness of an action should be judged by the goodness of its consequences. In general, utilitarianism evaluates all consequences for their contribution toward preference satisfaction. Consequentialism is open to other ways of evaluating consequences and is not necessarily homocentric.

If a consequentialist considered preservation of biodiversity the preeminent value, all proposed actions would be evaluated in terms of their effects on biodiversity, and those most favorable for biodiversity would be chosen. Other objectives would be subordinate to biodiversity. However, the preeminent-value status of biodiversity is not intuitively obvious. Since many of the world's richest
ecosystems and many of the world's poorest people are in the tropics, the legitimate human desire for improved living conditions frequently clashes with biodiversity objectives. In such clashes, it is not clear that biodiversity should always prevail. So choosing biodiversity as the preeminent value would avoid slick terrain, but at the cost of subordinating other worthy objectives. Considering other worthy objectives to be preeminent would, of course, return us to slick terrain. The primacy of biodiversity cannot be assured in a clash of preeminent values.

**Appeals to Moral Duty.** Duty-based (e.g., Kantian) moral theories attempt to identify humans' moral obligations and the morally correct actions these obligations entail. (For people whose basic needs are assured, moral duties outrank mere prudential concerns.) Ehrenfeld (1988) offers a solution to the “slick terrain” problem: “If conservation is to succeed, the public must come to understand the inherent wrongness of the destruction of biological diversity” (p. 215). Clearly, Ehrenfeld’s is a duty-based approach: right action respects human beings’ moral obligation to preserve biodiversity.

When several considerations have moral force (cannibalism is morally evil; self-preservation is morally worthy), clashes among them (can self-preservation justify cannibalism?) can be resolved only via deduction from higher moral principles. Slick terrain can be avoided only by asserting that preservation of biodiversity is a first principle, a trump among moral principles, that defeats all others. Without such an assertion, Ehrenfeld’s “inherent wrongness” does not solve his problem. Many would argue that enhancing the life prospects of the worst-off people has moral force at least as powerful as that of protecting biodiversity. Again, biodiversity is on slick terrain.

**Contractarian Approaches.** Contractarians argue that arrangements are justified if they respect the rights and observe the moral obligations of all the affected parties. In contractarian theories, rights are enforceable claims. Change occurs when all affected parties who are endowed with enforceable rights consent to it; without consent, the status quo prevails. Consent justifies change, but lack of consent for change does not justify the status quo. The starting point (or constitution) must itself be justified directly, typically by arguing that it was (or might have been) chosen by voluntary agreement among all concerned.

Contractarian approaches encounter considerable conceptual difficulties, which are exacerbated when the contract is extended to nonhuman species (Norton 1989) or to future generations (Randall and Farmer 1995). Yet, these difficulties do not prevent the obvious conclusion: species survival is not assured unless, implausibly, all parties to the contract rank the survival of all species above all other pressing concerns.

**A Strong—but Circumstantial—Case for Conservation**

We can do more than deny the viability of a fail-safe case for biodiversity. I have argued elsewhere (Randall 1991, Randall and Farmer, 1995) that it is possible to work more affirmatively toward constructing a strong but defensible circumstantial case.
A utilitarian who thinks most readily in terms of benefits and costs but takes seriously human ignorance and myopia would choose rationally to impose constraints on his own present choices for prudential reasons (Elster 1979). In the case of biodiversity, a plausible constraint is a Safe Minimum Standard of Conservation (SMS). Maintaining the SMS is a highly plausible duty in a duty-based approach to biodiversity. Yet Hubin (1994) has shown that even those who think primarily in terms of duties have reason to take benefits and costs seriously. A plausible contractarian solution would also include some form of SMS, and contractarians would take benefits and costs seriously when transaction costs limit compensation of all parties for all losses they might incur as a result of government action.

Before we jump to the conclusion that the major streams of western philosophy all generate the same policy framework for biodiversity (maximize net benefits within the constraints of a SMS) we should examine the SMS constraint itself. A SMS usually requires preservation of a sufficient stock of biodiversity (in practice, a species, or a habitat) to ensure sustainable regeneration, so long as the costs of so doing are not intolerably large (Ciriacy-Wantrup 1968, Bishop 1978). So the SMS has an escape clause; and the philosophical convergence that benefits and costs matter—subject to the SMS constraint—weakens when the escape clause is made explicit. Utilitarians think first of benefits and costs, and may naturally gravitate toward a benefit/cost view of the intolerable cost: e.g., an intolerable cost is any cost that is grossly disproportionate to the expected benefit. Duty-based and contractarian approaches would tend—for different reasons—to relax the SMS only in the face of a higher-ranked duty or right; the prospect that maintaining the SMS means sacrificing a large expected net benefit may not be reason enough to relax it.

Eating Owls

For the remainder of this lecture, I will bring these lofty concepts into clearer practical focus by examining a remark attributed to once and future Presidential candidate H. Ross Perot. Addressing the northern spotted owl controversy, Perot reportedly said “If your children are hungry, you’ll cut all the trees and not give a thought to the owl except maybe to eat it.” The remark hardly seems worthy of analysis, but by specifying initial conditions about the extent of hunger and the necessity of consuming owls to relieve it we can construct cases that illuminate the biodiversity issue.

Case 1: Human consumption of owls is a necessity and hunger is pervasive.

To say that consuming owls is a necessity means that human welfare would fall below a minimally-acceptable threshold if owl consumption dropped to zero. Starting from a high level of owl consumption, people may be able to maintain an acceptable level of welfare as owls become scarce by substituting other kinds of food; but substitution has its limits, and some positive level of owl consumption is essential for maintaining welfare.

Assume that the population of uneaten owls will regenerate in sigmoid fashion. The figure on the next page is a two-period diagram and the sigmoid regeneration
Setting the SMS
(Safe Minimum Standard) for Conservation

function traces the relation between

\( S_t \), the stock of owls withheld from consumption in time period \( t \), and

\( S_{t+1} \), the stock of owls available in the next period.

The gray line of slope \( = 1 \) starting from the origin is diagnostic: At points above that line, \( S_{t+1} \) exceeds \( S_t \) so that the natural resource is at least potentially sustainable; but at points below the line, the natural resource will eventually be exhausted, even if none of it is harvested.

If less than \( S_{\text{min}} \) is withheld from harvest in each period, exhaustion of the owl supply—a natural resource necessity—is inevitable.

The optimal stock to carry forward is \( S_t^* \), at which point the steady-state efficiency condition \( 1 + r = 1 + h \) holds, where \( r \) is the marginal efficiency of capital, \( h \) is the marginal regeneration rate of the natural resource, and \( D_t^* \) may be harvested in each period. (\( D_{t+1}^* \) is the optimal sustainable harvest.)

To capture the idea of uncertain regeneration, assume that the regeneration
function is stochastic and that its lower bound is traced by the dashed curve. Then, if SMs is withheld from harvest in each period, resource exhaustion will be avoided, even in the worst case with respect to resource regeneration. We take SMs as the literature’s SMS; we would call it the safe minimum standard of preservation.

SMs sustains the resource, but we have cast the issue as one of sustaining adequate consumption levels for the human population. Assume that \( D_{\text{min}} \) is the minimum harvest of owls required to sustain adequate consumption. Let each time period, \( t \), represent a generation of people. Then, any generation that uses less than \( D_{\text{min}} \) suffers extreme deprivation (welfare levels less than the minimally-acceptable threshold). We identify SMs as the minimum stock withheld from consumption that will provide \( D_{\text{min}} \) for each succeeding generation, i.e., draws of \( D_{\text{min}} \) and regeneration of the stock are guaranteed. SMs is the safe minimum standard of conservation. While conservation of SMs is required to assure sustainability, the odds are in favor of a society that abides by an SMs constraint: if regeneration turns out to be better than lower-bound (as it probably will) subsequent generations will be able to use more than \( D_{\text{min}} \) and/or conserve more than SMs.

An SMs rule requiring present society to conserve resources to avoid exhaustion in some (perhaps distant) future generation is not enforceable: One cannot imagine a real contract that would bind present society to abide by SMs for the benefit of distant future societies. Rather, SMs is a commitment that a society might undertake for ethical reasons, and it might abandon that commitment in the face of intolerable costs.

We have defined \( D_{\text{min}} \) as the natural resource use necessary to avoid extreme deprivation for the current human society. One could expect a society that inherited a natural resource stock less than SMs to nevertheless use at least \( D_{\text{min}} \) risking eventual resource exhaustion. To do otherwise would be to voluntarily accept an extreme self-sacrifice for the benefit of future societies. That seems too much to ask: The level of cost that is intolerable in practice is surely no greater than the sacrifice involved in holding current consumption below \( D_{\text{min}} \).

The ethical theories we have discussed are likely, in this case, to converge on this same definition of the intolerable cost. It is hard for any ethical theory to justify the present population consuming more than \( D_{\text{min}} \) if that would create a substantial likelihood that some future generation would inherit less than SMs. And, it is hard for any ethical theory to require a generation to sacrifice itself by consuming less than \( D_{\text{min}} \) in order to save future generations.

To deal with the case where consuming owls is necessary for humans threatened by pervasive hunger, a viable SMS policy must seek to conserve not SMs, but SMS to avoid forcing present or future societies to choose between starving themselves or starving future generations. In practical terms, a SMS policy would emphasize early warning and early implementation of conservation policies requiring only modest sacrifice of each society. Since unilateral withdrawal from any intertemporal contract or obligation is always a possibility, conservationists have a strong interest in keeping the costs of conservation tolerably low.
Case 2: Owls are necessities, but only some children are hungry.

Perhaps the hungry children belong to Pacific northwest timber workers, whose income suffers when society enacts measures to conserve owls.

This case is relatively simple. The necessity status of owls ensures that there will be little disagreement on ethical grounds with a policy to abide by SMS, thus assuring sustainable harvests into the indefinite future.

The problem will be to stop the hungry children from eating the owls. Police could stop the owl-gatherers, just as they stop looters (I'm sure some looters' children are hungry, too). Alternatively, we could induce them to reduce their owl intake to a level compatible with SMS by providing a more palatable diet that we could afford for them. This, of course, is what most of the present noisy posturing about property rights is about; exactly who will be protected from whom, or bribed to forego doing exactly what to whom.

Some questions now arise which have ideological overtones. The timber industry in that region may be subsidized and, despite that, declining. Community viability issues might color discussions about retraining or relocation of timber workers. Taxpayers' unwillingness to shoulder additional burdens—even for good causes—could limit the options considered. Nevertheless, the necessity status of owls and the relatively modest number of hungry children dictates finding viable solutions: Preserving owls is essential and affordable. Intolerable cost is not an issue, but it would be set at the same high level as in Case 1.

Case 3: Owls are not necessities and only some children are hungry.

If owls are not necessities and plenty of alternatives to owls are available, owl consumption could fall to zero without affecting human welfare. We can live well with or without owls, but the fact that we are living well means we can afford to save the owls if we decide to.

The fact that owls are not necessities does not undermine our basic conclusion that there is broad support across in western philosophy for taking benefits and costs seriously within SMS constraints. However, the relevant constraint is SMS because nonnecessity status implies that $D_{\text{min}} = 0$, and the intolerable cost that would justify abandoning SMS might be quite different for nonnecessities.

Homocentric utilitarians may find owls and their habitat valued for amenity and existence services, and may be willing to abide by SMS unless the costs of so doing are intolerable. Yet, the level of cost that would be considered intolerably high may, for a utilitarian, be quite modest. Rolfe (1995) argues on standard utilitarian grounds that SMS serves merely as a warning flag, or a speed-bump on the path to owl extinction. It would alert society that owls are in trouble and warn against strategies that would trash the owls for trivial gain. Yet, it would not commit utilitarians to disproportionate sacrifices in order to preserve the owls. So, the survival of the owls remains dependent on human preferences, and utilitarians are notoriously unwilling to require much of preferences.

Kantians (as Hubin has shown) cannot ignore human preferences. Nevertheless, they oppose giving preferences free rein. The Kantian view of aesthetic judgement exalts connoisseurship (i.e., studied appreciation) and some environ-
mentalists readily apply connoisseurship to the natural environment. To them, studied appreciation of the owls counts for more than fickle and untutored preference for owl-services. In addition, moral duty outranks mere prudential concerns once prudential needs are met (i.e., once we are living well). It is possible that a combination of Kantian connoisseurship and a high ranking accorded to the duty to preserve biodiversity would lead to setting the intolerable cost at a high level: no higher than that set in Case 1, but perhaps much higher than the utilitarian intolerable cost in the present case.

The contractarian view of the intolerable cost in this case depends on whose rights count, or who is admitted to the contract. Another Presidential hopeful, Senator Phil Gramm, found no problem with preserving owls (actually, in his case, woodpeckers), so long as the public that cared to preserve the birds fully compensated the landowners in whose woodlots they nested. A contractarian process that enfranchised owl-lovers, owls, and potential future owls would likely come to a somewhat different conclusion.

Conclusion

I have presented several ways of thinking about biodiversity—to what extent does the value of biodiversity justify sacrifice to preserve it; whether we have a duty to preserve biodiversity; and whether right action requires preservation of biodiversity—and explored some of their implications. A perhaps surprising conclusion is that an approach that takes benefits and costs seriously but subject to a SMS of conservation would be taken seriously by consequentialists, ethicists who argue from appeals to moral duties, and contractarians. Benefit/cost analysis provides a rather good accounting of human preference satisfaction, and any coherent moral theory values the satisfaction of human preferences. However, there are good reasons from a variety of ethical perspectives to impose a SMS of conservation unless the costs of so doing are intolerably high.

Where the conservation issue affects resources essential to human survival, there is convergence among ethical systems as to the intolerable cost: no living society can be asked reasonably to decimate itself in order to provide sustainable consumption for future generations. When the issue concerns a species the loss of which would be unlikely to threaten sustainable consumption for humans, the ethical consensus starts to break down. A utilitarian may well define the SMS rule in such a way that it resembles a benefit/cost criterion with a thumb on the conservation side of the scales. Some ethicists arguing from moral principles may set the intolerable cost at the maximum level (i.e., so high that society must conserve the species unless so doing would cause extreme deprivation for humans). The outcome of a multigenerational contractarian process may range between these extremes, depending on whether nonhuman species were included in the negotiations.

I noted that the personal pocketbook topics—jobs and property rights—tend to arise in discussing preservation issues. In the extreme case—where preservation may require considerable sacrifice from humans already near the minimum acceptable level of welfare—these sorts of issues are central to the preservation
decision. But, in the typical United States preservation controversy, preservation is well within the resource capacity of the human population. In such cases, jobs and property rights would play no special part in the preservation decision. They may, however, be central to discussion of the right way to go about preserving.

**Questions from the audience**

*In the context of eating owls, the obvious question generated by that line of thought is: When we run out of owls, will we be eating our children?*

In the end, in a pinch, we will, yes. The only thing that is not totally clear is whether we will eat our parents first.

If you think about end games, about what really happens in a disaster, it is quite demoralizing. In the end, when there are two guys left, the question is, who dies last. There is no way out of that.

**Intrinsic value**—the notion that things have value in their own right without needing justification as instruments that produce other values—is tough to demonstrate and very tough for economists to understand. (We just don't understand stuff like that. I think that is partly our problem not a problem with the argument.)

One of my reasons for saying that most arguments starting with an assertion of some kind of right are thoroughly disreputable is that it usually turns out that the claim is really one of intrinsic value. Take the case of claims that a fetus has rights. The claim is made without carefully considering the implications; for example, could it sue its mother for malpractice during pregnancy? It turns out that what we are claiming is that there is an intrinsic value in the unborn that should be respected: We should not sacrifice them trivially.

Rights claims have been spectacularly successful in the case of race relations, and so a tendency has developed to frame a wide range of controversies in terms of rights. The emotional appeal is obvious, but an appeal to intrinsic value has a lot more logical clarity. I forgot one other thing I wanted to say earlier to balance the bit about rights: Most arguments that begin with jobs are also thoroughly disreputable.

**Could you elaborate on that?**

If you look at what government subsidizes (subsidies could be cash money, or a license to trash the environment) you will find it has a bad habit of subsidizing declining industries that are on the way out. It is extremely shortsighted to allow biological resources to be destroyed in order to briefly delay the inevitable mobility of the labor involved.

You can all sit there and say, “Hey, an Australian academic mercenary in the US can say what he likes about labor mobility. My concern is for my community.” But if you take a cold-eyed look at it and ask about the sustainability of those enterprises, is it owls versus those communities forever, or is it owls versus another five or ten years of employment. That is an important part of the story.
I had a professor of forest management about 50 years ago who expressed the idea that you cannot manage a forest until it becomes scarce. Is that true?

It is true because, by economic definition, anything that has positive value is scarce, and it is hard to imagine managing something that had no positive value. I think, though, that the key point is that scarcities must be balanced regardless of the extracted commodities we are after, whether it is residential land for human habitat or biological resources. It is important to conserve ahead of the game while it is still cheap to do so, because it is hard to conserve when conserving becomes expensive. That is an important point that sometimes gets lost in the early stages of resource conversion.

The classic definition of development is the conversion of natural capital to man-made capital. That is what it is really about and, of course, that man-made capital might be retained and invested or it could be consumed. If we wait too long, consumption needs predominate, and it becomes very costly to conserve. I feel better with a conservation strategy based on getting ahead of the game, conserving (perhaps) too much too soon, rather than too little too late: The too-little-too-lates are so difficult to pull off.

Much of the discomfort with the Endangered Species Act approach simply reflects that it is crisis management, that it springs into action only after things are too far gone. The argument I am making is consistent with the ecosystem management approach, in that we identify things worth saving and get on with it fairly soon. I have observed some pretty sharp opposition to ecosystem management from private interests here, there, and everywhere. It scares the heck out of private land owners because they imagine the eco-police at the front gates. So the challenge for those promoting ecosystem management is to find ways to present it which are not threatening.

I do think, in principle, it is the way to go, rather than crisis management: the "spring into action, after you have got it listed" sort of approach that the Endangered Species Act has followed.

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References


Can't See the Forest for the Trees: 
A Native American's Perspective

F. Henry Lickers
Mohawk Council of the Akwesasne, Cornwall, Ontario, Canada

**Introduction**

Bob Pfister, Associate Director,
Montana Forest and Conservation Experiment Station

F. Henry Lickers is an Iroquois citizen of the Seneca nation and the Director of Environment for the Mohawk Council of the Akwesasne. Today he will share with us the knowledge, understanding, and wisdom his Native American culture applies to environmental concerns.

Please welcome F. Henry Lickers.

Good afternoon. I am very glad to be here. In the last 1,500 years, whenever our people would gather together in a council, one would be selected to give an opening thanksgiving. We call it “words before all else.” Since I have been invited here to speak, I will take that as an invitation to do it. Our people, the Haudenosaunee (People of the Longhouse), would sit during the thanksgiving, so I allow you to sit. The person who gives the thanksgiving stands, which I think is good sense because the thanks-giver will eventually get tired, sit down and stop talking. So let me start off by saying that I am honored to be allowed to speak here.

I would like us to think about the world. The first thing that I would like us to think about is the people on the earth. We the people here are gathered together to think about those things that we call biodiversity because we think that they are important. As people of the earth we have a responsibility, and we try to fulfill that responsibility in every way we can. So I ask you to bring your minds together and to think of the people of the earth: Those sitting beside you, and those far away. Can we agree they are important to us?

I next want you to cast your minds to the earth itself, the mother earth which sustains us and on whom we walk. Our colors are reflected in her and in the way she is. So I would like you again to bring your minds together and think about the
mother earth and give her your greetings and blessings. Can we agree that she is important to us?

The waters of this world are important, and the fish therein. The waters purify and cleanse the earth and the fish live in that water. The fish are brothers and sisters to us, and they sacrifice themselves for our goodness and our health. They give themselves in order that we may gain their strength so that we may do our duties for their cycle. So I would like us to think about the water and fish of the earth and cast our greetings and thank yous to them. Can we agree that the water and fish are important to us?

I would like us to think about the plants of the world—the trees, the medicinal plants, the herbs, the shrubs, and the ones we sometimes call weeds. Each of them have a duty and they have been performing their duties for the Creator for as long as they have been here. Some, like the three sisters, the corn, the beans and the squash, feed us. Trees give us shade on a hot summer’s day. Our children play under those trees and feel at peace. So I would like us to bring our minds together and think about the trees and plants of this earth. And can we agree that they are important to us?

I would like us to think of the animals of the earth, all the four-leggeds that run around the earth doing the things that they are supposed to do and have been assigned to do by the Creator. I would like us to think about them, each in our own special way. Can we agree that the animals of the earth are important?

Many birds of the earth have started to migrate south, but others stay with us, living among our people and making glad our hearts with their small bodies which hold their great songs. When we hear them and see them flying, our spirits are lifted and we should appreciate them. So I ask you to think of the birds in the world. And can we agree that the birds are important to us?

I would like us to think about the four winds that blow across the world, the four winds that bring the waters, and the rain, and that blow the currents all over. I would like to think on those winds. And can we agree that even their storms are important to us?

The Haudenosaunee People look on thunder as the loud voices of the grandfathers speaking to us. Those loud voices make us realize how small and humble we are. They reawaken a spirit that we felt when we were children, and that is a very useful thing to remember, sometimes. So I ask us to think about the thunder. Can we agree that it is important to us?

Next, we give greetings and thanks to the sun. I arrived here wearing my huge winter coat expecting a blizzard. The sun came out and shone brightly and has made my stay here very, very pleasant. So I would like us to send greetings and thank you to brother sun, for he is carrying out the duty set to him by the Creator.

Next I call on you to think about grandmother moon, who turns her face toward us and away from us and whose 28-day cycle rules the women in the world and enables us to bring forth children. So I ask you to think about grandmother moon and the women of the earth. Can we agree that they are important to us?

Next look to our brothers and sisters in the stars that look down on us, whose
voices we once could interpret to see into our futures. I would like us to think about the stars and send our greetings and thank you to them. And can we agree that the stars are important to us?

Lastly I would like us to gather together our greatest and best words and thoughts and pile them together into one huge greeting and thank you to the Creator that made all things. I ask all of you to be appreciative and send our greetings and thank yous to the Creator.

With those words I open up this council fire for this afternoon’s talk.

Those words open the important meetings of my people, the Haudenosaunee, and I think it is one of the best definitions of biodiversity. It includes everything from the ground to the sky, and thanks all of them for being there and doing their duties. The content may vary depending on who offers the prayer, and what concerns us at the time, but the form remains about the same.

On July 18, 1995, the Haudenosaunee presented their restoration strategy to the United Nations. I am a pale imitation of the tribal elder—a good speaker—who opened that meeting. When he was finished, Noel Brown and Boutros Boutros-Ghali were so moved by his greeting that they asked for Haudenosaunee permission to allow the United Nations to use the greeting to open and close the many meetings that the United Nations have, including the General Assembly. We are discussing that right now with the United Nations.

But we are here together today to talk about biodiversity and native awareness. I am honored and proud to be here because I can bring you greetings from the Mohawk Council and the Mohawk People of Akwesasne. Your university has a very special place in our hearts because The University of Montana helped Akwesasne when we needed help. At that time, fluorides were poisoning our community and we needed friends and allies who could help us solve our environmental problems. Clancy Gordon, who taught biology here at that time, gave us that much-needed help and I would like to dedicate this talk to his memory, for he is a friend and colleague long past, gone from this earth, to another place. I dedicate this talk to him and also fulfill the obligation that the Mohawk Council of Akwesasne has to him.

I would like to start by telling a story from a long time ago, from my early childhood. I was hunting with my grandfather. Even at that young age I was very interested in the world, so I would follow him around and he would tell me how the world functioned and many other things. I was always interested. He taught me tracking, so I loved looking for sign, finding the deer, learning how they moved and watching what they did.

One day we decided to go hunting. It had been a while since we hunted together and grandfather said, “Today you do the tracking. Today you are the one to be the hunter that walks through the woods to see where the deer are.”

Boy, I can tell you I was proud! Thirteen years old and I know everything. I am ready. So off we go and we come across some sign. I can see this buck track going through the forest. I said, “Wow, this is it, grandad, I see some good sign here.”
He comes over and says, “That’s good. Tell me what you see.”

Full of the confidence of a 13-year-old with a little bit of knowledge I say, “Ah grandad, he is a pretty big buck, probably a white-tail, and he is heading down that way. I think he is probably going down toward the creek there to get a drink of water.” There is a little bit of light snow on the ground, so it is quite easy to see the tracks.

Grandad says in his quiet way, “Yeah. Tell me what else you see about this deer.”

Looking at the track I say, “I think he is maybe a couple hundred pounds. The way he walks he’s male.” I’m really trying hard to see everything I can in this track.

“Very good. What else about this deer?”

Now I’m sweating. “Um..., he seems to be dragging his left front foot. Just a bit. He might be hurt there.”

“What else?”

Now the sweat is really coming. I don’t know what else I should see. “Grandad I have looked as hard as I can, I can’t see anything else.”

Grandad looks up and says, “I think you are right about that hurt leg. His shoulder has a little scar there.”

“I can’t see that grandad.”

He said, “Yeah. And right above the right eye there is a little black spot.”

I am looking real hard at this track and can’t see this for the life of me. I am completely perplexed and I said to my grandfather, “I can’t see this.”

My grandfather said, “Henry. When you go out tracking in the woods it’s very good to look at the track and to see what the tracks say. But the deer walked by right over here. You can see him right now if you look.” Then he said, “You have to learn to always be vigilant in the forest. That is the only way you will survive here.”

It was a very good lesson for me as a biologist. It taught me that what you see may not be as important as where you look. I was so involved in watching that deer’s track that I forgot to look up and take in the rest of the ecosystem that existed there, and I lost that deer completely. The track was only a sign. I could have seen the animal. When I read about biodiversity, I often think we are doing the same thing.

One definition of biodiversity I have heard is “the variability of the world’s genes, species, and ecosystems.” When I hear that I say, “Wow that’s a neat, neat thing,” because I know that there are probably over thirty million species out there. (That is probably a low count because we rarely include the creepy-crawlies—bacteria, bugs, and those things that slime along underneath the leaves and stuff, so it is probably well over that.) We know there are trillions of genes out there that each of those animals require to reproduce themselves and to keep their systems going, and there are millions of different types of ecosystems.

So the word biodiversity sounds really cool, but, like my grandfather taught me, I have to look up from that track, away from the thirty million, and see the bigger picture. And when I look at the bigger picture I run into stories about my children.
My children were born at Cornwall, at Akwesasne, and they have known Akwesasne all their lives. One day my sons and I were out on Cornwall Island in a large buckwheat field, playing around as kids and fathers will, and they took off running through the buckwheat field.

I called to them, "Wait, wait, hold it!" because at Six Nations where I grew up, if you ran through a buckwheat field you got stung because the bees were thick when the buckwheat bloomed. But at Akwesasne my children didn't get stung because there were no bees in that buckwheat field. There were no bees because they had been killed by pollution.

So when my children looked at the biodiversity of Cornwall Island, they won't make a tic mark beside bees because they are gone. And we won't make a tic mark beside passenger pigeons, because they are gone.

When we look at the biodiversity that exists today as the variability of the world's genes, species and ecosystems, we are taking a snapshot of the present time. We look at it and say here is what biodiversity is. (Minus, of course, the creepy-crawlies. We don't count them because they are not appealing to look at.) Another thing this narrow view ignores is the concept of space or area. It is like those movies on late-night TV, "Mad Max" is one, where they show you a desert world where nothing much grows and you wonder what these people eat. I look at the quality of that desert world biodiversity and wonder what the inhabitants would say about it.

My grandfather wondered about space. He said non-native people were always talking about "making North America." "Well, I've seen it from an airplane," he said, "and I wonder just how many square miles of territory they have added to North America these last 500 years. It can't be that much." Time and space become very important when you are looking at biodiversity as a living system.

From a native point of view there is another problem in trying to define biodiversity. Many people feel biodiversity refers only to wild stock. So if I look at dog or canine species I see a wild stock of wolves and coyotes, and I also see a huge diversity of domesticated dogs—but now there are feral breeds being raised and released again back into the wild and a huge complexity of different types of species and different types of animals interrelating together. Where does that fit into biodiversity?

When I was asked to give this talk I tried to think about everything that biodiversity includes. It was very hard to do. So I decided to talk about some of the structures that native people in our area work with.

I am director of the Department of the Environment for the Mohawk Council of Akwesasne on an Indian reserve that straddles the international boundary between Quebec, Ontario and New York State. If you want to talk about diversity of governments, boy I could tell you about the diversity of governments. A minor meeting on water quality at Akwesasne requires that at least one person come from each agency in the area—a minimum of 80 people. It requires a high degree of diplomacy to work as a director at this place.

Native people view the world holistically. They say all the things that happen in the world happen like ripples on the water. The elders in the various communities.
In a native people's Naturalized Knowledge System a single cause has many resulting effects. The effects move out from the cause like ripples in water and, like ripples, increase in complexity, and cover more time across Canada. Asked me if I could come up with a model that would help all people understand what we mean when we talk about a holistic view of the world. The model we came up with is called a Naturalized Knowledge System. Here is how it would work as far as biodiversity is concerned.

In a Naturalized Knowledge System you naturalize, or adapt, to a given area. The Haudenosaunee have lived in the eastern United States and Canada for centuries, and have learned to adapt to and to live within that sphere, within that system. What they have learned is different from what the people in the prairies have learned, and different from the experience of the people in the north. While the knowledge systems these native peoples developed in different areas were not the same, they had similar underlying principles. The Naturalized Knowledge Systems native peoples developed to look at the world were holistic, but banded in various shells.

The easiest way to describe these systems is through an expanded concept of cause and effect. In the Western world we tend to view a cause as producing a single effect. But native people looking at the same cause would see a multitude of effects, radiating outward and growing in complexity as they move away from the original event. (See illustration, this page.) For biodiversity the increasing complexity is significant.

Viewed along several familiar continuums, the cause and effect equation looks like the chart on the next page. Starting at the left, we first look at life at the subcellular scale where we find one atom, or two atoms coming together. Events last microseconds and occupy microscopic areas. We can know with a high degree of certainty what happens in there.
Can't See the Forest for the Trees: A Native American's Perspective

**Naturalized Knowledge System**

<p>| Cause $\rightarrow$ Effect $+$ $E_1$ $+$ $E_2$ $+$ $E_3$ $+$ $E_4$ $+$ $E_5$ $+$ $E_6$ $+$ $E_7$ |</p>
<table>
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<th>Cellular</th>
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<th>Group</th>
<th>Community</th>
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<td>Seconds</td>
<td>Minutes</td>
<td>Hours</td>
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Here is a Naturalized Knowledge System applied to several familiar continuums that are

Moving to the right, within cellular systems areas are larger and events last seconds. Individuals have many subsystems working within them—bacteria, mites, and various other things. We can estimate that 10 square meters is sufficient space for an average individual on earth, although individuals obviously vary—blue whales need considerably more space, pygmy shrews less.

Western scientists (I will put that hat on, too. I am a biologist.) can stand in the box on the left half of the chart and talk with the confidence, as we say, of a preacher with a full church. We know that we can keep an individual alive on a simple diet of so many calories and a minimum of biodiversity. But we also know that keeping that person happy and balanced will require interrelationships with other species. Take that individual and add a pet. The pet brings both commitment and satisfaction to the relationship as the person begins to better understand who she is, and her place in the scheme of things. (Some interesting research has shown, for example, that people with Alzheimer’s disease who have pets are happier.) But adding a pet adds considerable complexity to the individual’s life.

As we move from considering individuals to looking at groups (as “how many” grows larger) the complexity of relationships increases immensely. For example, if a family decides to go someplace the decision may be instant, but if there are a few small children involved it may take hours to prepare for such a major excursion into the environment. For a family group of that size, the complexity of that issue is quite great, and requires a commensurate area.

In terms of biodiversity we would say, “What is necessary to support a group and keep them happy within their region?” I suggest that having roughly a square kilometer of territory, with trees, plants, water, and a great diversity of activity in that intimate area is very useful to the group, and that reducing the area’s diversity would create a less beneficial environment.

Biodiversity: Toward Operational Definitions
F. Henry Lickers

To sustain a community, the diversity must increase still more and the area needed is now hundreds of square kilometers. A good stand of forest, a lake, and all the animals and plants that exist in them are necessary to sustain the community ecosystem and to grow crops; the soils will need those creepy-crawlies that build up the horizons and sustain fertility. The community will need to manage its ecosystem wisely to keep it in harmony and in balance.

At the nation level we have a much bigger problem. There are now many thousands of demands and stresses upon our native, public and private lands. As resources shift to the communities and diversity decreases, preserving diversity may require that we set aside or protect lands. In Landsat photographs of southern Ontario, we saw a huge tract of Carolinian forest, a very nice occupation of savannah grasslands, and incredible types of wooded islands. When we visited those places on the ground we found they were all either Indian reserves or National Parks. So in southern Ontario, we see a vast cleared area, and in the center of it is Six Nations Indian Reserve where the land’s natural diversity has been preserved.

People concerned about preserving biodiversity in Canada say we must set these areas—these last few that native peoples were given—aside. But while the biodiversity people are saying that, the economic development people are saying these lands are underdeveloped. So at the national level we have many things to grapple with and biodiversity requires us to understand what we as nations need to keep us in harmony and happy.

At the confederacy level, where nations come together, interests are global. We have the Biodiversity Convention, Agenda 21, Chapter 26 (on native peoples), and Chapter 28 (on local initiatives) that ask how nations can determine what biodiversity really is, and how they can protect it once it is identified. When I look at the world, I see that those areas into which native peoples have been relegated or pushed are areas in which biodiversity is most intact. How can we work with native peoples to protect those areas?

Finally, on that much greater level that is out there, the spiritual level, I can only say it saddens my heart to think of all of the species (and native peoples) that, like the passenger pigeon, have been wiped out by human greed. How can we curb that need to possess the world that unbalances and often destroys the very spirituality that we depend upon?

An Oneida elder inspired the human development row of the chart. He considered that in human life, egg and sperm would fall in the subcellular column. When they come together to form an embryo, they become cellular. An individual exists at the instant of birth and develops into a child who is part of a family group. Community is equivalent to adolescence, when we are trying to overcome hormonal surges and, at the same time, come to grips with the workings of our families, communities and peer groups. It is at that point that a person begins to understand that he is one of many people in the world, that his group is one of many in his community, and that his community is one of many in the world.

Adulthood represents the national level and for we Haudenosaunee, the aunties and uncles are our international ambassadors, helping many nations to under-
Can't See the Forest for the Trees: A Native American's Perspective

Basic Principles of Naturalized Knowledge Systems

1. The Earth is our mother.
2. Cooperation is the way to survive.
3. Knowledge is powerful only if it is shared.
4. The spiritual world is not distant from earth.
5. Responsibility is the best practice.
6. Everything is connected to everything.

stand one another, and as they travel further through this life, they progress and learn, finally attaining emeritus status as elders. Elders, with their experience and knowledge, are the data bases of our native society. (As you can see I am becoming one of the white hairs of the Haudenosaunee. I have been told that I am lucky to have the white hair of wisdom, and not the grey hair of ulcers.)

As we looked at this Naturalized Knowledge System and tried to understand how it worked, certain principles (See box, above.) seemed to bode well for biodiversity. When we say the earth is our mother, that implies that the animals and creatures that exist on the earth are our brothers and sisters: We are one family. My grandfather told us that if the family left us, if all of our brothers and sisters abandoned us, we wouldn't survive very long. But if some force plucked one of us out of the environment and threw him or her into the sun, the earth would continue to grow and be quite merry, and our brothers and sisters and family would go on almost as if nothing had happened.

The Haudenosaunee say that in this family of the earth we are the younger brothers and sisters, and as the youngsters of the family we must approach the rest of the earth with appropriate awe and respect. We must look on other species as our brothers and sisters and understand our responsibilities as younger family members. We must learn our older brothers' and sisters' ways, accept their knowledge and experience, and give them help and support. We know from experience that it is cooperation that enables us to survive. Can we learn to cooperate with the world around us to preserve biodiversity?

All of our brothers and sisters on the earth need food and land to live. The human race's unregulated growth is not a way of cooperating with our earth family. The Haudenosaunee consider it important for a family to have three children—one to replace the mother, one for the father, and one for the cruel winter. The Haudenosaunee are matriarchal, matrilocal and matrilineal. It is important for us to fulfill our responsibility to the family, the nation, the community, and the confederacy. Limiting the number of children we have enables all of us—men and women—to participate fully at all levels of our lives, including choosing our chiefs or voting them out of office. Women and men participate as equals in our community functions.

Knowledge is powerful. In biodiversity I think of our knowledge of the healing power in plants and other things in this world. That knowledge is only powerful if it is shared. The plants of the world have been doing the duties the Creator has set
for them when they share their power to benefit the world. Sometimes we have to
wrest knowledge and power from them, but that is the way it is for a younger
brother.

The spiritual world is not distant. The spirit world is here, and when I look at
the way animals play in this world, the way we interrelate with them as pets, as
companions, and as they exist in the world around us I see the spirit of those
animals functioning and operating. I think it is sheer arrogance of humankind to
believe that only we have a soul. Every one of those creatures have a soul, a being,
a spirit that functions within this world.

Responsibility is the best practice. We have a responsibility as the younger
brothers—as people—to the world, and we need to fulfill that responsibility.

And last is the ecological principle that everything is connected to everything.
Everything we do has consequences for the world now or in the future. What we
destroy today may have had an unknown future use that could have saved lives,
species, or ecosystems.

When we look at the world we like to say—as far as biodiversity is concerned—
that we need indicators of how the world is doing. The scientific world, the
western world, talks a lot about disease and death. When I was in university it
made me uncomfortable to talk about all of these death indicators—mortality,
morbidity, and natality. We would talk about how many animals die, how many
animals we are culling, or what type of forests we would chop down.

The women in our community said, “Oh boy. This is really morbid stuff. Those
non-native people concentrate their efforts on death. Why can’t we give them
something else?”

I asked them, “What should we give them?”

They said, “Why not life indicators, things that show how the world can be
good and alive?”

We were talking with native people who think in terms of circles. The drawing
on the next page developed quickly as we discussed what was important in the
community. As the drawing shows, slicing the circle vertically, corporal functions
are on the left, and spiritual concepts are on the right. Dividing the circle horizon­
tally, the upper issues are intellectual, and the lower ones are visceral and
emotional. If you choose an issue, an indicator of that issue is diametrically
opposite it. Environment, for example, is across from morality. You wind up with a
denominator and a nominator of an issue.

Here is an example. The elders said, “Henry as a biologist, as a scientist, can
you measure the amount of sunlight falling on an area where people
live?”

“Well, yeah sure,” I said. “With a solarity ball you can measure the amount of
sunlight.”

They turned to a sociologist and they said, “Sociologist, can you count the
number of picnics in the community?” He said, “Yes we could do that. We go out
and count all the picnic baskets and divide by the number of people and we will
have indicators of how many picnics are there.”
And the elders said, “If you have a nice high degree of sunshine, we should have a correspondingly high degree of picnics, because people want to go out and have a good time playing in the sunlight. If you go into a community that has a high degree of sunlight and no picnics, you had better look at this community because there is something wrong there.” To the elders that is a good way to tell how a community is doing.

They talked about other indicators that would tell things about a community. You can easily count the churches in a community and see how many people are at church on Sunday. If there are 100 churches and two people go to church, you had better start worrying a bit about the community. There is something happening. If there is one church and everybody goes to it, there seems to be a good connection there. That life indicator for that community is strong. The elders said those were the types of things we should look at.

The elders see biodiversity touching all parts of the circle. Economics, which is often a basis for human activity, would look at the value of species in a community, would determine how to keep those species there, and what that might cost. Each one of the areas in the circle suggested a nominator and a denominator that you could match it with.

Looking at diversity from a native point of view is looking at the world, seeing what is there, and in which part of the circle it fits. It told us to look at the forest and the trees to see how biodiversity operates, and not just one or the other.

When I was at university I heard the philosophy conundrum that asks, “If a tree falls in the forest and no one is there to hear it fall, does it make a sound?” I was
really perplexed. It didn't make sense to me because the question only considered human presence—we were leaving out everything else that exists in that forest that would "hear" that tree fall. So I would like to end by answering that question from a native perspective. If no one was in the forest when that tree fell, our people would say that the tree would hear itself fall. The earth would hear it fall. And every brother and sister in the world would hear it and feel it fall, and be affected by it. Non-native society is just beginning to understand that answer. Believing that a tree can fall silently is both wrong and dangerous.

Questions from the audience

How you relate to the concept of stakeholders?

Stakeholder is a really vague concept unless you are a vampire killer or at a barbecue.

I don't hear people in the community using the term. When I talk to my mom she doesn't call me a stakeholder—except at a barbecue. I don't know why we insist on creating new jargon.

We are people in the community. You are related to me because you live in this community. We work together as community people and when somebody calls me a stakeholder the first thing I want to know is what they are up to, because governments are notorious for saying, "Oh yes, we would like to talk to you," but they do not consider themselves part of the group. If they are stakeholders and are in the group, I will invite them to the barbecue too. But they have to be part of the system.

I don't like using the word in the community because if I do, I will be thrown off the stage. I think that we should be looking for good words that work within and for the community. Maybe "partners." Industry can be a partner in my community, maybe a reticent one, maybe not the best partner, but still a partner. Then we can work it out. Some of these new concepts like stakeholder and a couple of others worry me, because creating jargon when there are already good words to describe a situation is a way of confusing the issue. Maybe the Hopi are right and there are no new words. We have to learn to effectively use the ones that we have.

How do you bring 80-some people to work together?

At that level you are, of necessity, looking for some very broad agreements. We work with a thing called (sounds like Hollywood), "The Zeal to Deal." We say that to generate community enthusiasm for a deal you need three things: respect, equity, and empowerment.

Respect is built by mutual understanding. When these 80 people come together we spend a lot of time trying to understand each other's point of view, and telling each other how we think. Once we have established mutual respect, we look for equity in the situation under discussion.

In western society the issue is often money, but in native communities, it is likely to be social or political power, personal agendas, network connections,
**Naturalized Knowledge Systems**

**The Zeal to Deal**

is generated by a balance of:

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<tr>
<th>Respect</th>
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<th>Empowerment</th>
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<td>Honour</td>
<td>Social Power</td>
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**Elements of the NKS “The Zeal to Deal”**

knowledge, and a host of different things that we can bring to the equation that’s not bucks.

We want the equity to be transparent, which means that everybody sees that the work that they and everyone else put into our community is important. In the Eastern Ontario Model Forest we have a way of accounting for that effort and equity. I don’t like the term, but it is called “in kind contribution.” We set a value on all the things our people do for the community that is not in our financial budget—it could be $19 or $36 per hour, it could be $100 per day, it could be whatever because in western society it seems necessary to assign things a monetary value. We found that when you do the accounting this way, the federal government gave 1.3 million dollars to the community to do this type of work, and the community contributed 7 million dollars. That is good equity. That’s a big commitment by a community.

The empowerment part of it says, let’s get on with it. Once we have the respect and the equity, then let’s get the job done. We build credibility, responsibility, and partnerships. I like to add authorship, too. We scientists come into native communities, collect all the knowledge we can, produce wonderful papers for ourselves, and then leave without acknowledging the community and the people who provided the information for our research. So authorship is something that has to be discussed as empowerment.

So there are various principles and tools that can help get those 80 people working together. It is amazing, when you are talking about environment, just how common everybody’s points of view are. I very rarely found a demon out there who says, “To hell with everything. I want to blow the world up.” There are some, but they are rare.

For 1,500 years the Haudenosaunee have been trying get the great law of peace to work. The great law of peace is the basis of our governmental structure. It was
translated into English and is the basis of the American constitution. In Russian Marxism it is what they call the basic and purest form of Communism. My grandfather said, "We gave you tobacco, toboggans, and tools, and you did all right with them, I guess. But we also gave you the two greatest forms of government in the world today and you buggered them both up." (So when you are talking to a Haudenosaunee, especially a Seneca, it is a dangerous thing to give them the floor because they talk forever.) Those are some of the things that the Haudenosaunee have been studying. I find it interesting that the United Nations is now asking to work with us to see how these things function.

Could you comment on how we can combine scientific knowledge and natural knowledge in the context of biodiversity?

There are many examples, and some of the best that I have seen are the GIS applications of what we've been calling the Naturalized Knowledge System. In the Northwest Territories, the Yukon, and many of the areas in the north, GIS technicians are on the ground working with communities. They ask the elders, "Can you help us? We would like to learn about the land from you." That has generated mutual respect, acknowledged equity and empowered those communities.

So an elder sits down in front of a computer with a technician and talks about the area. "I was born here," he might say, "this is where I was born, and I grew up over here, and this is where I picked berries, and I went over here in 1947 and got this, then we went up there and got these...", and as he describes what the land was like years ago, the technician maps it, the same way you would map a distribution system of trees or what have you. The elder might visit with the technician periodically over a 10-year period, filling in the details as he remembers more and more in his database.

We have many elders that have that type of information, and you integrate all the databases you collect. Now, when a wildlife biologist comes into the north and says, "I want to study the migration of caribou herds," you can call up caribou herds and view their migration patterns—all this information from the elders in that area—on the monitor. Now the biologist goes out to the area, looks around and realizes, "My God, there are very few caribou coming through here. I wonder what has happened to the caribou."

We are now able to document major changes that have taken place in the north—track what has happened to caribou herds, for example—using the database the elders have built. Researchers are starting to acknowledge the sources of the information in those data bases, saying, "The authors of our information are the Lynmacotnee people from interior British Columbia." The elders of our tribes are listed as authors on scientific papers. Recognizing the people who supply the information gives researchers credibility with native people.

Native people are not averse to using technology. Native people use sophisticated scanners to simultaneously count salmon swimming both up and down the Fraser River in Canada. Scientists had believed that salmon only swim up-river but the native people knew they swam both ways, they just couldn't prove it scientifically. Technology enabled them to show that it was so.
Can't See the Forest for the Trees: A Native American's Perspective

So there are lots of areas in which you can fold in the Naturalized Knowledge System of the people.

The term traditional environmental knowledge is usually assigned only to native people and usually only to things that happened in the past. How you eat your roots and berries, for example. With Naturalized Knowledge Systems we are saying that anybody who lives in an area—a non-native trapper, a non-native people who have lived in that area for centuries—develop a way to live in that system, and their knowledge should also be acknowledged and used. It is just another way to access a database.

We are working with the Five Communities. One of the Five Communities said they were worried about moose populations because when moose populations fell below 750 in their area, crime, wife beating, and alcohol abuse increased. When they worked to increase the moose herd, and the moose population rose to more than 1200, those things disappeared. We have the information and it correlates exactly. Understandably, they don’t want the moose population to drop below 1200 because all these bad things happen. It may sound simplistic, but it obviously works for them.

Now how do university-trained biologists count moose? Because we often work alone in a community, we develop methods that enable one person to do the count. We have marked recapture systems, we have satellites and we have lots of computers and other technology. When the biologist went to the community we were just talking about and said, "Let's count moose," the community said, "Yeah lets count moose."

The biologist says, "We need to do this in a way that is objective and good science." The community says, "Yeah we want that, too. Now where do you want to put the 1,000 people to count moose."

The biologist guy goes "What?" The community says, "We have 1,000 people. Now, do you want us to count all the legs and divide by four or what do you want us to do? We are ready and able to do it. And if, of that 1,000, you don't think that some of them are qualified, then we will take 500 of our best hunters and trappers that could go do the counting for you."

This guy was thinking that maybe he would get 1 or 2 helpers and go out and look down the roads. What he ended up doing is one of the most extensive moose counts ever undertaken in this very substantial area., and he and the community came up with a good number of moose. Both the biologist and the community were confident of the accuracy of their numbers.

That is something that is really hard to get, when the community leaders say, "Yes we agree with this number," and the biologist says, "You know something? We agree with them, too."

Missoula, Montana, November 14, 1995
Biodiversity: Buzz-word or Fundamental Concept?

Malcolm Hunter
Professor of Wildlife Biology, University of Maine

Introduction
Dan Pletscher, Director, Wildlife Biology Program, The University of Montana
Good afternoon and welcome to today's Plum Creek Lecture.

It is my pleasure to introduce Professor Malcolm "Mac" Hunter, a wildlife ecologist at the University of Maine. Mac received his Bachelor's Degree in Wildlife Management there, and earned his Ph.D. from Oxford University in England. He is probably best known for his work on the "coarse-filter" approach to maintaining biological diversity—the idea that maintaining a representative array of ecosystems will protect a large proportion of the total species on the landscape. He has worked with a broad variety of species, organisms, and organism groups throughout his career, including arthropods, ducks, and song birds. He has recently published two well-received books, "Wildlife Forest and Forestry," (1990) and a new book, just out, called "Fundamentals of Conservation Biology."

Please welcome Dr. Mac Hunter.

I think biodiversity’s best shot at becoming a buzz-word came during the week of the Earth Summit in Rio de Janeiro in June 1992. On every evening news that week biodiversity was on the lips of Dan Rather and Tom Brokaw. For that entire week the world waited to see whether or not George Bush would sign the biodiversity treaty in Rio. As most of you know, he didn’t and we still haven’t ratified that treaty, so I think biodiversity missed its chance at buzz-word status.

On the evening news biodiversity meant something like “endangered plant and animal species.” I will begin this afternoon by getting beyond that, and briefly giving you a better idea of what biodiversity really is, and why it is important, although I am going to spend more time talking about what biodiversity is not because the term is increasingly misused, particularly in natural resource management circles. I am going to give you a broad overview of maintaining biodiversity that will take about as much time as you care to hear me.

When I say “biodiversity” I refer to all forms of life at all levels of organization. “All forms of life” includes not only plants and animals, but also the microorganisms that we often overlook.
“All levels of organization” refers primarily to the species, gene, and ecosystem levels.

I’ll start by talking about species. When we think of the species level of biological diversity we tend to focus on birds and mammals, particularly those that have gone extinct or are at a great risk of doing so. But this is just a small part of the more than 1.5 million species that have been described by scientists. About half of those species are insects which we overlook—unless they are eating our crops or sucking our blood.

Two families of beetles—the longhorns and the metallic wood borers—contain more than twice the number of species of all the birds, mammals, reptiles, and amphibians in the world. (These two families, incidentally, are uniquely associated with the resource we call dead wood, snags, coarse woody debris, what have you.) A clergyman asked 19th-century biologist J.D.S. Halding, “Tell us Dr. Halding, you’ve spent a lifetime studying God’s creations. What insight has this given you about our creator?” Halding replied, “He seems to have an enormous fondness for beetles.”

When we talk about 750,000 or so species of insects, that is just the tip of the iceberg. When people go into tropical forests to identify new species of beetles, they find new species of insects at a rate that suggest there might be 30 or 40 million species of insects out there. If we don’t begin to know all that is going on with insects, think how little we know about microorganisms.

To date we have identified roughly 4,800 species of bacteria. Norwegian scientists performed DNA extraction techniques on a single gram (a pinch) of forest soil, made some assumptions about overlapping gene pools of individual species, and estimated that there were 4,000 species of bacteria in that single gram of soil—almost as many as have been described for the entire planet. The scientists then did a similar assay off the coast of Norway and came up with another 4,000 species from gram of marine sediment with virtually no overlap with their first sample.

Well, there is an incredible number of species out there. So what? Are they important? In some cases it’s easy to think in terms of the importance of species. I don’t need to convince you of the importance of pine trees, or large game animals and such. But how much value can we ascribe to the whole array of species out there. My favorite picture of an endangered species is never going to appear on the cover of National Geographic. It’s a Houston toad. Curled up on the ground it looks pretty much like a cow flop. Seeing a Houston toad reminds me that we need to think beyond the species we know to have value, and to consider that species might have intrinsic value, value beyond what they mean to us.

People have long been reluctant to accept the idea of species having value in and of themselves. Here is a quote about amphibians written a couple of centuries ago. “These foul and loathsome animals are abhorrent, because of their cold body, filthy skin, fierce aspect, calculating eye, offensive voice, squalid habitation, and terrible venom. And thus their creator has not exerted his powers to create very many of them.” That quote is from Karl Linnaeus, the father of taxonomy.

Of course that was a couple hundred years ago. Here is a more recent quote. If you are roughly my age, it is likely that as a young naturalist you relied on the
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Golden Field Guides—those little pocket guides to mammals, birds, reptiles, and amphibians. This is the section “The Importance of Amphibians” from the Golden Field Guide to Reptiles and Amphibians. “Frogs are used in laboratory experiments and some people eat frog legs. Otherwise amphibians are not very important” it goes on “if they were all to disappear it would not make much difference.”

Now back to Houston toads. For years I have been using them to make the point that we need to consider the possibility of species having intrinsic value only. It turns out, however, that Houston toads may well be quite valuable to us. A chemist recently isolated compounds from the skin of Houston toads that have analgesic properties more powerful than morphine, and may be very useful in the treatment of heart attacks, elevating Houston toads from cow flop status to nobility. The take-home message here is: We can never say that any species “lacks value.” We never know what potential value species have.

One last point about the species level of biological diversity. People often comment that extinctions are natural, so why should extinction rates concern us? Species have been going extinct forever, and indeed 99% of species that have ever lived on earth are now extinct. No big problem. However, consider the graph (see next page) of biological diversity measured by the number of families of marine animals capable of leaving a skeleton in the fossil record. There is good news and bad news here. The good news is that the trend is distinctly upward across time, and I happen to believe that it will continue upward until the sun runs out of
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The rise and fall of biodiversity as indicated by the fossil record of families of energy. The bad news is that there are significant dips along that graph. About 65 million years ago, earth experienced a global extinction event so severe that it defines the boundary between the Cretaceous (K) and Tertiary (T) geological periods. Called the K-T extinctions, this event took out the dinosaurs and a lot of other species. The Permian extinction a little over 200 million years ago was even more severe. Many people believe that we are currently in a new spasm of extinction. Extrapolating from fossil records of previous extinction recoveries, it would take 10 million years for the earth to recover from the extinction event we may be creating now. That is the bad news.

If you have a biocentric view of the world and you look at the whole earth in very long time frames, however, the news looks pretty good. The trend is upwards. On the other hand, if you are concerned about the human species ability to enjoy that biodiversity—given our likely relatively brief tenure on earth—a 10 million year recovery period is not very sanguine.

Let's talk about genetic diversity. All the familiar vegetables pictured on these pages are variations of a single species of mustard. This variability among
individuals and populations is genetic diversity. The value we see here is not the genes themselves, but the functional value of the genetic information: What it can do for the organism.

This really comes down to three things.

First, it allows us to use the same species for different purposes. A multitude of different mustard plants allows us to get Brussels sprouts, cabbage, cauliflower, kohlrabi, broccoli and radishes all from the same species of plant—*Brassica sativa*. It allows us to have dogs which are poodles, retrievers or great Danes. This genetic diversity is very useful to us.

Secondly, genetic diversity is very useful to organisms because it enables them to adapt to changing environments. A classic example is that of industrial melanism. A population of lichen- cryptic moths contains a small number of melanistic (black) ones that used to get hammered by predators. Along comes the industrial revolution and the associated heavy soot. The lichen-colored moths get eaten now because they are the exposed ones, and the black moths survive because they are concealed on sooty surfaces. This story has reversed itself (in some regions) with the cleanup of Europe, and we again have a population dominated by lichen-colored cryptic moths. Again, genetic diversity allows species to adapt to changing environments.

Lastly, genetic diversity is important because it allows small populations to persist. The genetic bottlenecks, and random drift that affect small populations are basically an issue of genetic diversity.

We will talk now about the ecosystem level, the third level of biodiversity. Here we have the variety of marshes, lakes, forests, and streams. Why should we protect them? Why is this ecosystem-level of diversity important? One reason is that it represents a reasonably efficient way of capturing species-level diversity. This is the coarse-filter approach that Dan Pletscher mentioned when he introduced me. The idea is to protect an array of representative ecosystems across the landscape. For example, if you chose some lowland forest in the Zaire basin, some upland forest from the Eastern edge of the rift valleys, and some mangrove swamps from the coast, and protect this representative array of ecosystems, 80-90% of the species will be protected—all of those microorganisms, insects, and other species that constitute the bulk of biodiversity are likely to be protected via this coarse-filter approach.
Hypothetical lists of species for three ecosystems

<table>
<thead>
<tr>
<th>Ecosystem A</th>
<th>Ecosystem B</th>
<th>Ecosystem C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Oak</td>
<td>Black Oak</td>
<td>Black Oak</td>
</tr>
<tr>
<td>White Pine</td>
<td>White Pine</td>
<td>White Pine</td>
</tr>
<tr>
<td>Red Maple</td>
<td>Red Maple</td>
<td>Red Maple</td>
</tr>
<tr>
<td>Yellow Birch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abundance of species (n/hectare) in three ecosystems and measures of richness, evenness, and the Shannon diversity index ($H$).

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black oak</td>
<td>40</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>White pine</td>
<td>30</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Red maple</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>Yellow birch</td>
<td>10</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>Richness</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Evenness</td>
<td>0.92</td>
<td>0.88</td>
<td>0.99</td>
</tr>
<tr>
<td>$H$</td>
<td>0.56</td>
<td>0.39</td>
<td>0.47</td>
</tr>
</tbody>
</table>

$H = p_i$, where $p_i$ is a measure of the importance of the $i$th species. Evenness = $H/H_{max}$, where $H_{max}$ is the maximum possible value of $H$.

Some species will fall through the pores of the coarse filter; they will require a fine-filter approach. The spiny lobster, for example, is exploited for medical research. Simply protecting its habitat would not be sufficient, you would also need a species-specific approach to managing spiny lobsters as well as the coarse-filter approach for managing the ecosystems of which it is a part.

Now, I would like to switch and talk a little bit about what biodiversity is not.

Usually when we have a complex concept, reducing it to quantitative levels allows us to become more rational and objective about our discussions. There are ways of quantifying biological diversity. There are diversity indexes. I am sure all of you would recognize in the tables above that forest A with four different species of tree is more diverse than forest B or C because of the amount of what we call richness or species richness.

Also you would recognize that the forest C is more diverse than forest B because of evenness. That is a little bit harder to grasp, but think of it this way: If you had two juries, one with five men and five women, the other with nine women and
Biodiversity: Buzz-word or Fundamental Concept?

one man, you would call the one that is more even—five men and five women—the more diverse of the two. We can combine these two concepts of richness and evenness and come up with diversity indexes, etc., but where does this get us in terms of managing biodiversity? What if you were given the choice of protecting one of the three different types of ecosystems (represented below) and your goal is to protect biological diversity? If you are thinking simply in the context of species richness, you would choose the forest, because it has the five species, but if you knew very much at all about the big picture, you would be more inclined to go for that prairie. You would recognize that all of the species listed here are extremely common, with the exception of the black-footed ferret.

<table>
<thead>
<tr>
<th>Forest</th>
<th>Marsh</th>
<th>Prairie</th>
</tr>
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<tbody>
<tr>
<td>Black oak</td>
<td>Reed-grass</td>
<td>White prairie-clover</td>
</tr>
<tr>
<td>Shagbark hickory</td>
<td>Painted turtle</td>
<td>Horned lark</td>
</tr>
<tr>
<td>Gray squirrel</td>
<td>Red-winged blackbird</td>
<td>Black-footed ferret</td>
</tr>
<tr>
<td>White-tailed deer</td>
<td>Muskrat</td>
<td></td>
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<tr>
<td>Raccoon</td>
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The ferret, being a globally endangered species, would suggest that it is a much more important focal point for any sort of conservation effort. Let me tell this same basic story again with an anecdote from Clear Lake in California. Back in the early 19th century there were 12 species of fish native to Clear Lake. Beginning at that time, fisheries personnel started bringing fish to the lake trying to “improve” it. In total they introduced 16 new species of fish to the lake. And in the process, three species disappeared from the lake, so they ended up with 25 species. Had they improved the biodiversity of the lake? Well, yes if you measure in terms of the species richness of this lake. But it turns out that of that three species that disappeared, two of them—the Clear Lake splittail and the thicktail chub—were endemic to the Lake and occurred nowhere else in the world. They disappeared from the earth when they disappeared from the lake. That strikes me as a pretty poor trade off: to increase the species richness of a given lake at the expense of decreasing the species richness of the entire planet.

Forest issues interest most of us in the room. Consider the longleaf pine forest of the southeastern United States, an ecosystem that in terms of the overstory is very simple, dominated by a single species, the longleaf pine. People for years have recognized that through various silviculture prescriptions they could diversify this forest, particularly by suppressing fire. They could get oaks growing in those longleaf pine forests and that would have an impact on species richness. With oaks in the stand you are going to have mast, and that’s great for various animals, particularly some favorite species, like white tail deer and bobwhite quail.

One of the species that is likely to come into a longleaf pine stand if you have some oaks is the southern flying squirrel. Here is the rub: The southern flying squirrel is an aggressive competitor for nest cavities, and one of the species that it is likely to displace is the red-cockaded woodpecker—an endangered species. So
Malcolm Hunter

in the process of having improved the biological diversity of this longleaf pine stand by getting some oaks and associated species in there we may have diminished (or threatened to diminish) global biodiversity, by threatening a limited population like the red-cockaded woodpecker.

Another forestry example I frequently hear comes from forest managers referring to fairly mature landscapes that have few early successional habitats within them. Foresters observe that these landscapes are not diverse and that they can increase the diversity by harvesting timber. Harvesting introduces early successional stands and increases diversity. That is absolutely true. A partially cut landscape is likely to support more species than a mature forest landscape, but we have to think of the big picture, the overall context, and in most regions, extensive tracts of mature forests are very uncommon today.

We need to think about the bigger context, the larger scale, when we are thinking about this issue of what is the right thing to do about biodiversity. I have given you three examples of natural resource managers sort of misusing the concept of biodiversity, doing actions which are not perhaps entirely defensible from a big picture biodiversity prospective. But let me end up with an example of a conservation biologist, a Ph.D. scientist, making the same sort of mistake.

A paper published in the journal Conservation Biology a few years ago compared the herb species richness in a series of paired stands: half old growth virgin stands and half stands that had been cut 45 to 87 years ago. Because the virgin stands contained more species than the cut stands, they concluded that clear-
cutting had had a negative effect on biological diversity.

However, it is possible (probably unlikely but still possible) that all of those virgin forest species were weeds, exotic species from Europe, and on the cut forests we might have had some endangered species of herb that is likely to disappear in the absence of early successional habitat. We don't know, because we have reduced the issue to species richness and we are left with an unclear picture of what is going on.

The way to lend some resolution to this is by thinking in terms of scales of diversity. There are basically three: alpha, beta, and gamma diversity. Alpha diversity is diversity within a habitat. On the left of the figure on the previous page, the lizard in the top of the tree and the lizard living at the bottom of the tree, within the same forest stand, would represent alpha diversity—diversity within a single type of habitat.

Beta diversity is diversity between or among habitats. The lizard living out in the grassland (as opposed to in the forest) would represent beta diversity.

Gamma diversity is regional scale diversity. If, on another island 100 kilometers away, we had a 4th lizard, that would exemplify gamma diversity.

Somebody could look at this picture and say, "Gee there's more species in forest than there are in grassland. Let's plant trees in the grassland because we have two species of lizard rather than one." But if in the process the grassland lizard disappeared we would have not done something good for biodiversity. Somebody might say, "Let's go get some of those lizards from the other island and bring them to our island. Then we'll have four species here instead of three." But if in doing so they introduce a disease, or the new lizard causes the extinction of native lizards because they are competitors, they would not have done the right thing.

I think the bottom line here is that it is generally inappropriate to think in terms of increasing, enhancing, or improving biodiversity. To me the appropriate verbs to use when thinking about biological diversity, is to maintain native biodiversity wherever it is in a reasonably good state—and thankfully many parts of the earth have healthy native biodiversity—and where it is not, we should think in terms of restoring native biodiversity.

Let me say a few words now about how to maintain biodiversity and the differences between the fine-filter approach (dealing with one species at a time) versus the coarse-filter approach (looking at the ecosystem level). Let's focus on the fine-filter approach first. If we are thinking in terms of managing individual species and biodiversity issues, the focal point will be endangered species. These species are clearly the highest priorities because they are in jeopardy of disappearing now. There is much we can do at the fine-filter level to try to maintain these populations. It can be a very expensive proposition fraught with the likelihood of failure—but it can work, and it does work.

A great example of a system that has worked is the Kirtland's warbler—a bird dependent on early successional jack pine forest in Michigan—that was threatened by cowbird parasitism. Now folks trap cowbirds and maintain the early succes-
sional habitat, and the Kirtland’s warblers are doing much better these days. But the key is to not get into this situation. The key is to deal with species before they become endangered, rather than waiting until the 11th hour. We should be thinking in terms of a preventative public health-type approach—vaccinations and clean water—rather than heart transplants and emergency room procedures because that is a very expensive way to save lives or to save species. The California condor is clearly an emergency room case. We are spending more than a million dollars a year to keep it from becoming extinct.

Here is a good example of species preservation foresight. There’s been a lot of recent attention on the declining populations of Neotropical migrants—birds that migrate from our forests to the Caribbean and Central America. Although very few of these species are near extinction now, we have worked pro-actively to stem their decline before their situation becomes dire. We have already helped them to a large extent. The spotted owl, I would argue, is an intermediate case, one where we moved before it reached the condition of the California condor, but not quite fast enough. If we had started 20 years ago to think about the spotted owl (or more importantly, the ecosystem it occupies) we wouldn’t be in quite the bind we are in today. Of course the story with the spotted owl is complicated by the fact that we are not really dealing with a fine-filter issue here. The spotted owl is a flagship (or a scapegoat depending on your perspective) for what is really an ecosystem-level issue.

That’s a good bridge to saying a few words about the ecosystem level of maintaining biological diversity. To understand my perspectives on this you need to understand a classification system called a *triad* that I use to understand the way we use land. Triad is just a word meaning something with three parts and I like to recognize three basic ways of using land. First there are the lands we use to produce commodities as efficiently as possible. This is the agriculture paradigm, and the goal is to capture the resources of a site to generate maximum commodities from a limited land base.

Next are the “Multiple Use” or ecosystem management areas. Here we think of an ecological or ecosystem paradigm where the goal is to derive both economic commodities and other values from the forests.

Thirdly we have reserves, preserves, set-asides, or whatever you want to call them. These are the areas we take out of commodity production. They are important in the coarse-filter approach to maintaining biological diversity and they serve as benchmarks for studying ecological change. They are places where we can be humble enough to realize that perhaps we don’t know how to manage ecosystems as finely as we could. I happen to believe that all three of these types of land use have validity; they all deserve a place out there on the landscape. The exact proportions will vary, from context to context. Some folks see this figure as an equilateral triangle and assume I am advocating allocation of one-third to each. The world is not that simple. There is not a “right” prescription or allocation for any large circumstance.

I’ll say a few words now about managing each of these legs from a biodiversity perspective. In the agriculture paradigm, where we are trying to maximize the commodity produced on a limited land base, the key is not to export problems by
importing soil, fertilizers, and pesticides, but to use sustainable agriculture as a model. There will be species that use these habitats. At the mouth of the Columbia River there is an endangered subspecies, the Columbian white-tailed deer, that is doing very well in the aspen plantations there. But maintaining biological diversity isn’t the goal here. The goal is to get the commodities off a limited land base and to not cause biodiversity problems elsewhere.

In the ecosystem management areas, the key idea is to think in terms of natural disturbance processes, and to emulate those with artificial disturbance processes like timber harvesting. We can look at the patterns of a given landscape, at the patterns of fire, for example: the spatial patterns of fires, the temporal patterns of fires, the cyclical patterns of fires, and ask ourselves how well can we emulate those spatial and temporal patterns with our timber management. We can look at a site’s appearance after a natural disturbance and after a human disturbance and start thinking in ways that bring these two things closer together.

Lastly, we have the reserve areas. We need to devise ways to set aside representative portions of different ecosystems. In Maine we take a two-tier approach. At the first tier we have identified 15 biophysical regions across the state, based primarily on climate and soil issues verified by the distribution of woody plant species. Within each of these biophysical regions our goal is to set aside at least one example of each of roughly 120 ecosystem types.

Conservation biology has traditionally focused on setting aside reserves, and reserves are important. I don’t think we have misspent our efforts in this direction but I think conservationists have been a bit myopic—maybe very myopic—in thinking only of reserves. You can build a fort around our reserves and ignore what happens between them—but this is clearly short sighted. We worry about how small our reserves are and how isolated they are from other reserves. If we start thinking about the larger context of these reserves, about having ecosystems managed in a manner that emulates natural disturbance patterns for example, then many of these problems will start to go away.

I have rambled on awhile. Some of you may be wondering, “When is he ever going to get to the question in the title?” Is biodiversity a buzz word, or is it a fundamental concept? Maybe it is a buzz-word, but probably only in the halls of academia and the halls of natural resource managers in this country. I hear the word biodiversity a lot in the circles that I travel in, but it is not out there in the public’s vocabulary. We know that because a poll taken this summer (sponsored by the Pew trust, and others) asked the American public. “What is biodiversity?” Most people heard the word biodiversity and thought the survey was about ethnic diversity, affirmative action, and civil rights. It means nothing to them in the context of ecosystems and these sorts of issues. When they hear the word biodiversity, they do not think in terms of a fundamental idea of ecology: They make distinctions rather than interconnections.

Is biodiversity a fundamental concept? I think so. I think so because it has made us think in two fundamentally different ways. The term biodiversity has clearly moved us beyond thinking about birds, mammals, and trees, to thinking about the wide array of species out there. I know we are not all out there identifying individual species of longhorn beetles, but we are starting to think about them in the
Malcolm Hunter

broad sense. We are concerned about the big picture. That is a very positive thing. It also has us thinking about other scales of diversity beyond the species scale. We are thinking much more about genetics these days although I haven't said a great deal about that this evening. We are thinking much more about the ecosystem level, and if biodiversity is in the process of being displaced as a buzz word, a fundamental concept at the tips of the tongues of natural resource managers, it is being displaced by the term “ecosystem management.” I think biodiversity can take some credit for getting us thinking about that big picture, partly because we realize that we just can't deal with all these species that we now need to care about. We've got to think about them at the level of ecosystems.

I think that with a broad vision of life on earth, from magnificent grizzly bears to now-noble toads, we are moving from a myopic focus on a handful of species like birds, mammals, and trees, to thinking about everything from unknown genes to sublime ecosystems.

We are moving in the right direction. Thanks for listening.

Questions from the audience.

What about maintenance of processes?

To me, all systems have two things: They have structure and they have function or processes. I have emphasized the structural aspect as opposed to the functional aspects like biogeochemical cycling, pollination systems, and predator/prey systems. I fully believe that those processes are extremely important, but for the most part, I think it is a lot easier dealing with the structural attributes than the functional attributes.

If you make sure you have insects that pollinate and plants that need pollinating in your ecosystem, the process of pollination will inevitably occur. It is a lot easier for me to ask, “Are these two species happening,” then it is to say, “Is pollination happening?” I think it is easier conceptually to manage the structural attributes than the functional attributes, although I don't mean that functional or process attributes are unimportant.

For example, in some ecosystems we need fire or we will lose certain structural attributes. If you take care of the fire process all of the fire dependent species will be taken care of. Generally, however, I’m inclined to think that focusing on structural attributes is the key.

Are there situations where species richness is a useful index?

I'm not aware of a case where I couldn’t have learned just as much from being told what species were present (or absent) or which had (or didn’t have) a healthy population. Attempting to reduce it to a single index can be problematic.

James Karr at the University of Washington has devised an index of biotic integrity (IBI) that has several components, including species diversity. He makes a pretty convincing case for his IBI—which can reduce reams of documents to a few numbers—as a tool to help busy policy makers set priorities. There might be times
Biodiversity: Buzz-word or Fundamental Concept?

When the number of species might give me that information but more often than not it leads us astray.

What about switching from agriculture to agriforestry?
To me the benefits all seem positive. I'm not sure I can think of any negatives. If we are getting more commodities from such a system—and I have seen excellent examples in tropical countries—the positives all seem to be there. I suspect soil erosion is less of a problem in an agriforestry system than in an agriculture system. Pesticide needs, in my experience, are almost always less in agriforestry systems than in agriculture systems.

You mentioned that the coarse-filter approach may preserve 80-90% of an ecosystem’s species. Where did you get those figures?
Straight from the hip. They are not mine, they are from The Nature Conservancy, so I can pass the buck. I have never seen a systematic analysis of that, and it depends on how finely you define your ecosystems, how well you distribute them geographically.

How could we determine the accuracy of the statement that 80-90% of species are protected in the coarse-filter approach.
I don’t think you could, because to do it you would need a complete species inventory of your reserves and the inventory of all the species that are outside the reserve and that is just not going to happen. There is not a single forest anywhere in the world for which there is a complete inventory of all the macro-organisms, let alone the micros. I suspect there are few ecosystems of any sort—maybe some desert spring somewhere—where people have done a pretty complete job of inventorying the macro-organisms. Practically speaking, because of the multitude of unknown smaller species, we never really could answer that question. Its always going to be a black box, at least for the next few decades.

There may come a time when DNA characterization is so sophisticated that we can stick a piece of organic matter in a machine and have its DNA sequence in half an hour. If we ever reach that stage, we might be able to assess this question, but that is not going to happen any time soon.

Could you evaluate this question using a few groups of organisms?
Maybe. I worked particularly with two taxa on the assumption that they might be fairly easy to work with, and fairly good indicators of diversity. The core taxon is vascular plants, the other is birds, which add a nice vertical component in the way they use habitats.

My guess (and I stress that it is a guess) is that if you designed an ecosystem reserve system to do this coarse-filter approach, evaluated its effectiveness, and found that you did a good job with vascular plants and birds, getting 85-90% of them covered, then you might well have covered 85-90% of all species. But that is a big assumption. I have a graduate student who is evaluating that assumption, working with insects. He is looking at a series of different forest plots with different degrees of plant species richness and plant structural diversity, and looking at the
Malcolm Hunter

insect richness associated with those. So, we are working on testing that relationship with insects, although not with microorganism.

_Could you describe how the Maine biophysical regions were delineated?_

Janet McMann used climate, soils, topography, and surficial geology to create the map originally. Then she validated it with the distribution of the 203 species of woody plants for which we have excellent state range maps. She found good correspondence between the distribution of those plants and the boundaries that she had drawn.

_Are there problems associated with the coarse-filter approach?_

I think it may fail to pick up some of the smaller species. When I think of species that I know are falling through the cracks, I think of the endangered species—the California condors, the black-footed ferrets. We already know about them and can deal with them on a case by case basis. Species the size of insects and smaller fall through the cracks whether or not we use the coarse-filter approach. We are not doing a very good job with those less conspicuous species anyway.

I suppose there is some danger in putting so much of our resources into doing the coarse-filter approach well. We could be training more entomologists to go out and look for butterflies that have fallen through the cracks. But my guess is the most efficient strategy is to focus on that coarse-filter approach and the species that we know are falling through the cracks. The ones that are falling through the cracks that I know about are species we are exploiting. That is easily regulated.

_Which species are being shortchanged by the coarse-filter approach?_

I think in proportion to their abundance large species are much more likely to fall through the cracks. But I think that the total number of small species is likely to be greater simply because they are small. There is a very steep inverse relationship between body size and number of species. In an absolute sense, more small species are falling through, in the relative sense, more large species.

_Is the idea of developing corridors for migration or dispersal of organisms really a fine-filter issue or can that be tied to the coarse-filter approach?_

When corridors first came into the forefront of conservation biology we thought, “Here are two reserves. We need a linear strip of reserve land to connect them.” In that context, corridors are best thought of as a single species approach, a narrow corridor that would be permeable to a given species or a handful of species. I really encourage people to stop using the word corridor and thinking more about connectivity—the idea of having wide swaths of semi-natural lands managed in an ecologically sensitive way. To me those are more likely to be permeable to a wide array of species than a narrow, carefully preserved corridor. I think maintaining connectivity through semi-natural ecosystems would be consistent with the coarse-filter approach. The old idea of corridors is perhaps more of a fine-filter approach to things.

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Respect for Nature: An Essential Foundation for Sustainable Forest Management

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Introduction
Bob Pfister, Associate Director,
Montana Forest and Conservation Experiment Station
Welcome to the final lecture of the 1995 Plum Creek Lecture Series.
Today’s speaker, Dr. Hamish Kimmins, is not a stranger to Missoula nor to this auditorium. He was our featured speaker for the celebration of Earth Day’s 20th anniversary in 1990, and he participated in a sustainable forestry conference here in 1993.

Dr. Kimmins earned his Bachelor of Forestry degree in Wales, his Master of Science in forest entomology at the University of California-Berkeley, and his Ph.D. in forest ecology at Yale. He is the author of a widely-used textbook on forest ecology, and recently published “The Balancing Act,” in which he discusses conflict resolution and balance in approaching forestry issues, including biodiversity.

Please welcome Dr. Hamish Kimmins.

With the world’s population approaching 5.8 billion, with the annual increase in global wood demand estimated to be equivalent to the sustainable annual allowable timber harvest in British Columbia (Sutton 1993), and with the potential to have a world population at least double the present level by the time a seedling planted in Canada’s boreal forest in 1996 is a mature tree, it is clear that forests must be managed sustainably. Couple this concern over the future supply of wood products with the need to expand the world’s parks, ecological and wildlife reserves, and to modify forest management within critical watersheds to achieve water supply and quality objectives, and one can only conclude that forestry has never faced greater challenges and responsibilities.

There is nothing new about the loss of forests, their mismanagement, and public concern about them. Major deforestation has been going on for many thousands of years in the ancient cultures of Asia, several thousand years in the...
Mediterranean region, and for nearly a millennium in Europe. The beautiful English countryside, beloved of British poets and artists for centuries, is mostly the result of deforestation as land use shifted from forest to food production. Citizens protested large scale clearcutting and deforestation in Europe as early as the 13th Century, especially in mountainous areas. More recently, it was concern over deforestation and unregulated forest exploitation late in the 19th and early 20th century that led to the development of the parks system and forest management in North America. And, finally, the rapid acceleration in loss of tropical forests over the past 50 years led to the international meeting in Rio de Janeiro which produced international conventions on biodiversity and the current debate over forestry.

The rate of global deforestation increased exponentially over the past few centuries, driven by the growth of the human population. It accelerated each time new harvesting technologies were developed and new markets for wood products developed, and consequently the two separate activities of forest harvesting and deforestation outstripped the growth of the population. The news is not all bad, of course. Areas of land in Scandinavia, Europe and North America which were stripped of forest cover in the last century and early part of this century have been returned to forest, either naturally as marginal farmland was abandoned, or by reforestation. In some areas, fire control has resulted in increased forest area and forest biomass. However, these temperate and northern recoveries have been overshadowed at the global scale by continued loss or degradation of forest at tropical latitudes.

Human ability to mismanage forests increased enormously as the power of technology increased. Technological forestry, in which natural patterns and processes are modified to fit an industrial paradigm (Maser 1988), can be very successful in the short run in providing high rates of timber production with high economic efficacy. However, there is increasing concern, and evidence to support this concern, that this high productivity may not be sustainable unless the management is modified. There is equal concern that the industrial paradigm frequently fails to conserve non-timber forest values. This concern has generated public demand for a greater ‘respect’ for nature, and the redesign of forestry based on this respect. It is hard to argue against this demand. However, a difficulty arises in defining this respect, and without this definition we cannot design forest management that will indeed respect nature.

Respect has several formal definitions which fall into two groups. The original meaning is to notice with special attention, to consider, and have due regard for, to take into account, to look at attentively—in other words, respect for nature means to carefully observe what nature is, and to take this into account in human relationships with nature. Another meaning is to venerate, to show reverence towards, to show honor and esteem for—in other words, to treat nature as we would a deity, a religious icon, a spiritual place, object or idea. This meaning can—and does for some people—lead to the conclusion that humans are separate and different
Respect for Nature: Foundation for Sustainable Forest Management

from nature, that nature knows best, and that it is ethically wrong for humans to alter an ecosystem's structure and function from its 'natural' condition.

The conclusion that we must respect nature if we are to achieve sustainability seems unassailable. The challenge is to agree on what we mean by respect. With the rapid increase in support for the certification of forest management as sustainable, we are similarly challenged to define what we mean by 'sustainable forest management that respects nature.' Without agreement on what is meant by these concepts, it is unlikely that we will be able to design sustainable management strategies, and we will continue to have difficulty defining criteria and indicators of sustainable forestry.

I will speak today on the role of disturbance in forest ecosystems and the need to match the disturbance we create by forest management to both the ecological diversity of the forest and the historical role of disturbance in defining the ecological characteristics of forest ecosystems. I will conclude with a consideration of the design of forest management that does indeed respect nature.

The take-home message is that, yes, we must respect nature if we are to achieve sustainable forestry, but that respect means far more than simply revering nature and minimizing human impacts on forest ecosystems. It means gaining an understanding of the ecology of the forest values we want to sustain, and designing management-induced disturbance regimes that are consistent with—and therefore respect—that ecology.

Respect For Nature: Disturbance And The Role Of Humans

Discordant Harmonies: Is Nature Like Mozart or Stravinsky?

Botkin (1990) warned that we will not succeed in working sustainably with nature unless we respect what nature is and how it operates. He noted that the 19th century romantic vision of nature as a perfect machine, or the religious view of undisturbed nature as the perfect temple, existing in perpetual balance except when disturbed by human activity, is inconsistent with our current knowledge of forest ecosystems. Rather than being balanced equilibrium systems in which everything is harmonious and well ordered, most forest ecosystems are constantly changing. They are a temporal mosaic of frequently violent and disruptive change interrupting periods of more orderly development and small scale change.

The romantic view of nature reminds one of the music of Mozart: harmonious, sweet, and soothing to the human senses. In contrast, nature is often more like the compositions of Stravinsky, with periods of sharp discord and changes of mood and pace which are woven, nevertheless, into a whole that has structure, pattern and an overall harmony despite the periodic discontinuities and discords.

Sustainable forest management requires the recognition that some forests have a character that is reminiscent of the music of Mozart, while others remind one more of Stravinsky. The latter are periodically and violently disturbed by fire, wind, insects and/or diseases. They owe their ecological character to this disturbance. Other forests have an intermediate character and level of disturbance. As
J.P. (Hamish) Kimmins

Botkin points out, failure to respect (as in notice, and pay due regard to) the variable role of disturbance in ecosystems will generally result in failure to achieve sustainable resource management.

**Ecosystem Disturbance: Disrespect for Nature or Part of Nature?**

A sustainable relationship between humans and forests clearly requires a respect for nature, defined as having due regard for the ecological characteristics of nature. In contrast to the veneration definition of respect, this requires that where disturbance is a ‘natural’ part of the ecology of a forest ecosystem, or of one of its values, disturbance regimes must be sustained that are appropriate for the maintenance of specific ecosystem conditions and values.

A frequent feature of the veneration interpretation of respect is the idea that nature is fragile and delicate, and that it requires protection from disturbance. While natural disturbance may be accepted in this second definition of respect, human-caused disturbance is not. How realistic (i.e. how much does it respect the ecological character of nature) is this approach? Is this truly ‘respect for nature’ or does it represent a romanticized view in which adherents of this philosophy want nature to be the way they would like it to be or think it should be? Is this philosophy partly a reflection of our spiritual, aesthetic and emotional evaluations of nature, an indulgence of our feelings about nature, rather than taking due account of what nature is and how it really operates?

Take, for example, the disturbance created by clearcut harvesting of timber. Clearcutting in the hot, dry forests of the southern interior of British Columbia is inconsistent with sustainable forest management because the microclimatic conditions it creates render forest regeneration very difficult. Clearcutting in such forests is more appropriate for the creation of rangeland, golf courses or subdivisions than for sustainable forestry. Clearcutting is equally inappropriate on steep unstable slopes in coastal areas that experience high rainfall and strong winds, in mountainous areas with high snow instability, or in areas where growing season frosts prevent or severely damage regeneration. In contrast, the disturbance created by appropriate patterns and methods of clearcutting is consistent with the ecology of wind-disturbed or fire-disturbed coastal forests and many fire or insect-disturbed interior forests. Applied with a sensitivity for local conditions, the clearcutting silvicultural system is appropriate in the management of naturally even-aged forests of shade intolerant, light-demanding species, and with forests in which the balance between diseases, insects, tree parasites and their host trees has historically been regulated by periodic stand-replacing disturbance events.*

The disturbance created by clearcutting is clearly inappropriate in some forests and for the maintenance of some forest values, and, when done with a sensitivity for local site conditions, appropriate in other forests and other forest values.

* In this discussion I am not referring to all examples of clearcutting. Clearcutting that has created undesirable sizes of forest openings and blocks of one age class, undesirable landscape patterns, a lack of wildlife habitat supply at the landscape level, has failed to protect the streambank environment and fish habitat, has failed to create appropriate seedbeds and seedling recruitment where natural regeneration is desired, has caused unacceptable slope instability or soil alterations, and has caused unacceptable alterations in hydrology, is generally not an acceptable disturbance.
Humans: Natural or Unnatural?

For many people, nature is everything except humans: ecosystems unaltered by human impacts. The damming and flooding of valleys and killing of trees by beaver; vast areas of forest burned by 'naturally-caused' wildfire; trees killed over large areas by epidemics of insects; loss of soil and the sedimentation of fish streams by 'natural' landslides; and maintenance of areas without trees due to grazing by unmanaged populations of wild herbivores are all natural and part of nature. In contrast, harvesting of trees, maintenance of agricultural land free of trees, soil damage, and forest fire caused by *Homo sapiens* are considered by many people to be 'unnatural' and outside of nature. There are good reasons for this attitude, of course. Although dam-building beavers, nest-building birds and various other animals use 'technology,' none do so on a scale comparable with technological humans, and no other species uses external, non-metabolic sources of energy to alter their environment the way humans have done. However, if one accepts that humans equipped with modern technology are 'different,' then one must decide at what point in history humans became 'unnatural.'

Humans have been harvesting and clearing forest using only human energy, relatively primitive tools, fire or grazing animals for millennia. Both deforestation and human alteration of the structure and function of forests are ancient phenomena that predate modern technology, and are analogous to deforestation and alteration of ecosystems caused by high populations of insects and other mammals. Much of the world’s tropical rain forest has been subjected to shifting cultivation for millennia, and temperate forests in various parts of the world are believed to have been burned by indigenous peoples for equally long periods.

This relatively benign level of human impact has been replaced over the past century by a much more widespread, and in some areas much more dramatic, alteration of ecosystem structure and function. Two world wars, the Chinese civil war, and more localized conflicts like the Vietnam war, have done what war has always done to forests (serious disruption of structure and function) but on a much larger scale than before. The more powerful technology that was developed during these conflicts was subsequently used to harvest and manage forests, and, combined with the technology-addiction and human population growth of the 1950s and 1960s, this led to a dramatic escalation of forest lands significantly altered by humans. However, this increased human impact was as much a reflection of the application of an industrial production philosophy to forestry and a failure to respect ecological processes as it was the increase in the power of technology and the number of humans. It was the failure to understand the ecology of the values that were being managed for and to respect this in the practices that were used. The 'unnaturalness' of modern *Homo sapiens* is therefore as much a consequence of the failure to take due account of (to respect) forest ecosystem function in the application of technology as it is the application of technology itself.

An unfortunate consequence of the notion that humans are unnatural is that we are outside of, and not a part of nature. This notion can lead to a reverence for nature (a green religion) that concludes that humans have no ethical right to change or even use nature. It can equally lead to the conclusion that nature was
made for humans to use, and that we can use and alter nature in any way we want. The former ignores the reality of 5.8 billion people, headed for about 12 billion. The latter ignores the ecological limitations on the degree to which we can alter ecosystems before they fail to sustain the functions we expect and need from them.

A more effective philosophy, one which has a greater chance of achieving sustainability, is to consider humans to be as natural a component of nature as any other species, and equally as dependent on their environment. This philosophy forces us to recognize that because we are a part of the 'environment' and are dependent on it, failure to respect the ecological processes that sustain the values we want and depend on is unacceptable; that this is ultimately one of the major threats to our continued existence. It leads to the idea that disturbance to forests caused by humans is simply one of a complex of disturbance events that collectively determine the ecological character of our forest environment.

Examples of the Ecological Role of Disturbance in Sustaining Forests

The failure to respect the important ecological role of disturbance can have many unexpected and undesirable consequences. Botkin (1990, 1995) warned that inappropriate paradigms of nature cannot provide a successful foundation for sustainable resource management. Attiwill (1994a, b) reviewed the role of disturbance in conservation and the conservative management of Australian eucalypt forests, and summarized the extensive literature that attests to the role of disturbance in forests. He argues that failure to understand this role and to sustain appropriate disturbance regimes is as much a disrespect for nature as is the application of disturbances like clearcutting in environments where it is not appropriate. The following are examples from several biogeoclimatic zones in British Columbia (B.C.) and one example from Australia where disturbance is not only tolerated by nature, but is required if nature is to remain within its historical range of conditions.

The Coastal Western Hemlock Zone

There are few useful generalizations that apply to all forest site types in any of B.C.'s biogeoclimatic zones, because variations in climate, in disturbance type, severity and frequency, and in geology and topography within any zone combine to define a variety of different local ecological conditions and circumstances. The two examples given here from the Coastal Western Hemlock (CWH) zone are location-specific and can only be extrapolated to ecologically equivalent sites.

1. In the drier portions of this zone (in the rain shadow of the Vancouver Island and the Olympic mountains) the prevailing wind comes from the southwest, so southern Vancouver Island is partly in the rain shadow of the Olympic Peninsula, and at drier, lower elevations on the B.C. mainland there is a usually significant summer moisture deficit (the demand for water by plants is greater than the ability of the climate and soil to supply water). These forests are therefore not true temperate rain forests, and historically they have been affected by large, stand-replacing fires with a periodicity of about 300-400 years. This disturbance history has maintained a forest dominated by Douglas-fir on all but very moist and wet sites, with a secondary canopy
of the shade-tolerant, climax western hemlock and western redcedar.

Western hemlock in coastal forests is the host for a parasitic vascular plant: the hemlock mistletoe (Bloomberg and Smith 1982; Unger 1992). This parasite infects branches and causes abnormal, hand-like swellings and growths. Where a hemlock is growing rapidly, such as in a large gap or a clearcut, and where there is an even-aged, closed canopy, the infected branches will be shaded out and die before the infection reaches the stem. In contrast, hemlocks growing slowly in small openings and/or in the lower canopy layers of an uneven-aged, multi-layered, mistletoe-infected canopy frequently retain the infected branches long enough for the infection to reach the stem. There, it allows entry of fungal pathogens and causes distortion in the development of the stem wood. This weakens the stem, renders the tree susceptible to stem break during wind storms, and reduces the trees' value for lumber and pulp. Such stem-infected trees do have value for certain wildlife species: cavity-nesting birds may be able to utilize the decayed and deformed stem sections, or the standing snags created when wind causes stem breakage. However, heavily infected hemlock forests have significantly reduced economic and employment values.

If these relatively summer-dry coastal forests are protected from stand-replacing disturbance, the process of succession steadily depletes the early-seral, shade-intolerant species (e.g., alder, bitter cherry, dogwood, cottonwood on wet sites, Douglas-fir, lodgepole pine on very dry sites), and replaces them with shade-tolerant species (western hemlock, western redcedar, with minor components of western yew and grand fir on some sites). The forests develop from a relatively even-aged stand with a uniform overstory canopy of Douglas-fir and a relatively even-aged, shade-tolerant lower canopy to a multi-aged, multi-layered canopy of shade-tolerant species. This successional alteration in species composition and stand structure generally leads to a progressively more hemlock-dominated forest with increasing mistletoe infection if the parasite is present in the overstory: a condition which is not unnatural but is relatively uncommon in this part of the CWH zone because of the historical role of disturbance in controlling the mistletoe and maintaining higher tree species diversity and lower stand structural diversity.

2. In the cool and humid portions of the Coastal Western Hemlock zone (a true temperate rain forest) where summer moisture deficits are uncommon, wind is the major disturbance factor: fire is rare in this area. These forests are dominated by shade-tolerant western hemlock, western redcedar and Pacific silver fir and are frequently in a climax condition.

Wind damage in these forests (windthrow, stem break, crown damage) generally does not push the ecosystem back to an earlier seral stage as fire does; it simply creates younger, late-successional or climax forests. Nevertheless, wind damage has a major effect on ecosystem form and function. Forests that have experienced stand-replacing wind damage in the last 200 years are dominated by western hemlock and Pacific silver fir. They are characterized by high levels of net primary production, high tree biomass, and very little understory.

Forests that have not experienced stand-replacing disturbance by wind for a long time (perhaps 1,000 years or more) become dominated by western redcedar with an understory of ericaceous species of the genera Vaccinium
and Gaultheria. This condition is associated with a progressive slowing of nutrient cycling, a deep, acidic, slowly-decomposing forest floor dominated by large decomposing cedar logs (cedar coarse woody debris, or CWD), and intense competition for soil nitrogen by the shrubs. Under these conditions, the growth of hemlock and Pacific silver fir decline dramatically. The long-lived cedars progressively lose their crown and develop a candelabra growth form. This promotes the growth of the ericaceous understory and restricts tree regeneration to the cedar CWD. Cedar appears to be the most successful species at regenerating on these logs. Given sufficient time without disturbance, the forests in this area appear to change slowly from the productive condition to the unproductive condition, and eventually to an ericaceous shrub ‘heath’ with scattered old cedar and moribund hemlock and Pacific silver fir. A full explanation of the differences between these ecosystem conditions and their temporal and successional relationships is not yet available: Prescott and Weetman (1994) summarize our present understanding of these forests. However, it is clear that disturbance is related to the presence of closed-canopy forest and high forest productivity in this area, and the long-term absence of stand-replacing disturbance is associated with a very different forest condition.

The Sub-boreal Pine-Spruce Zone

In the rain shadow of Mt. Waddington (the largest mountain mass in the B.C. coastal range) and its associated ice fields is a rolling plateau that is warm and very dry in the summer and very cold in the winter. The winter cold is partly due to arctic air masses that periodically invade the B.C. interior from the prairie provinces over the low spot in the Canadian Rockies in the area of Chetwynd and Lake Williston; it is also due to cold-air drainage from the extensive ice fields in the coastal mountains to the southwest. The area is also characterized by frequent summer lightning storms. This combination has resulted in a long history of frequent wildfire (both crown and ground fires), and, except in poorly drained sites, the landscape is dominated by a mosaic of monoculture, even-aged, fire-origin lodgepole pine stands. Most of the fires have been small-to-medium in size, but most of the area burned has been the result of a small number of very large fires (D. Andison, personal communication).

Where the fire results in complete stand replacement, the regenerating lodgepole pine trees are free of the lodgepole pine mistletoe (Hawksworth and Johnson 1989), a closely related species to the hemlock mistletoe described above. Where the fire results in only partial kill (analogous to partial harvesting), the pine stands develop several age-classes and canopy levels. If the overstory trees are infected with mistletoe, most of the trees in this mixed age stand will eventually become infected and significant growth reduction will result. Intense, stand-replacing fire has been the natural agent that has maintained most of this forest relatively mistletoe-free.
Respect for Nature: Foundation for Sustainable Forest Management

The Engelmann Spruce/Subalpine Fir Zone

Climatically one of the most variable of British Columbia’s ecological zones, the interior subalpine zone (the ESSF) supports a relatively open-canopied climax forest of Engelmann spruce and subalpine fir. Following a stand-replacing, light­ning-caused wildfire, the forest regenerates to either shade-intolerant lodgepole pine in the lower elevations of the zone (where there is a pine seed source), or to spruce (in the absence of a pine seed source), or to a mixture of pine and spruce. Less commonly it may regenerate to subalpine fir if seed of the other species is not available. Pure pine stands are invaded, and subsequently replaced, by the moderately shade-tolerant spruce, and, as time passes, an understory of subalpine fir develops. The forest at this stage is relatively closed-canopied. The pine can live up to 300 years, and the spruce up to about 600 years. The subalpine fir, being more prone to fungal pathogens is shorter lived than the spruce (up to about 300 years).

In the wetter subzones of the ESSF, the old-growth forest is characterized by patches of ericaceous shrubs growing in canopy gaps on better drained microsites, and a complex of herbs in gaps on the moister microsites. These herb and shrub patches appear to be rather resistant to invasion by tree seedlings, especially pine and spruce, unless disturbed physically or by fire. As mature pine and spruce trees die, the canopy gaps that are created may be invaded by these herbs and shrubs, or by subalpine fir seedlings; where trees at the edge of existing gaps die, the gap vegetation may expand to take over the newly-released space.

If these wetter ESSF forests remain free of stand-replacing disturbance (hot fires) for more than about 400 years, the moderately closed-canopied forest that developed following the previous disturbances begins to develop into a rather open, subalpine-fir dominated woodland in a matrix of shrub and herb patches, a process that may be promoted by greater snow accumulation and delayed snowmelt in the expanding canopy gaps. The scarcity of this type of open forest, especially in the drier ESSF subzones, is a reflection of the historical frequency and severity of stand-replacing disturbance by fire, which has sustained a relatively closed-canopy forest over much of the landscape. Severe disturbance facilitates the reinvasion of the herb and shrub-dominated areas by trees, and the reestablishment of pine and/or spruce.

The Boreal White and Black Spruce Zone

If the fire interval is long enough in the humid portions of this zone in northeastern British Columbia, there is a post-fire succession from light-demanding early seral hardwoods (various combinations of aspen, birch, willows, alder and poplar, depending on climate, soil, topography, seed source and the pre-fire presence of vegetatively reproducing hardwood species) and/or pine, first to white spruce, and then to black spruce or a combination of white spruce and subalpine fir; again depending on climate, soil and seed source. This is not the final climax vegetation, however. In flat or depressional areas, or on north slopes, the very cool, microclimate and thick, acidic forest floor under the black spruce promotes the growth of feathermoss. As the soil becomes colder under the insulating blanket of litter and moss and the canopy begins to open up, the feathermoss is replaced by sphagnum. As dead sphagnum accumulates, the mineral soil becomes

Biodiversity: Toward Operational Definitions
progressively colder until permafrost is formed, isolating tree roots from first the mineral soil, and subsequently from the buried forest floor. Provided only with the nutrient-poor sphagnum peat, tree growth declines, further promoting the growth of sphagnum. After a long time without disturbance, what was a closed forest can become a treed-muskeg and finally an expanding treeless muskeg. This process can be reversed by a stand replacing wildfire or a summer fire burning through the dry surface layer of sphagnum. Fire is less common on cold north slopes and in wet depressional areas, and the black spruce-muskeg tends to persist in these locations, spreading slowly to surrounding areas in the long term absence of fire. The climax vegetation in these areas is, therefore, not forest; forest persists over the landscape as a consequence of infrequent disturbance (Heilman 1966; van Cleve et al. 1986; Shugart et al. 1992).

In all these B.C. examples, the ultimate climax, (i.e., self-replacing vegetation in the long term absence of stand-replacing disturbance) is probably not a closed-canopy, productive forest. It may be an open community of scattered trees and either ericaceous shrubs, shrubs and herbs or, in cold and humid areas or wet sites in the north, sphagnum bog or muskeg. Periodic disturbance appears to be a necessary prerequisite for maintaining a closed-canopy, productive forest on at least some sites in these ecological zones. If the interval between disturbance is long, a high degree of ecosystem disturbance may be required. The more frequent the disturbance, the lower the severity of disturbance required to maintain productive forest.

The Fire-Dependent Wet Sclerophyl Forests of Australia

Perhaps the classic example of the necessity for ecosystem disturbance to sustain a particular forest type is the wet sclerophyl eucalypt forest of parts of Australia (e.g. western Tasmania). In this area, severe summer wildfires kill the overstory eucalypts which either resprout from the stump or lignotuber, or reproduce from seed released after the fire from serotinous cones. The latter species require exposed mineral soil seedbeds (provided by fire) to successfully establish. The result is generally an even-aged stand of similar composition to the original stand, which itself was of fire origin. Many of the eucalypts grow to giant sizes, living 300-400 years after which, in the absence of wildfire, they decline and are slowly replaced by the much more structurally diverse and tree-species-rich, climax temperate rain forest. Visually beautiful and more biologically diverse, this climax forest generally lacks the cathedral-like grandeur of the eucalypts, which require a periodic massive fire disturbance to perpetuate them as a closed eucalypt forest (Attiwill 1994a, b).

These examples all suggest that periodic significant disturbance is a requirement for the maintenance of historical ranges of ecosystem form and function in forests that have a history of periodic, stand-replacing natural disturbance. Maintaining the character of forests that have a history of smaller scale disturbance will require a less severe disturbance regime. As one moves from higher to lower latitude, from colder to warmer
climates, disturbance regimes in humid forests are often dominated by more frequent, lower severity and smaller-scale disturbance, leading to more of a ‘gap dynamics’ forest mosaic. However, even some tropical rain forests are periodically subject to stand-replacing fire and wind damage (e.g., Nelson et al. 1994). 

Ecological Diversity, Biological Diversity and the Great Mistake

The great mistake that characterizes both exploitative pre-forestry and the early, 'administrative' stage of forestry (see discussion below) is to ignore the spatial variability in the ecological characteristics of forests. This ecological diversity is ultimately defined by climate and soils, which are related to latitude, longitude, elevation, aspect, slope, and distance to large water bodies, and to geology, topography, slope and climate, respectively. Ecological diversity provides the physical-chemical framework within which biological diversity develops as the combined result of evolution, species migrations, ecosystem disturbance, and the processes of ecological succession.

Each of the many different biogeoclimatic forest zones (which reflect broad patterns of variation in climate) and each of the many different forest site types (which reflect local variations in soil moisture, fertility and aeration) within each zone in Canada has its own ecological personality, and its own characteristic history of type, scale, severity and frequency of disturbance. This requires that different management practices and silvicultural systems be applied in different zones and site types, and that where natural disturbance regimes have been altered, their ecological effects be emulated by management-induced disturbance if it is the management objective to maintain the ecosystem conditions within the historic range characteristic of the particular ecosystem. Management and conservation objectives cannot be achieved if one single approach to forest management and one single silvicultural system is applied everywhere, whether this is clear-cutting or minimal-disturbance selection harvesting.

In British Columbia, the westernmost province of Canada, ecological diversity is especially high. Arguably one of the most ecologically diverse landscapes of comparable size anywhere in the world, the need for ecological sensitivity in the design of management strategies is even greater in British Columbia than in the rest of Canada, and is as great as in any other forest region of comparable size. This ecological diversity is recognized in the biogeoclimatic classification of the province (Meldinger and Pojar 1991). This ecological classification system recognizes a hierarchy of regional units based on climate (zones, subzones and variants), and a local hierarchy of ecosystem units within these climatically-defined regions based on variations in soils and vegetation along local topographically-induced gradients of soil moisture and nutrient availability.

Respect for nature in British Columbia requires resource managers to recognize the role that this ecological variability plays in defining the multitude of B.C. forest types, their structure and function, and their productivity and various measures of biological diversity. It also requires that resource managers respect the role of past disturbance in defining these ecological and biological characteristics.
**Ecological Role of Disturbance**

As already discussed, natural disturbance in Canadian forests is dominated by fire and insects, with wind and diseases being important in some areas. Small scale disturbance occurs as a part of successional processes operating between the major disturbance events, but for many of Canada’s forests, their ecological characteristics are more closely related to these large scale allogenic (physical) and biogenic (biological) disturbances than to the smaller scale autogenic processes. This is in contrast to many forest types at lower latitudes or in heavily human-modified environments (e.g. Europe) where historical disturbance regimes no longer occur and small-scale autogenic (community-based successional) processes play a more important role in many of the forests than large scale, stand-replacing allogenic or biogenic disturbance events.

While periodic, large-scale, severe disturbance is a characteristic feature of many Canadian forests, and may be necessary to maintain their historical ecological characteristics, these disturbance events are often socially undesirable. Fire can kill people, destroy homes, businesses and communities, cause the loss of socially important wood supplies with attendant economic impacts, and, in very severe fires, can cause damage to soils, some aspects of wildlife habitat, and fish and streams. As a result, efforts are made to limit forest fire and, though often less successfully, to limit insect and disease activities, and wind damage.

Although it may be socially desirable in the short-term, the elimination or reduction in ecosystem disturbance causes significant alterations to the ecology, productivity and biological diversity of forests that have a history of periodic severe natural disturbance. If forest management objectives include sustaining the historical character of the forest, including the historical temporal and spatial patterns of variation in that character, resource managers must ensure that the combined effect of the frequency, spatial scale, landscape pattern and severity of both management-induced and continuing natural disturbance approximate the combined effect of historical disturbance regimes. In forests managed for a sustained supply of wood products, it is harvest-related disturbance that emulates the ecological effects of natural disturbance that no longer occurs, and this harvest-related disturbance must be designed with this in mind.

Harvest-related disturbance can vary from minimal, in the case of individual tree single-tree selection system harvesting with minimal soil and minor vegetation disturbance (e.g. winter logging), to the maximum disturbance that results from the clearcutting silvicultural system followed by site preparation. The entire range of disturbance types, covering the entire range of tree retention and a wide range in soil disturbance, is applicable in British Columbia because of the great ecological diversity. However, disturbance severity on its own is not sufficient to define a disturbance regime; one also needs to know the scale and frequency of disturbance, and ecosystem resilience. The combination of these defines the ‘ecological rotation’: the time taken for a particular ecosystem or
ecosystem value to recover from a particular disturbance. Defining sustainable forestry requires the definition of ecological rotations (Kimmins 1974).

**The Great Mistake and the Evolution of Forestry**

Forestry, the first organized attempt to conserve and sustain desired forest values, has always developed in response to the unacceptable consequences of unregulated forest exploitation. The first stage of forestry, the administrative stage, is characterized by laws, rules, regulations and policies that ignore the ecology of the values that are to be sustained; this stage of forestry is the Great Mistake. As a result, this stage is partially or completely unsuccessful. The next stage is characterized by ecologically-based rules, regulations and policies; forestry is practiced that is sensitive to the values that have usually characterized this stage: silvicultural values, wildlife game species, soil fertility and watershed values. Sustainable in terms of these values, this stage of forestry may nevertheless fail to sustain a variety of other values, such as aesthetics, spiritual values, and habitat for certain other animal species. As public demand for these other values grows, forestry evolves to the next stage—social forestry—in which forestry sustains a much wider range of values at either the stand or the landscape level, or both (Kimmins 1992).

In many parts of the world, forestry is still in the administrative stage or has only recently evolved to the ecologically-based stage. Public opinion, however, has suddenly overtaken forestry and is demanding that forestry practices be selected according to the dictates of the social stage. While such an evolution is inevitable and ultimately desirable, its speed has resulted in the bypassing of the ecologically-based stage. In the absence of experience gained from this stage, some of the demands for changes in forestry are being based more on belief systems about nature than on the ecology of the values that are to be sustained. Regrettably, in some cases this is leading to a repetition of the Great Mistake: a demand by some that all forestry must cause minimal disturbance, and that the same methods of harvesting and the same silviculture system be applied to all forests.

The evolution of a 'green religion' about forests and forestry has made a positive contribution to the development of forestry: it has created the political pressure that has made desirable change possible. However, this is balanced by the danger that the same pressure may lead to undesirable change. Some of the demands based on a 'green religion' view of nature would repeat the Great Mistake if permitted to become the basis for forest policy and practice. They would return both conservation and forestry to the administrative stage rather than advancing it to a truly sustainable social forestry stage (Kimmins 1992).

**Design of Appropriate Harvesting Practices**

Although many forests have a requirement for periodic, stand-replacing disturbance if their historical ecological character is to be sustained, the disturbance created by clearcutting has not always emulated natural disturbance events adequately. Although large-scale clearcutting may resemble the overall scale of large fire, wind or insect events and initiate generally similar successional sequences, natural disturbances often follow natural boundaries and leave a mosaic
of small patches (‘islands’) of live vegetation. In contrast, the shape and
landscape pattern of clearcuts has often ignored natural boundaries and
created a very unnatural checkerboard pattern of geometric openings
across the landscape. Fires, windthrow or landslides create seedbeds and
eliminate or reduce competing herbs and shrubs; where trees have serotino­
ous cones, or where individual seed trees or islands of live forest remain
across the disturbed area, there is a seed source to ensure natural regen­
eration. In contrast, some types of clearcutting, especially winter logging,
may not disturb the soil sufficiently to create suitable seedbeds, and in the
past clearcutting has often removed seed sources from such a large area
that natural regeneration has been very slow. Cones left on the ground
may not open to release seed before they get wet and rot. Clearcutting has
often been required by law to remove all snags and live trees from within
the harvest area because of worker safety and other considerations. In
comparison, natural disturbance leaves most of the woody biomass on the
site as snags and downed logs, which may alter microclimate (and thereby
favor tree regeneration) and provide habitat for wildlife. Any type of
timber harvesting, whether it is clearcutting or partial harvesting, removes
this woody biomass, although in any harvest or silvicultural system the
choice can be made to leave snags or coarse woody debris, and to retain
‘wildlife’ trees.

If the objective of management-related disturbance is to replace or
emulate natural disturbance, there must first be a clear understanding of
the ecological effects of the natural disturbance that has defined the
character of a particular ecosystem. The management-disturbance must
then be designed in terms of the spatial scale and pattern, frequency and
severity needed to emulate the natural disturbance it replaces, or to
complement natural disturbance events that continue to operate. The
following two examples illustrate this.

1. Fire has been the major agent of disturbance in the boreal and the
subboreal forests of B.C. Fires have occurred at a high frequency (60
to 150 years) and most of the landscape is occupied by even-aged
stands that resulted from very large fires (~20,000 ha). However,
most of the fires have been much smaller than this, and the natural
landscape is a mosaic of a few very large patches, and very many
smaller patches of various sizes (D. Anderson, personal communica­
tion). Harvesting in this area in the past was often an exploitative
diameter limit cut that left the forest depleted in spruce and in a
‘poor’ silvicultural condition. This led to a period characterized by
clearcutting, often followed by planting. The clearcuts were some­
times large (up to 1000 or more ha), and where insect-killed or fire­
killed forest was being salvage harvested, continuously-clearcut
areas were sometimes tens of thousands of hectares in extent,
reflecting the extent of the insect or fire-caused tree mortality.

Public pressure against clearcutting contributed to the develop­
ment recently of a 60-80 ha limit on clearcut size in this area. The
question arises as to which of the three types of harvest — the early
diameter limit cut, the variable clearcut size, or the recent 60-80 ha
clearcut limit—most closely resembles natural disturbance regimes in these forests. In terms of size of disturbance patches, the variable clearcut size came closest to the natural disturbance regime, although it generally failed to duplicate the larger natural disturbance events. However, in the shape and spatial distribution of these past clearcuts, in the removal of all standing snags and live trees >3 m tall, and in the frequent failure to locate cut-block boundaries along natural boundaries and to reserve forest around wet areas, lakes and streams, this type of harvesting failed to emulate the natural disturbance closely.

Clearly, there was a need to change the many aspects of timber harvesting in the boreal and sub boreal forests of B.C., but the administrative approach of applying a fixed 60 - 80 ha maximum harvest area limit is inadequate. While recent forest legislation requires stream protection, the retention of tree islands and snags where appropriate, and the following of natural boundaries, the imposition of a fixed maximum opening size to one that is much smaller than the historical natural disturbance regime is inappropriate if one’s objective is to sustain reasonably natural disturbance regimes. A more ‘natural’ strategy would be to have a diversity of types of harvesting and sizes of clearcuts, including some very large clearcuts.

2. In the drier portions of the Coastal Western Hemlock zone described earlier, there is strong public pressure to abandon clearcutting and move to shelterwood or small patch harvesting. Clearcutting, it is argued, is too ‘environmentally destructive.’

The structure of much of this forest on well drained sites is an overstory of fire-origin Douglas-fir, and a secondary canopy or understory of western hemlock. The removal of the Douglas-fir overstory by clearcutting with minimal disturbance to the soil and understory releases the ‘seedling bank’ of hemlock. Rather than disturbing the ecosystem and setting succession backwards, such clearcutting actually accelerates successional development towards a hemlock-dominated climax forest. This is one reason why slash burning has historically been used after clearcutting on such sites. It sets succession back, facilitating the establishment of Douglas-fir and other earlier successional species, including early seral broad-leaved hardwoods if suitable seedbeds are created.

Partial harvesting with minimal soil disturbance also promotes successional progression towards the hemlock climax, and may exacerbate the hemlock mistletoe problem described earlier (clearcutting tends to reduce the problem by promoting rapid growth of even-age hemlock stands). The forest that results from this ‘kinder, gentler’ type of forestry is not unnatural—however, it is relatively uncommon in this ecological subzone because of the historical role of stand-replacing disturbance. If the objective is to sustain the historical structure, composition and productivity of stands in this region, the clearcutting silvicultural system, designed to match particular site conditions, will generally ‘respect’ nature’s pattern and process much more than the ‘kinder, gentler’ forest practices that the public generally supports. This does not mean no change from past harvesting practices. It does mean designing the changes with a respect for the way nature works.
Conclusions

History suggests that societies which persistently ignore the ecological characteristics of the ecosystems they depend on will alter those ecosystems in a way that results in negative consequences. They will frequently fail to sustain the historical character of those ecosystems.

The major problem with forestry around the world has been that the laws and regulations that have guided it have ignored the ecology of the values that are to be sustained: the Great Mistake of forestry.

Thanks to public pressure, governments have developed a sensitivity to environmental problems in forestry, and this has created the possibility of necessary change. However, the very pressure that made this possible threatens to disrespect nature because it, like earlier forestry, also ignores the ecology of many of the values it desires to sustain. Pressure from ‘green religion’ threatens to repeat the Great Mistake.

Respect for nature, one of the essential foundations for sustainable forestry, requires that management emulates nature to the extent of maintaining critical ecosystem processes. Of course, ‘nature’ is not a single entity, and there is no such thing as a single ‘natural’ disturbance. Fire, insects, disease and wind exhibit large variations in their frequency, pattern, scale and severity of impact on forest ecosystems. Management-related impacts should be limited to this range of natural disturbance effects if ecosystem processes are to continue to operate within their historical range of rates.

Because management should attempt to emulate nature if the objective is to maintain forests within their historic range of conditions, and because natural disturbance is so variable and does not necessarily conform to what is socially acceptable, management-related disturbance should be evaluated in terms of unique combinations of frequency, scale, pattern and severity that in combination will emulate the effects of natural disturbance, while sustaining desired values.

Forests harvested for timber will never be exactly the same as forests subject only to natural disturbance. To imagine so is a delusion. This is true irrespective of the harvesting method or silvicultural system being used. However, with appropriately designed and implemented management systems that truly respect the way nature has been on a particular site, and not how we might wish it to be, forestry can respect nature and sustain the many different values we want from our forests.

Questions from the audience

I guess I found your definition of what things fall inside and outside of the range of nature to be a bit arbitrary. Perhaps I misunderstood your message. It seems that you are arguing that the historical and evolutionary background is to endure or to accommodate large scale natural disturbances. Then when we limit fire, for example, it seems that we are on the slippery slope toward blocking all natural disturbances.
Certainly if you don't have large scale disturbance several things can happen. Another disturbance can come in. If fire doesn't get the lodgepole pine the beetles will, or if the beetles don't maybe succession will proceed and your lodgepole pine forest will be replaced by spruce or subalpine fir in the very large areas—which would be natural but very unusual. It would be outside the range of nature for that area, and many of the native species in that area which have adapted over thousands of years to lodgepole pine—because as far as we know, it has been lodgepole pine after lodgepole pine since the glaciers left in that area. So it would be natural but very, very unusual and you would get a loss of some species that were native to that area.

I don't necessarily say you shouldn't go outside nature because frankly I don't think society would accept natural or human-caused disturbance on that scale. Those big fires did not do nice things to rivers. We tend to think of nature's disturbances as benign, but there clearly were some very negative effects on rivers and fish resources from those huge fires. So—for many reasons—we might not want to follow nature exactly. I think that is the point you are making.

There would be cases where we shouldn't attempt to follow nature because nature's disturbance is socially unacceptable. But in going outside of that we have to be very clear of what choice we are making. We have to understand what we are doing and we might want—if, for example, going outside the range of nature was going to result in some loss of habitat for some critical species—to deliberately manage some areas to make sure they still had habitat.

It is important to recognize that you are going outside that historical range. Similarly, I think it is quite appropriate for society to designate some of its landscape to high intensity fiber production. Some recent calculations have shown that we could get the same allowable cut on about 22 percent of our forest areas if we took the productive areas, put them into high production, and left the remaining area completely undisturbed. If you look at total conservation strategies and total environmental impact, I think there can be a real case made for occasionally going outside of nature in either direction. But you have to understand full well the environmental consequences. You have to be explicit about that.

I do not believe in slavishly following nature, because nature does some terrible things. I don't think we want to have a Mount Saint Helens blowing off once every 500 or 600 years. I don't think we want to follow that kind of natural example. But as an ecologist I generally find that the range of nature's processes is a pretty good range for forest management. Everything is adapted to that range. Does that help you understand my feeling on it? We may still differ—but do you understand my position?

How do you know what sort of natural disturbance a man-made treatment should mimic?

We don't have enough or will we ever know it all and that is why I am a great believer in, “When in doubt, look at the forest.” Look at the combination of severity and frequency of natural disturbance as the best available guide to what combination of frequency and disturbance we should apply to that landscape or site. For example, if nature does very severe disturbance on long intervals and we want to
go in and harvest every 100 years and nature is only doing it every 400 years then we have to create commensurately less disturbance. Ecological rotation is that unique combination of degree of disturbance, severity of disturbance, resilience, and frequency. If you want to shorten the frequency, and you don’t change the resilience, then you have to reduce the disturbance.

You don’t mention setting aside ecological reserves. Don’t you feel they are necessary, especially to preserve old-growth forests?

Of course we need ecological reserves. Absolutely. Coming from Canada, I assumed that goes without saying. Canada will only ever manage about 22 percent of our forest landscape, so 78 percent of it is de facto wilderness. Of course, a lot of that is in the far north with low productivity. With our protective area strategy in British Columbia we are striving to get 12 percent of all ecological zones and all ecosystems represented in our protective area network. In some areas we can’t achieve that because it is all in farms, golf courses, or rangeland.

The old growth rain forest is, in fact, not our most threatened forest type. Our most threatened forest type is our savannas. Because the savannas have been ranched, they have been turned into golf courses, retirement homes, and orchards. The big species threat is in the southern dry semi-desert ecosystems. There isn’t that threat on the west coast. There is a lot of rain forest left although there is not a lot of rain forest left within a day’s drive of Victoria, where people go to recreate.

There is not very much left of East Coast Vancouver Island. That is highly threatened. There is not much left in our dry interior, that’s highly threatened. Its the same in Brazil. Everybody worries about the Amazon, and so they should—we should worry about all tropical rainforests, they are all highly threatened. But in my limited experience of the tropical rainforest, the Amazon is probably the least threatened. The savannah ecozone is much more threatened in Brazil: It has been 98 percent deforested in the last 70 years, whereas Amazon Basin deforestation is about 8 percent and the rate is now declining because much of that was driven by government grants and speculation. The speculation has collapsed. It will come again, but right now its a much less threatened ecological environment than the savannah or Brazil’s coastal rain forest, which is just about gone.

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Bibliography


Sutton, W.R.J. 1993. For environmental reasons, should we or should we not harvest British Columbia (BC) forests? Unpubl. mss. Canadian For. Serv., Pacific Forestry Centre, Victoria, B.C.

