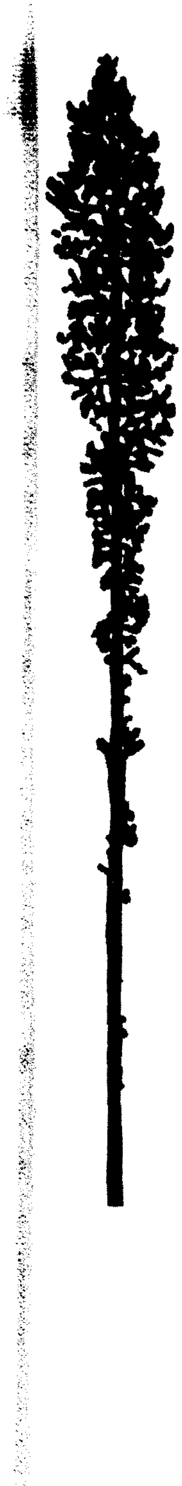


Sustainable Forestry:
Can We Use And Sustain Our Forests?

J. P. (Hamish) Kimmins

Professor of Forest Ecology
Department of Forest Sciences
Faculty of Forestry
University of British Columbia
Vancouver, B. C.

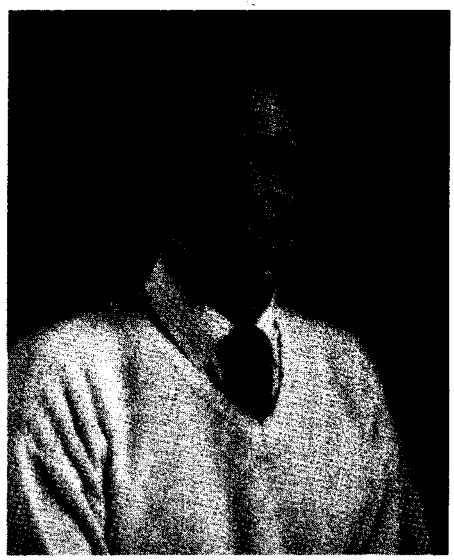
Forest Industry Lecturer

Forest Industry Lecture Series
Forestry Program
Faculty of Agriculture & Forestry
University of Alberta

21 November 1991

FOREST INDUSTRY LECTURE NO.27

James Peter (Hamish) Kimmins



J. P. (Hamish) Kimmins holds degrees in Forestry from University of Wales (B.S., 1964), Forest Entomology from University of California (M.S., 1966), Forest Ecology from Yale University (M. Phil., 1968), and Forest Ecology from Yale University (Ph.D., 1970).

He has been with the Faculty of Forestry at the University of British Columbia since 1969, where he currently is a Professor of Forest Ecology. Most recent Canadian forestry graduates are familiar with his work because they have had readings from his 1987 textbook in Forest Ecology.

He has authored numerous papers and reports. In Canada, he has consulted on various topics with the B.C. and Canadian governments as well as various commissions and conservation groups. Abroad he has had projects with the Tasmanian and New Zealand governments.

His work has been recognized by an IUFRO Scientific Achievement Award in 1986 and by his selection by the University of Toronto as the 1986 Eddy Distinguished Lecturer. In 1987, the Canadian Institute of Forestry awarded him a Scientific Achievement Award.

He has served as a consultant to the Government of Tasmania on landuse issues and also with the Government of New Zealand on impacts of site preparation practices.

He has also been affiliated with the B.C. Ministry of Forests on slashburning, whole tree harvesting, ecological reserves, and impacts of clearcutting.

THE FOREST INDUSTRY LECTURERS

The forest industry in western Canada cooperates with Alberta Forestry, Lands & Wildlife to provide funds to enrich the Forestry Program at the Faculty of Agriculture & Forestry at the University of Alberta through sponsorship of noteworthy speakers.

The Forest Industry Lecture Series was started during the 1976-77 term as a seminar course. The late Desmond I. Crossley and Maxwell T. MacLaggan presented the first series of lecturers. The contribution of these two noted Canadian foresters is greatly appreciated.

Subsequent speakers in the series have visited for periods of up to a week, with all visits highlighted by a major public address. It has indeed been a pleasure to host such individuals as C. Ross Silversides, W. Gerald Burch, Gustaf Siren, K. F. S. King, F. L. C. Reed, Gene Namkoong, Roger Simmons, Kenneth A. Armson, John J. (Jack) Munro, Peder Braathe, K. N. Johnson, V. J. Nordin, J. Paivanen, Conor Boyd, Peter Rennie, John A. Marlow, Gordon W. Gullion, Hugo Von Sydow, Mary Jo Lavin, Harold R. Walt, Adam H. Zimmerman, T. M. (Mike) Apsey, Bjorn Hagglund, Jerry F. Franklin, John Zasada, and Clark S. Binkley.

This paper contains James Peter (Hamish) Kimmins' major public address given on 21 November 1991.

SPONSORS

We would like to take this opportunity to express our thanks again to the sponsors of this 1991 program. We appreciate very much their willing and sustained support:

Alberta Forest Products Association - Edmonton

Alberta Forestry, Lands & Wildlife - Edmonton

Alberta Newsprint - Whitecourt

Beck Consulting - Edmonton

Blue Ridge Lumber (1981) Ltd. - Whitecourt

Canadian Forest Products Ltd. - Grande Prairie

Daishowa Canada Company Ltd. - Peace River

Dempster and Associates - Edmonton

Forestry Canada - Northern Forestry Centre - Edmonton

Procter & Gamble Cellulose Ltd. - Grande Prairie

Rocky Mountain Section - Canadian Institute of Forestry

Silvacom, Forestry Consultants - Edmonton

Slave Lake Pulp Corporation - Slave Lake

Weldwood of Canada Limited - Hinton Division

Weyerhaeuser Canada Ltd. - Alberta Division

ABSTRACT

Forestry has always had its origins in the desire for conservation and sustainability, yet many people believe that forestry is the antithesis of conservation. In particular, many believe that timber management and conservation are incompatible, and that timber harvesting threatens the sustainability of a variety of ecosystem values.

There are many different dimensions to the sustainability question in forestry. These include questions of stand-level sustainability vs. whole forest or landscape-level sustainability, sustainability of site productive capacity vs. sustainability of achieved yields of products, sustainability over different time scales, sustainability of non-timber vs. timber-related forest values, and sustainability of the biophysical system vs. sustainability of social values that depend on the forest. Answering the question "can we manage forests for a sustainable supply of timber and other values requires that all these and other aspects of the topic be considered.

Understanding sustainability in forestry requires a consideration of both its ecological and social dimensions. The major social and environmental threats to sustainability must be identified and acted upon, and a firm commitment made to implement mechanisms that will ensure those aspects of sustainability that the public wants and can afford. To achieve long-term sustainability, forestry must be based on an accurate knowledge of ecosystem function and change, and a recognition of the spatial variability of the resource through an ecological site classification. But it must also consider social needs and constraints, such community stability, economics, and the desire for a variety of values and products. A much more integrated, systems-approach to forestry is required if the public's present demand to sustain multiple forest values is to be achieved.

INTRODUCTION

There are few issues that have united the nations of the world more than concern over the environment. Although there are still some countries which have not yet given environmental issues a high priority, their number is declining. An important contribution to this growing international unity over the environment was the report of the World Commission on Environment and Development, ("Our Common Future") which promoted the concept of "sustainable development".

There is widespread support for the principle of sustainable development, but not everyone agrees. Some consider that the term is an oxymoron: that "sustainable" and "development" are incompatible concepts. These people point-to the numerous examples in which industrial development and the application of technology have resulted in environment damage: deforestation in the tropics, non-sustainable agriculture, over-exploitation of marine resources, air pollution and the alteration of the earth's atmosphere. Many environmentalists have challenged the claim made by foresters that our forests are being managed in a sustainable manner, they assert that industrial utilization of forest resources is not sustainable. The current public criticism of forestry demands a careful analysis of what is meant by sustainable use or development of forests. The question, "can we use and sustain our forests", which must be answered by those who manage public forests, transcends the traditional concern over sustaining the supply of timber products, important though this is. Today's society is demanding that a wide range of values be sustained.

The purpose of this paper is to draw attention to the complexity of the sustainability issue, and the many dimensions of sustainability in forest management. Unless the full complexity of the question is explicitly recognized in policy, regulation and practice, it is unlikely that we will achieve our sustainability goals, whatever we decide they are.

Sustainability and the Origins of Forestry

Forestry is a human activity that has developed at various times and places around the world, but always in response to the same need: to sustain some forest-related condition or resource value. The desire to maintain wildlife for hunting, strategic supplies of timber to support armies and navies, supplies of fuelwood for domestic or industrial use, or forest cover to protect villages or roads from avalanche are among the many reasons why governments or land owners acted at various times over the past millennium to restrict unregulated forest exploitation. Forestry and the modern forest preservation movement thus share a common ultimate objective and sprang from common roots: the desire for conservation and sustainability.

Environmentalists can be forgiven for a moment of incredulity when it is suggested that they share much in common with foresters. Forestry normally evolves through a series of rather predictable stages. The first stage generally fails to achieve its goal of sustaining particular forest values, and the results have often differed little from unregulated exploitation. This is because the first stage of forestry is usually characterized more by legal restrictions and an administrative, bureaucratic approach to resource use and renewal than by regulations that reflect the needs and desires of the local people and the spatially and temporally variable ecological character of the forest. One cannot successfully manage a complex, living, changing ecological system such as a forest as though it was coal in the ground or a manufactured commodity. Nor can one expect simple regulations that ignore existing and traditional uses of the forest by local communities, the needs of these people, and their increase in numbers and impacts on the forest over time, to effectively conserve forest values. Most of the early attempts to establish sustainable forestry failed either because of the lack of a sound ecological foundation, or because of the failure to recognize existing and changing social and political conditions, or both.

Because the failure of the first stage of forestry to achieve sustainability has often resulted from a lack of a sound ecological foundation, the second stage of forestry has been characterized by the development of such a foundation. This ecologically-based stage has generally focused on the sustained renewal of timber and associated values, and there are many examples where this silvicultural stage of forestry has been successful in maintaining the growth and harvest of tree crops. However, sustainable silviculture does not necessarily satisfy all of the desires of a "post-industrial" society. It may not conserve adequate areas of old-growth forest, and associated wilderness and spiritual values. Depending on how it is done, it may not sustain some aspects of biodiversity, and it may fail to satisfy requirements for landscape aesthetics, wildlife habitat and various other non-timber values. Consequently, the affluent, post-industrial societies of western countries are now requiring that forestry evolve to a third stage ("Social Forestry") in which the requirement for sustain-able tree crops is accompanied by the demand that a variety of other resource values, both social and environmental, be maintained.

Canadian forestry has only emerged from the exploitive, pre-forestry stage relatively recently (within the past century). The administrative stage of forestry was put in place in most parts of Canada in the first half of the century or soon thereafter. The subsequent two or three decades confirmed what was already well known in countries with a longer history of forestry: that the administrative approach is not an adequate basis for sustainable development of forests. There has been a steady transition into the second (ecologically-based silvicultural) stage over the past two decades, although in many parts of the country this transition is not yet complete. However, the public now expects that forestry will operate according to the objectives and policies of the third stage, and will achieve the results expected of this stage. Herein lies much of the current conflict between forestry and the public.

Some of the results of forest practices that the Canadian public can observe around them represent predictability unacceptable consequences of the administrative stage of forestry, or even a "leftover" from the days of unregulated exploitation. In other cases, what the public sees may be "good" silviculture - it may sustain timber production - but may not satisfy the expectations of "social forestry". It does not sustain the aesthetic, spiritual, bio-diversity and various other demands of an increasingly urban society. The Canadian public expects the standards of the most advanced stage of forestry from a resource sector that has only recently begun to emerge from an early stage in its evolution. The rate of change in the public's expectations of forestry has outstripped the rate of change in forestry, and this has resulted in a classical example of what Alvin Toffler called "Future shock".

In comparison to the development of forestry in Europe or Scandinavia, forestry in much of Canada is being expected by the public to skip a stage. The challenge to Canadian forestry is to make this change in a fraction of the time that was available to their European and Scandinavian predecessors, and to make the change without threatening the sustainability of any resource values.

Sustainability of Timber Values

It is an article of faith for most foresters that they are practising "sustained yield" timber management. Assessment of whether or not this is true requires analysis at two different spatial scales: the local site or stand level, and the regional or whole forest level.

1. Stand-level site productivity: potential vs. achieved

Sustainable timber management at the stand level involves two separate issues: sustaining the potential productivity of the site, and achieving this potential.

The potential productivity of a particular forest site is determined first by the region-al climate, and secondly by the soil conditions on the site. Climate is determined largely by latitude, longitude, elevation, aspect, distance from the ocean or large lakes, and position (leeward or windward) relative to mountain ranges. Soil conditions of importance include soil moisture, aeration and fertility. These are often closely related to the quantity and quality of soil organic matter.

Forest management can significantly affect microclimate for the period between harvest and canopy closure. However, sustained yield forestry is not believed to affect regional climate. In contrast, the large-scale deforestation that accompanies major land use changes has the potential to significantly alter regional climatic conditions in some parts of the world (e.g., the tropics).

Forestry often has a significant effect on soil conditions. It can either increase or decrease soil organic matter levels, and either improve or impair the moisture, aeration and fertility of the soil.

Achievement of the biological potential set by regional climate and soil conditions requires a community of locally-adapted plants, animals and microbes developing through the sequence of stages of ecological succession that is characteristic for the site. Attainment of the full potential production of specific plants (e.g. crop trees) or animals (e.g. game species) requires that the processes of ecological succession are managed to favour these particular species by maintaining the ecosystem in a particular seral stage, or a mosaic of seral stages across the landscape.

Achievement of the potential of the site to produce timber values also requires that the forest is protected from natural risks such as fire, insects, diseases or wind. Maintaining potential site productivity and ensuring that an appropriate biological community occupies the site will not ensure sustained economic stand-level production if these risk factors can-not be controlled.

Sustaining stand-level timber productivity is thus the combined result of conserving soil resources, managing the processes of natural succession through silvicultural interventions, and protecting the forest from natural risks. In areas of severe climates, the maintenance of a modified microclimate may also be important.

2. Forest level productivity

Sustaining stand-level productivity does not ensure a sustainable supply of resource values in a major valley or forest management unit. Forest-level (or landscape-level) issues are also important.

A sustained supply of timber products over time from a particular valley, forest management unit or region depends on having even-aged stands of commercial tree species of all ages up to the age of final harvest, or a large enough area of uneven-aged forest with an appropriate range of tree age and size classes to permit continuous harvesting of wood products. In both cases, there is the requirement for a particular age and size class distribution, and a sufficient area of economically operable (i.e. harvestable) forest available each year to sustain the harvest. If the age and size class distribution is not "normal", or if the area of economically-harvestable stands available each year is not fairly even, there will not be an even flow of wood products. This can result from a history of excessive rates of logging, or natural losses due to fire, wind, etc., or both, that have produced an unbalanced age class structure. It is also a common feature of forests as they are being converted from an unmanaged to a managed condition (e.g., conversion of old-growth to second growth forest). Failure to sustain the whole-forest level of timber supply can occur as a result of an inappropriate age class structure or lack of economic operability, even if the site production potential of individual stands has been sustained. Age class and operability problems are often a far greater short-term and medium-term threat to sustainability of timber and related social values in western Canadian forests than problems of damage to potential site productivity. However, long-term sustainability involves both issues.

The discussion in this section so far has focused on potential forest-level production. Achievement of this potential depends upon economics, technology, human resources and the land use strategy. As the national and international price of timber, pulp and other wood products fluctuate, the area of forest that can be harvested economically will change. Sustained directional changes in log values or the competitive status of forest companies will reduce or expand the area of forest managed for timber, thereby affecting the level of sustainable harvest. Changes in technology may increase the area of forest that can be harvested economically, or the area that can be harvested without unacceptable environmental impact. Technological change thus influences forest-level timber supply. It also affects the sustainability of employment. As harvesting methods and manufacturing equipment and processes change, there is often a loss of jobs. Conversely, the availability of an appropriately trained and skilled workforce determines the technologies and management methods that can be used. Strikes or lockouts may influence whether the annual allowable cut is achieved or not, and wage rates will affect the silvicultural techniques that can be employed.

Failure to sustain the landscape-level of timber supply can also result from land use allocation changes that reduce the area of forest to be harvested. Creation of new parks, wilderness or ecological reserves are valid land use decisions, but they may have significant consequences for the sustainability of timber production and associated social values in the region where they are created. Similarly, restrictions on silvicultural techniques such as slashburning, herbicides or clearcutting may sometimes reduce the success of reforestation efforts. If this results in significant delays in reforestation, it will influence the level of the annual allowable timber harvest. Such restrictions may affect the species of tree that can be grown and thus the supply of particular types of wood products.

The ability to sustain forest-level timber yields is obviously the combined result of a complex of factors, from natural risk factors, to changing social and cultural conditions.

Sustaining Non-Timber Values

Forests are much more than an industrial timber resource. They are complex ecosystems that provide a wide range of values desired by our post-industrial society: wildlife, trapping, range, watershed, fish, biodiversity, recreation, aesthetics, spiritual, the traditional cultural values of forests to Canada's forest-dependent indigenous peoples, and other miscellaneous values. It is both a requirement and an ethical responsibility of today's foresters to sustain a balance of these values across the landscape, with due regard to the consequences for economics, employment and community stability of the change from a focus on timber.

1. Wildlife and trapping

Sustaining wildlife populations involves the maintenance of both appropriate habitat values and populations of animals to utilize these habitats. According to how it is practised and the wildlife species you are considering, forest management may either improve or deplete the supply of habitat. However, the availability of habitat will have little influence on the actual abundance of wildlife if over-hunting and trapping, high populations of natural predators, or other mortality factors are maintaining populations of the species in question below the level which could be supported by the available habitat.

Sustaining the trapping industry is closely related to sustaining the populations of their target species, which is the combined result of the availability of habitat, the pressure of hunting and trapping on the population, and the effects of natural mortality agents. The availability of markets is also important. The recent rejection by many in society of animal furs as a form of fashion clothing has had a major impact on the sustainability of the social values created in the past by trapping.

2. Range

Range values are closely related to factors that determine the growth of herbs and shrubs. These include the duration of early seral conditions following harvesting, fire or other types of disturbance, the structure of mature forests, and silvicultural operations that maintain a partially open tree canopy. Delayed reforestation may benefit range values. Sustaining timber values at maximum levels will usually impact negatively on range values, and vice versa.

3. Watershed values

Questions about sustaining watershed values require that the impacts of forest management be considered at different "watershed orders". A small, unbranched stream draining a few hectares is a first order stream; it drains a first order watershed. Where two or more first order streams join, they form a second order stream, their combined drainage areas forming a second order watershed. The joining of two second order streams forms a third order stream, etc. Clearcut harvesting generally has a significant short-term impact on the quality, quantity, and flow regime in first order streams. This impact will persist until the harvested area is hydrologically recovered, which normally occurs when a closed-canopy forest cover has been re-established over the area. Where less than 25-30% of a third (or higher) order watershed is in the hydrologically-altered post-harvest (or post-natural disturbance) recovery stage, it is usually difficult or impossible to detect differences in stream chemistry or flow regimes at the outflow of this watershed. However, significant stream sedimentation or debris avalanche events in first-order watersheds can cause episodic turbidity or stream bed instability problems that are detectable at the outflow of second or third order watersheds. If roads are well constructed, maintained and provided with adequate drainage and culverts, if logged areas are carefully harvested, if unstable slopes are left unharvested, and if second and third order streams are appropriately protected by buffer strips, such problems should not occur.

4. Fish habitat

Sustaining fish habitat is closely related to maintaining the integrity and stability of streambanks and their vegetation, the stability and diversity of the stream channel, and the quality, quantity and flow regime of streamwater. Leaving appropriate riparian buffer strips (but careful removal of large trees that will be susceptible to windthrow may be better for fish habitat than leaving them), prevention of debris avalanche and sedimentation events, and restriction of the proportion of the watershed in a hydrologically altered condition at any one time should ensure that fish habitat is sustained. This will not ensure that fish populations are sustained, however. Overfishing at sea, in lakes and in rivers, or environmental pollution such as acid rain, acid mine drainage or other forms of water pollution that are unrelated to forest management can reduce or eliminate fish populations even if habitat is protected. In the long run, prevention of all debris avalanches (including naturally-occurring ones) and a reduction of large dead trees falling into streams may have a very detrimental effect of fish habitat and fish abundance. This periodic input of coarse woody debris is an essential component of the fish resource in many forest streams and rivers.

5. Biodiversity

After millennia of expropriating the ecological niches of other species, of overhunting, and of promoting the abundance of a small number of desired plant and animal species for food and fibre, the human race is finally beginning to recognize the need to conserve the globe's genetic inheritance. Sustaining biodiversity has become one of the cornerstones of both the environmental movement and the activities of a rapidly increasing number of concerned scientists. However, it is one thing to say "let's conserve biodiversity". It is another to decide how best to achieve it. This is to a great extent because there is a diversity of biodiversities.

Perhaps the most fundamental dimension of biodiversity is genetic diversity. As a species, we limit the genetic diversity of our food and fibre crops at our peril, and conserving species sometimes has as much to do with conserving the genetic variation in their populations as with conserving their habitat.

A second and closely related dimension of biodiversity is the number of species to be found in a particular ecosystem. Unmanaged ecosystems that have not been significantly affected by humans come in a wide range of species diversity. Some (e.g. mature tropical humid forest, especially those on fertile soils) can have an extraordinary number of species in a given hectare. Others (e.g. fire origin forests in many parts of the world) may naturally have but one species of tree, a handful of shrub, moss and lichen species, and, with the possible exception of soil animals, a small number of bird and animal species. The diversity of soil microbes is not nearly as well described as the diversity of plants and animals. This is partly because of the difficulty of applying conventional species taxonomy to the below ground microbial world, and partly because relatively little work has been done to inventory the genetic and species variation of microbes in forest soils. Thus, most statements about the species diversity of ecosystems refers to plants and animals rather than to total species diversity. Most of the work on animals has referred to the larger animals, and the full diversity of forest insects has not been described for many of the world's forests.

In addition to species diversity, ecosystems vary in their structure: the number of different plant life forms, (e.g. trees, shrubs, herbs, mosses and lichens) and their arrangement into different vertical layers in the plant community. Forests that have low plant species diversity will usually have greater total biodiversity if the plants form a multi-canopied community than if they are structurally very simple and uniform: a multi-layered, multi-aged, climax monoculture hemlock and will generally be more biodiverse than an even-aged, single layered monoculture hemlock forest.

Both species and structural diversity in the local ecosystem or forest stand constitute *alpha diversity*. But there is also variation in the species list and in the plant community structure at different locations in the landscape. This landscape scale biodiversity is called *beta diversity*. It is a consequence of the *landscape diversity* of soils and climates that result from latitude, longitude, elevation, aspect, geology, glacial history, the origin of soil forming materials, topography, distance to ocean or large lake, etc. -This physical and chemical diversity forms a basic mosaic of habitat or site conditions that constitutes the framework within which biodiversity develops as a result of ecological processes. The combination of disturbance and successional recovery on these different ecological site types creates the beta diversity across the landscape.

The discussion so far has treated biodiversity as though it was constant over time. Nothing could be further from reality. One of the relatively few attributes shared by all forest ecosystems is that they change over time. In some climax "old-growth" or mature forests, change may be slow, and it may occur as a mosaic of small gaps (5-50 m across) that are created when individual large trees die or are blown over. In most young forests (e.g., less than 100 years since the last major disturbance) change occurs more rapidly, and if major disturbance effects occur they affect patches that range from 1 hectare to many thousands or tens of thousands of hectares.

As forests are disturbed and recover from disturbance, there are characteristic temporal patterns of change in both alpha and beta diversity. Both species and structural diversity undergo such change over time. Where disturbance occurs at the individual tree or small patch scale, there may be little apparent change in biodiversity over time in an area as small as several hectares. Where disturbance operates at a larger spatial scale, alpha and beta species and structural diversity may be undergoing continual change across the landscape.

Sustaining biodiversity requires different strategies to maintain the different aspects of biodiversity. Maintaining temporal diversity is not compatible with constant levels of alpha diversity. Maintaining those aspects of beta diversity that depend on periodic ecosystem disturbance is also not compatible with the concept of unchanging species and structural alpha diversity.

Silvicultural strategies of site preparation, regeneration, weeding, spacing and thinning have certainly reduced both species and structural diversity in some forests. There is also concern that some modern forest nursery techniques and regeneration strategies may be lowering the genetic diversity of planted tree crops. However, appropriately distributed patch logging of unmanaged mature or climax forests can increase landscape (beta) diversity, and forest regeneration practices designed with genetic diversity in mind can increase the genetic diversity of the mature forest. There is, therefore, no simple relationship between forest management and biodiversity. Specific biodiversity goals that are appropriate for different ecological zones and forest site types must be identified. Specific management regimes can then be designed to achieve these goals.

6. Recreation. aesthetics and spiritual values

Sustaining aesthetic and spiritual values and certain types of recreational activities will certainly require a different approach to forest management than that which has occurred in many forests in the past. These values are often associated with large trees, mature stand structure, and vistas of forest that provide a pleasing mosaic of colour and texture that blend in with the form of the local landscape. These values have often been dam-aged in the past by management (especially patterns of timber harvesting) that was not designed to sustain them. When a society has both the desire and the affluence to conserve these values, they will be sustained; similarly, where these values have been damaged in the past, future management should be designed to ensure their renewal and future maintenance. Sustaining these values may involve a significant economic and social cost. Consequently, they will not be managed and sustained at the same level in all forests. The balance between timber and these non-timber resources will vary from location to location according to both their absolute and relative values, and the willingness of society to invest in maintaining them.

7. Traditional Values of Forests for Indigenous Peoples

Forests have many values for modern industrial societies, ranging from industrial raw materials and employment, to recreational and spiritual values. But forests also have values for the indigenous peoples who used the forest before the coming of European and other settlers. Sustaining these traditional values sometimes conflicts with sustaining the values desired by other sectors of western societies. In other cases, careful planning of management, or appropriate changes in land-use allocation, may resolve these conflicts. Direct involvement of forest-dependent indigenous peoples in the management of forest resources may be the best way to resolve conflicts between traditional and other forest values.

8. Miscellaneous Other Values

Harvesting berries, nuts, foliage, honey and mushrooms are some of the other consumptive activities that may be important in particular forests, both by indigenous and non-indigenous people. Sustaining these values may require a modification of forestry practices. In other cases, these values depend upon, or are compatible with, sustainable management and harvesting of timber.

The Temporal and Spatial Scales of Sustainability

If one observed a decline in agricultural soil fertility and crop production over five successive growing seasons, it would be reasonable to conclude that the farm was not being managed sustainably. In contrast, five years of declining soil organic matter and nutrient availability in forests does not necessarily indicate nonsustainability; it is a common phenomena after natural or human-caused disturbance. There is a natural variation over the tree crop production period (the rotation) in the depth of forest floor and the availability of nutrients, just as there is a similar variation over a single year in a farmer's field. Just as the farmer must judge the con-sequences of his or her actions over several successive (annual) crop rotations, the sustainability of forest values can only be assessed by comparing several successive complete management cycles, or from a knowledge of the expected variation in ecosystem processes and conditions over the rotation in a forest that is being managed sustainably.

Judging the sustainability of forest values should not be based on whether or not there is any change in forest conditions over time, but whether the combined frequency and intensity of human-caused or natural disturbance exceeds the capacity of the ecosystem to recover between successive disturbances. The concept of ecological rotations can be used to evaluate this temporal aspect of sustainability. An ecological rotation is the time taken for a given ecosystem to recover back to some original condition, or to some desired new condition, following a particular intensity of disturbance (Figure 1). Some ecosystems recover slowly. Some recover rapidly. Others are intermediate. As long as a particular ecosystem is managed on its ecological rotation, always returning to some particular condition, the values associated with that condition will be renewed in successive rotations. However, if the rotation is shortened, the level of disturbance must be reduced if ecosystem processes and conditions are to be sustained in successive rotations. Similarly, if the intensity of disturbance is increased, a longer rotation will be needed to renew the values. If this is not done, there may be a progressive decline in ecosystem conditions in successive rotations. This is illustrated in Figure 2.

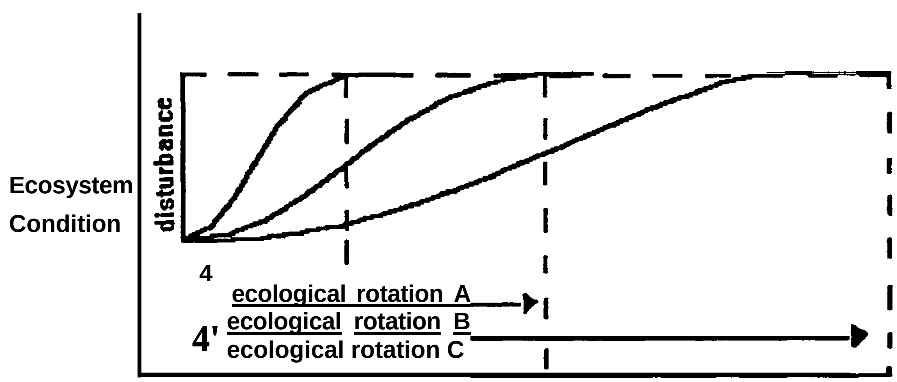


Figure 1 Diagrammatic Representation of the Concept of "Ecological Rotation". Different ecosystems, or different ecosystem parameters, recover from a given disturbance at difference rates. Each will have its own "rotation of recovery" or ecological rotation.

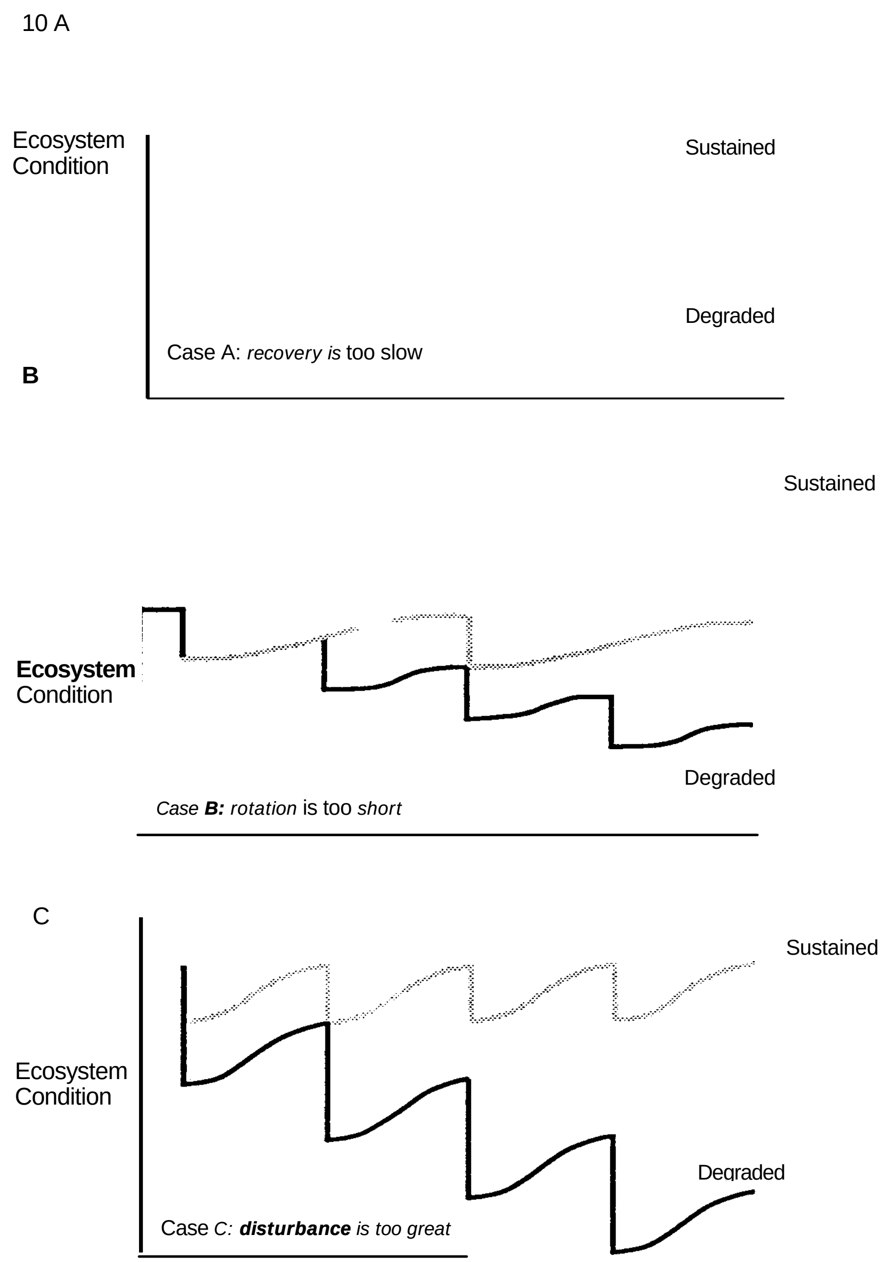


Figure 2. Diagrammatic Representation of the Effects of Variations in the Ecosystem Resilience (A), Frequency of Disturbance (B), Intensity of Disturbance (C), on the Longterm Sustainability of Ecosystem Condition..

The conditions of, and values provided by, a particular forest stand will vary over time because of natural or human-caused disturbance and ecosystem recovery. However, if there is a mosaic of stands of different age distributed across the landscape, it will be possible to find some area in any particular forest condition at any particular time. Thus, if an area of forest is managed to provide a mosaic of stand ages and condition, a wide range of values will be continuously available within the landscape. This will only be true, however, if the mosaic includes the appropriate range in size of patches of forest of different ages distributed in a spatial pattern across the landscape that satisfies wildlife habitat, hydrological, aesthetic and other considerations. Like any ornamental mosaic, sustaining forest values at the landscape level requires more than merely having all the correct pieces of the mosaic: they must also be arranged in the correct pattern.

Assessing whether or not sustainable forestry is being practised involves comparing the "temporal fingerprint" of change in a particular ecosystem-with the expected pattern of change in a "healthy" ecosystem of comparable ecological character. It also involves comparing the existing landscape mosaic (the "spatial fingerprint") with the ideal mosaic that would sustain all desired landscape-level values. Where we have several rotation's experience of the effects of management, we can use this experience to design and establish these temporal and spatial "fingerprints" for a particular forest. Where we lack such experience, we must harness our knowledge of ecosystem function, change over time and species ecology into computer-based management decision support tools. Where we lack the knowledge needed to develop and use these tools, it is the responsibility of foresters and forest scientists to ensure that appropriate research is undertaken to fill the knowledge gaps. Imperfect though these are, in the absence of appropriate long-term experience such computer-based decision aids are often the only way of assessing sustainability.

Threats to Sustainability

1. <u>Population Growth</u>

As Pogo said in what is probably one of the most significant cartoon strips of our time: "I have been out and seen the enemy: it is us".

The greatest single threat to sustainability on earth is the vast and rapidly increasing number of humans. Simple numbers of humans is not the whole story, of course. The earth is a bountiful place. If all the agricultural land and all the forest land were well protected and the areas dedicated to food and fibre crop production were well managed, all the present population, and a considerable expansion thereof, could be provided with the basic necessities of life. However, given the disproportionate allocation of resources between rich and poor countries and between rich and poor within a country, and given the waste of resources on war, the mismanagement of soil, the pollution of air, soil and water, and the wasteful, materialistic life styles of the affluent people of the world, our planet is almost certainly overpopulated. We cannot sustain the present number of people under the present circumstances indefinitely, let alone the expected increase in human numbers.

It was a major conclusion of the World Commission on Environment and Development that the greatest long-term threat to the global environment is poverty. Uncontrolled population growth sustains poverty. The key ingredients for long-term global sustainability are thus arresting human population growth and raising the standard of living in the world's poor nations to the point at which protection of the environment can become the primary objective of all governments. As long as extreme poverty and rapid population growth continue, there is little hope for global sustainability.

2. **Climate Change**

The global patterns of vegetation, soil, land productivity and "traditional" human settlements are largely a reflection of climate. Climates have always been changing as glacial periods have come and gone and as continents have drifted, but the time scales of these changes have been so long that the climate and the consequent vegetation of an area have been thought of as fairly constant. However, if the global climate change that is predicted as a result of the "greenhouse effect" does occur, there are expected to be significant changes in the geographical location of the major climatic and vegetation zones of the earth within the next century. Caused largely by human alteration of atmospheric chemistry, this poses the greatest single potential threat to a wide variety of forest values. Although there is still much controversy about whether or not it has already begun, and even if it will occur at all, the evidence appears to be significantly strong that global climate change will occur and will have significant effects on forest ecosystems.

3 **Soil Damage**

Within a climatic area, the potential productivity of the land is closely related to the soil: its fertility, moisture condition, physical structure and aeration. Soils have been mistreated and mismanaged around the world, and this threatens the sustainability of many resource values, even if human-caused climatic change is averted. Reduction in soil organic matter, loss of soil nutrients, compaction, exposure to wind and water erosion, and the loss of soil stability on steep slopes have been much too common in both agriculture and forestry, and much more respect for these soil values is required. However, this does not imply that soils should never be altered. Some soils degrade naturally if they remain undisturbed for long periods of time, and all soils have a natural rate of recovery from disturbance. It does imply that the disturbance regimes that we apply to agricultural and forest soils must be of a character, intensity and frequency that results in the maintenance of desirable soil conditions over multiple crop rotations.

4. **Loss of Genetic Variation**

The ecosystem potential set by the climate and soil can only be achieved if there is an appropriate community of plants, animals and microbes that are adapted to the local ecological conditions. Evolution has provided a wide range of genetic variation that equips organisms to survive and function under a variety of environmental conditions. Faced with actual or potential human-caused changes in climate and soil conditions, it is extremely important that we conserve genetic diversity. Foresters must always be aware of the need to maintain genetic variation and ensure that their actions do not cause unacceptable genetic simplication of forests.

5. Natural Risks

Fire, insects, diseases and wind can all threaten the sustainability of a wide range of forest values. If global climates are significantly altered by human activity, it is probable that all these natural risks will increase in severity. Indeed, this may be one of the major negative impacts of global climate change. Foresters must give considerable thought to how these risks could be reduced if the global climate change that is predicted for the next 50 years does occur.

6. Lack of Investment and Loss of Confidence in Forestry

High quality, sustainable resource management costs money. Forest companies that are at the "economic brink" are rarely able to practise forestry to the same environmental standards as a company with a satisfactory bank balance. Just- as global poverty is a major threat to the sustainable global use and development of resources, so corporate or government poverty is a major threat to the quality of forest management. Confidence in the long term future of forestry is also very important. Unless forest managers are encouraged to take a long-term view, decisions will become short-term and focus on immediate economic rewards rather than on stewardship.

The current climate of public concern about the environment has led to a feeling of insecurity amongst many forest companies and individual foresters. Insecurity of land tenure, uncertainty about who will benefit in the long run from voluntary investments in forest management, and the loss of self esteem and confidence amongst some foresters after repeated and often highly critical attacks by the media and the environmental movement are having a significant negative effect. Some large forest companies are reviewing their investment in forest management and some are reducing their involvement in growing forests in favour of being processing industries. In some cases, they may be replaced by companies that do not have nearly such a good environmental "track record". Other companies are limiting their investments in forest renewal, silviculture and management to the minimum that is required by law.

Unless the current crisis of confidence and the growing reluctance to invest in long-term forestry can be reversed, we can expect to see the quality of forest management decline. In some cases, this could become a major threat to sustainability.

7. Lack of Secure Long-Term Tenure

One of the most important ways of building confidence in the future and promoting stewardship in forestry is to assign long-term responsibility and accountability for resource management. Long-term tenures, albeit with tough performance standards, are an essential ingredient of forest stewardship. In British Columbia, the public distaste for the concept of long-term tenures by timber companies is a significant threat to the practise of the type of multi-resource management that is required for sustainable use and management in the forests of the province. Steps must be taken to develop socially-acceptable tenure arrangements that will encourage stewardship and sustainable management.

Essentials for Sustainable Use and Development of Forests

Defined as the use of forests that satisfies present demands for a wide variety of values, but which does not reduce the options and the values available to future generations, sustainable forestry must involve the following:

1. A Sound Ecological Foundation

Although sustainable forestry involves much more than just science, and, within the realm of science, much more than just ecological science, forestry is unlikely to be sustainable unless it is soundly based on ecology. Just as a well designed building may collapse if it is erected on an inadequate foundation, sustainable use of forests requires a solid foundation in knowledge of ecosystem function, change over time, and spatial variability, and the ecological requirements and tolerances of forest organisms. The single most important component of this foundation is an ecological classification and stratification of the landscape. However, this is not enough. Site classification must be accompanied by knowledge of the functional process-es of forest ecosystems, their resilience, the processes that allow ecosystems to recover from disturbance, and how these vary from one type of ecosystems to another. The ecology and ecological role of crop and non-crop species must be understood and respected.

2. An Accurate Inventory of Major Resource Values,

Sustainable management is impossible in the absence of an adequate inventory of the extent and location of the values that are to be sustained. The best quantified forest resource in Canada is the timber, but even this inventory is inadequate to meet the demands of today's society. Improved inventories of wildlife, fish and streams, aesthetic, old-growth, cultural and spiritual values, etc. are necessary if plans to sustain them are to be successful.

Immediate development of all the inventories required to meet the public's current expectations of forestry and foresters is beyond the economic capabilities of the government agencies responsible for the management of public forests. This means that management will have to proceed in the absence of adequate inventories. However, a clear message must be sent to governments that if they intend to respond to public demands for changed levels of forest management, adequate funding of accelerated inventory activities is essential.

3. Ecosystem Prediction Tools

If in doubt, ask a tree or read the landscape". This adage suggests that experience is generally the best guide for the management of our complex forest ecosystems. However, we often lack the appropriate experience. Either we are still logging mature, unmanaged or old-growth forests, and therefore do not have multi-rotation experience of the consequences of our management, or the experience we do have may be valid only for the management practises of the past, many of which have been rejected by the public. Frequently, experience-based decisions must be replaced by knowledge-based decisions. Unfortunately, we generally lack the decision support tools that can effectively integrate all the relevant knowledge that exists. There is an urgent need to develop such tools.

Geographic Information Systems, computer simulation models, computerized "expert systems", and maps and field manuals are some examples of the kinds of integrative decision support tools that must be developed where they are lacking. The ability to rank the probably future consequence for a wide variety of resource values of the resource management decisions we make today is one of the most critical needs. Such tools must be developed and used if we are to make management decisions that will sustain resource values.

4. Stable Land Use Strategy

Long-term planning and stewardship require a stable land-use strategy and tenure system. There is no point in having long-term ecosystem prediction tools if there is no incentive to consider anything more than the short term. Society must decide, and rather quickly, how much forest land should be assigned to different intensities and strategies of timber management, how much land should be used for the harvesting of non-timber resources, and how much should be allocated to non-extractive uses such as parks and wilderness. Society must also decide where the different land uses should occur. The "shifting goalpost" problem, in which land managers do not know the size of the area they will be managing in the long term, or which forests they will be harvesting in the future, is very damaging to efforts to develop a stewardship ethic and sustainable management.

5. Integrated Planning

Much lip service has been paid over the years to "multiple use" of forests. Many foresters now subscribe to "the best use" concept: a zoning of land into intensive fibre production lands, lands for non-consumptive uses, and multiple use lands on which the relative priorities of the different resource values varies from place to place and from time to time.

Much of the conflict in forestry might be avoided if forests were planned in a more integrated manner, rather than assigning the planning and management for timber production to one agency of government or industry, with other values managed by other agencies acting as constraints on timber management. Management of entire blocks of landscape for all resource values by one agency or company, with firmly applied contracts to ensure that an appropriate balance of values is sustained, can offer a much more successful system of land management that the present administrative separation of management for different values; the latter has proven to be a recipe for conflict. Public attitudes towards such a management system will probably prevent it being used in public forests in the foreseeable future, but it is difficult to see how we will ever get truly integrated planning where responsibilities for different ecosystem values are divided amongst so many agencies.

6. Accountable. Well Informed Public

The public owns most of the forests of Canada, especially in the west. The public therefore has the right, and the obligation, to have a choice in how their forests are man-aged. There must be public involvement in decisions concerning the way public forests are managed, but it must be informed involvement. The forestry profession has the obligation to help the public understand the forestry-related issues they are concerned about, and the public has the responsibility to seek such knowledge. There must also be a mechanism by which there is sharing of responsibility and accountability for the consequences of forest management decisions between all those who make the decisions.

7. A Commitment to Sustainable Forestry

In spite of good planning, sustainable forestry will not occur unless there is a commitment to make it happen.

Foresters must work with concerned citizens to achieve the changes needed to man-age forests sustainably. They must have the knowledge and confidence to resist public pressures to manage forests in ways that are counter to the principles of long-term resource sustainability, but must not hang on to traditional attitudes and methods where these are no longer appropriate.

For their part, concerned citizens must leave behind the rhetoric and confrontation tactics that have contributed so positively to creating the awareness of environmental problems and the need for improved resource management. It is time for concerned members of the public to sit down with government agencies and resource managers to decide exactly what sustainable forestry means in the fullest sense of this term, and how to achieve it. Unless there is a commitment by all parties to move away from polarization, confrontation and rhetoric, to embrace positive change, and to proceed to find ways of achieving sustainable forestry, it is doubtful that we will achieve it.

Conclusion

Sustainable forestry is an imperative, not a choice. The need is driven by the inexorable growth in human numbers and deterioration of the global environment. However, it is much easier to talk about it than achieve it. This is largely because it is such a multi-dimensional concept. There are so many values to be sustained at so many different temporal and spatial scales.

Sustainability does not imply constancy over time. The challenge is to decide at what spatial and temporal scales we will evaluate sustainability, what balance of values is to be sustained in any particular forest, and what pattern of variation in values over time is consistent with the concept of sustainability.

Sustainable forestry is not simply a technical and scientific issue, although to be sustainable, forestry must be well founded in science and use appropriate technologies. Sustainable forestry is also a political, social, cultural and economic issue. Only if all the dimensions of sustainability are considered will we be able to develop land-use plans and management methods that achieve this laudable but often elusive goal.

FOREST INDUSTRY LECTURE SERIES

1. Industrial Forestry in a Changing Canada. C. Ross Silversides. 17 November 1977.
2. The Role of Integrated Companies in Western Canada. W. Gerald Burch. 15 March 1978.
3. Premises of Energy Forestry in Sweden. Gustaf Siren. 7 March 1979.
4. Agro-Forestry - Prospects and Problems. K. F. S. King. 27 September 1979.
5. The Role of the Federal Government in Forestry. K. L. C. Reed. 5 March 1980.
6. Breeding for Variable Environments. Gene Namkoong. 14 August 1980.
7. Federal Forestry Commitments in the 1980's. Roger Simmons. 5 December 1980.
8. Space, Time, and Perspectives in Forestry. Kenneth A. Armson. 26 November 1981.
9. Labour's Role in Forest Resource Management. John J. (Jack) Munro. 25 March 1982.
10. Stocking Control and Its Effect on Yields. Peder Braathe. 4 November 1982.
11. Timber Management Scheduling on Public Lands - Why the Future Is Not Like the Past. Dr. K. N. Johnson. 29 March 1983. Talk Only - Paper Not Available.
12. The Canadian Schools of Forestry - Retrospect and Prospect. V. J. Nordin. 19 January 1984.
13. Increasing the Land Base and Yield Through Drainage. J.Paivanen. 15 March 1984.
14. Forestry Productivity Limits: Real, Imagined and Potential. Conor Boyd. 24 January 1985.
15. Air Pollution and Forest Resources - The Nature of the Threat. Peter Rennie. 28 March 1985. Talk Only - Paper Not Available.
16. Land-Use Planning for Forest Harvesting and Environmental Concerns. John A. Marlow. 28 November 1985.
17. Northern Forest Management for Wildlife. Gordon W. Guillon. 16 October 1986.
18. From NSR to Intensive Forest Management. Hugo Von Sydow. 12 March 1987.
19. Managing People Managing Trees: Understanding Today's Environment for Natural Resource Management. Mary Jo Lavin. 19 November 1987.

20. The Social Renewability of Forestry. Harold R. Walt. 30 March 1988.

21. Forest Policies: Public Duty and Private Action. Adam H. Zimmerman. 1 November 1988.

22.. New Dimensions in the Development of Forest Policy: A View From the Trenches T. M. (Mike) Apsey. 16 March 1989.

23. Vision and Reality - The View From Sweden. Bjorn Hagglund. 17 October 1989. Talk presented at the Annual Meeting, Canadian Institute of Forestry at Kananaskis. Printed in the Forestry Chronicle.

24. The Contribution of Old Growth to the New Forestry. Jerry F. Franklin. 4 April 1990.

25. Developing Silvicultural Alternatives for the Boreal Forests: An Alaskan Perspective on Regeneration of White Spruce. John Zasada. 7 November 1990.

26. Forestry After the End of Nature. Clark S. Binkley. 20 March 1991.

27. Sustainable Forestry: Can We use And sustain Our Forests? J.P. (Hamish) Kimmins. 21 November 1992.