2. AN ECOSYSTEM-BASED APPROACH TO FOREST PROTECTION AND USE: DEFINITION AND SCIENTIFIC RATIONALE

An ecosystem-based approach protects forest functioning at all scales through time as the first priority, and then seeks to sustain, within ecological limits, a diversity of human and non-human uses across the forest landscape. In other words, ecosystem-based approaches focus first on what to leave and then on what can be taken without damage to ecosystem functioning.

Where timber extraction is determined to be an appropriate activity, ecologically responsible timber management means that plans and activities are developed and carried out in ways that protect, maintain, and restore (where necessary) a fully functioning forest ecosystem at all temporal and spatial scales. Forest composition, structures, and functioning are maintained, from the largest landscape to the smallest forest community, in both short and long terms.

An ecosystem-based approach recognizes that a forest ecosystem is a continuum in time and in space. In other words, over time, a forest ecosystem is not static and unchanging. Natural disturbances constantly modify forest ecosystems as time passes. However, unlike disturbances from integrated forest management and other forms of conventional management, natural disturbances serve to maintain forest functioning and provide biological legacies (e.g. dead trees) that connect one forest successional phase to another. In a natural forest ecosystem, the most common disturbance or agent of change is the death of an individual tree or small groups of trees.

A forest ecosystem is also a spatial continuum. In other words, forests are interconnected, interdependent clusters of ecosystems, from patches of different soil types within a 4 hectare (10 acre) forest stand to a watershed of 500,000 hectares (1.2 million acres) or more. Understanding that a forest ecosystem is a continuum through time and space reinforces the wisdom that what we do to one part of the forest we do to all parts of the forest.

Two important concepts are encompassed within the understanding that forest ecosystems are spatial and temporal continuums: forest landscapes and forest stands/forest patches.

2.1 The Forest Landscape

The forest landscape is the large-scale view of a forest. When industrial timber managers use the term “forest landscapes,” they are usually concerned with scenery and visual impacts. In the context of an ecosystem-based approach, however, a forest landscape is a mosaic of interconnected, interdependent stands or patches that are repeated in a pattern across the larger landscape. This pattern has both spatial and temporal components.

An ecosystem-based approach requires that all planning and activities begin at the regional/landscape level. When planning for human use, landscape level decisions are made for watersheds of small to moderate size (less than 5,000 hectares to about 50,000 hectares, or 12,000 to 125,000 acres). In sub-regional or regional planning processes, forest landscape level considerations are expanded to large watersheds encompassing hundreds of thousands of hectares/acres.

In planning and carrying out forest uses, particularly timber management, many people tend to focus on small forest parcels. This is a result of our limited spatial view, short time frames, and cultural conditioning. In contrast, an ecosystem-based approach requires that all planning and activities start at the landscape level. The character and condition of the forest landscape dictate what is ecologically possible at the stand level.

The character of a forest ecosystem refers to how a forest works, from the landscape level to the stand or patch. For example, forests that have frequent fires have a different character than forests where wind and root decay are the primary agents of disturbance. Some forests are characterized by steep slopes, shallow soils, and well-defined drainage patterns, while other forests have gentle slopes, cold soils, and diffuse drainage patterns.

Forests of a different character will have different composition and structures, and therefore differences in how they function. Different composition, structures, and functioning lead to different kinds of ecological limits to human use. Ecological limits are natural factors or processes that are easily damaged or degraded if modified by human uses. For example, steep and/or wet slopes impose ecological limits because, if disturbed, they are likely to erode, causing problems like soil loss and siltation of streams. Cold soils are an ecological limit because nutrient cycling occurs in shallow organic layers which may be easily damaged by many types of human activities.

The condition of a forest describes how human uses have modified forest functioning from the landscape level to the stand or patch level. Conventional timber management frequently results in negative impacts, like fragmentation, loss of old growth, and soil degradation. An ecosystem-based approach protects forest composition and structure and respects the ecological limits of forests to various human uses. By respecting ecological limits ecosystem-based approaches avoid degradation of short- and long-term forest functioning.

Ecological limits to human use are determined by describing and interpreting the character and condition of, first, the forest landscape, and then the forest stand or patch.

2.2 Forest Stands/Forest Patches

Forest stands or forest patches refer to the ecosystem scale at which a relatively homogenous forest unit can be identified. The composition, structure, and ecological functions within a stand are similar enough that an ecologically responsible forest use prescription can be applied uniformly within the stand, without encountering changes in ecological parameters that may produce unexpected or undesirable results.

In conventional forestry, “stands” have largely been defined by narrow timber characteristics, which were in turn driven by short-term economic variables. However, in order to plan and carry out ecologically responsible forest uses within an ecosystem-based approach, stands must be defined in relation to whole ecosystem factors that are required to maintain fully functioning forests at the landscape and stand levels. In other words, the boundaries of a stand are not determined by rigid human management criteria such as timber size and timber quality, but by the full spectrum of ecosystem parameters that have been shaped by natural disturbance patterns and that reflect the movement of energy, nutrients, water, and animals into and out of a particular ecosystem.

Human scales are closest to forest scales at the stand or patch level. For example, the stand or patch level is the scale where visible human modification occurs. However, an ecosystem-based approach must always consider that what occurs at the stand or visible scale will also have impacts on a variety of other scales, from the large landscape to the microscopic.

2.3 Human Needs—Human Impacts

In an ecosystem-based approach, human needs (not to be confused with greed) are included as part of the needs of ecosystems. In other words, people are included as an interconnected, interdependent part of whole forest ecosystems. However, an ecosystem-based approach also recognizes that modern human beings have inordinately large powers to modify and degrade ecosystems compared to any other living organism or natural disturbance.

Activities such as clearcutting result in radical alterations of ecosystem composition and structures. In an attempt to justify these activities, government and industrial timber managers frequently compare the resulting alterations to the results of natural disturbances, such as fire or the effects of insect populations. However, this comparison fails to distinguish between exploitation of ecosystems for profitable commodities and the disturbance of ecosystems through natural processes. Clearcut timber management, for example, removes all of the merchantable trees from a cutting area, and plantation-style forestry plans the removal of all of the trees (i.e. logs) on short cycles or rotations, in perpetuity. In contrast, natural disturbances, such as root decay, insect feeding, wind, and fire, leave behind the tree trunks or tree stems, which become vital structures for maintaining forest functioning.

Some conventional timber managers have suggested that clearcuts nevertheless resemble some natural disturbances, pointing to volcanic eruptions and glaciation, which, like clearcuts, remove all of the trees from a particular area. However, this analogy is inaccurate and deceptive, for two reasons:

1. Clearcuts are predictable disturbances, planned to occur on short cycles of decades. In contrast, volcanic eruptions and glaciation are unplanned, unpredictable natural disturbances which occur on long cycles of millennia.
2. Clearcutting is a modification of an ecosystem which degrades forest functioning by removing biological legacies from a forest stand and forest landscape, including trees and beneficial soil fungi at the stand level, and old growth or late successional forests at the landscape level. In contrast, volcanic eruptions and glaciation leave behind important biological legacies, such as nutrient-rich volcanic ash and glacial

silt, which provide the foundation for the millennia of forests that follow such natural disturbances.

An ecosystem-based approach requires that people take seriously the threat of ecosystem degradation from the inappropriate use of human technology and that human uses of the forest mimic, as much as is feasible, natural processes. In other words, an ecosystem-based approach focuses on managing human activities in ecosystems, rather than on manipulating ecosystems to serve short-term human interests.

An ecosystem-based approach is consistent with the development and maintenance of stable human communities and diverse, sustainable human economies. Labor-intensive activities and value-added wood products manufacturing in close proximity to the source of wood are cornerstones of the development of ecologically responsible, community-based economies. Development of ecosystem-based, local decision making about forest use is critical to developing and maintaining ecologically responsible forest use.

2.4 Current Timber Management Approaches and Ecologically Responsible Timber Management: A Comparison

As a result of the extensive public criticism of large-scale industrial timber management, governments and timber companies around the world have developed a variety of practices that are being promoted as sustainable timber management. In many cases, these “new” approaches are simply conventional timber management in disguise or, at best, a more benign form of industrial timber cutting which still does not meet the tests of ecological responsibility.

We briefly describe and evaluate below some current approaches to timber management which do not, under most circumstances, meet the requirements of ecological responsibility. This list and discussion is not intended to be a comprehensive explanation or critique of these timber management approaches, but rather the list is included here to introduce key differences between ecologically responsible timber management and other types of timber management.

One central concept is common to all of the approaches described below: as currently practiced, all of these timber management approaches begin with the assumption that the dominant forest use will be timber extraction and the subsequent growing of timber crops. In contrast, an ecosystem-based approach focuses first on maintaining and protecting forest ecosystem functioning, and secondly, on providing for a diversity of human uses, which may or may not include timber management.

2.4.1 Sustained yield forestry

Sustained yield forestry is a concept that designs timber cutting and regrowing of timber crops to provide a perpetual yield of timber from a particular forest landscape. Initially, this concept embodied the commitment to non-declining timber yields over time. However, the determination of annual cuts under sustained yield forestry has commonly been overly optimistic when considering both tree growth rates and the portion of a forest landscape that is suitable for the cutting and growing of timber crops over time. Thus, as a result, "sustained timber yields" have tended to decline through time as a result of excessive cutting rates that cannot be matched by the rate of regrowth of timber and by extraction of timber from land that subsequently proves to be unsuitable for timber growth and/or necessary to protect for non-timber forest uses. Sustained yield forestry confuses timber or trees with forest ecosystems and fails to recognize that fully functioning forests are necessary to have trees, which are necessary to have timber. In contrast, an ecosystem-based approach protects forest functioning at all scales through time as the first priority; and then seeks to sustain, within ecological limits, a diversity of human and non-human uses across the forest landscape.

2.4.2 Multiple use

Multiple use is a system of forestry or timber management that assumes that a full spectrum of forest uses, from timber cutting and tourism to water production and non-timber forest products, can occur simultaneously throughout a forest landscape. When practiced across relatively large areas (500,000 hectares/1.2 million acres and larger), multiple use appears to work for a period of time. However, under this regime, all forest stands with merchantable and economically accessible timber are planned for eventual timber cutting. Thus, as logging progresses through the landscape, both forest functioning and non-timber forest uses are progressively degraded. Proponents of multiple use often attempt to convince other forest users that tree plantations are forests, and that society cannot afford to protect animals, plants, and microorganisms that stand in the way of economic growth. An ecosystem-based perspective maintains that human societies cannot afford not to protect forest functioning and maintain diverse forest uses that are the foundation for stable local economies.

2.4.3 Integrated forest management

Integrated forest management is a more recent version of multiple use, where timber managers attempt to "integrate" or merge forest conservation and non-timber forest uses with timber cutting and timber management across a forest landscape. However, as with multiple use, the vast majority of forest stands with economically viable merchantable timber are planned for eventual logging. Typically, integrated forest management includes extensive analysis of forest ecosystem features, such as wildlife, soil, terrain stability, and water. While this information could serve to significantly change both the amount of timber cut and the way in which timber is cut, such studies usually result in timber cutting levels and methods that best meet the short-term economic needs of the timber industry and government. In contrast, studies carried out as part of an ecosystem-based approach are applied to define ecological limits to timber management and to non-timber forest uses, and to provide for fair and protected land bases for all forest users, both human and non-human.

2.4.4 Ecosystem management

Ecosystem management is a confusing mixture of good forest ecology principles and integrated or multiple use forest management. Advocates of ecosystem management analyze and describe ecosystem functioning in ways that recognize the need to maintain natural composition and structures of forest ecosystems from the landscape level to the stand or patch level. However, while providing good information about forest functioning, practitioners of ecosystem management also continue to advocate methods and levels of timber extraction that degrade forest ecosystem composition, structures, and functioning necessary to maintain fully functioning forests through time. Conventional clearcutting and tree plantations are regular components of ecosystem management. In contrast, ecologically responsible timber management is ecosystem-based, which means that the character (i.e. composition, structure, and functioning) and condition of ecosystems determine what types of human use can be carried out and in what ways and at what level of intensity these uses can occur while ensuring the maintenance of fully functioning forests at all scales through time.

Conventional timber management approaches described above all utilize concepts oriented to exploiting natural forests for timber and to producing crops of trees in short time cycles. Most of these concepts have little or no application in ecologically responsible timber management, because conventional approaches are focused on *timber,* while ecosystem-based, ecologically responsible approaches are focused on *forests*.

2.5 Common Conventional Timber Management Concepts

Listed below are some of the more common conventional timber management concepts that have little or no application in ecologically responsible timber management.

2.5.1 Rotation ages

Also known as culmination age, the rotation age is the age at which average annual timber volume increase is the highest. This conventional timber management approach is oriented to maximizing timber *volume* as opposed to maximizing timber value and maintaining overall forest functioning. In ecologically responsible timber management, there may be reasons to cut small, young trees (e.g. when restoring natural stand structure to areas where fire suppression has occurred) and for growing trees to old ages in order to provide for late successional or old growth forests and to provide high quality, mature wood fibre. Thus, the concept of rotation ages has little or no application in ecologically responsible forestry. Trees are selected for cutting in ecologically responsible timber management by considering a variety of criteria other than age, including:

- stand condition,
- successional processes,
- the need for old growth forests and old growth trees, and
- production of high-valued, mature wood fibre.

Ecologically responsible timber cutting frequently is planned to grow trees to their ecological maturity, which both ensures that trees play their full successional roles and produce the highest quality, highest value wood.

2.5.2 Annual allowable cut (AAC)

An **annual allowable cut (AAC)** is an estimate of the timber volume that can be cut from an area on an annual basis, allegedly in perpetuity. Because AACs are based largely upon how natural forests grew in the past and on the liquidation of old growth forests, levels of timber cutting calculated according to these concepts tend to be exaggerated. The result is **falldown**—a reduction in the quantity of timber that can be cut in the future. AACs are about maximizing short-term timber cuts, as opposed to maintaining fully functioning forests. Therefore, in the long term, applying AACs to a forest landscape results in degraded forest ecosystems and non-sustainable timber cuts.

In contrast, the volume cut each year under ecologically responsible timber management is restricted by the requirement that cutting must maintain fully functioning forests at all scales through time. Thus, annual timber cuts will vary according to the needs of the forest. Once a forest landscape has been managed for an extensive period of time using ecologically responsible approaches, managers will be able to forecast a reliable range of annual cuts, depending on the needs of the forest.

2.5.3 Decadence

In conventional timber management, a forest stand is considered decadent if it includes a relatively large number of snags, fallen trees, and partially decayed, large, old trees. Conventional timber managers view decayed and dead trees to be waste. In fact, however, decadent forests are ecologically rich and absolutely vital forest phases for maintaining fully functioning forest ecosystems. Large, old, decaying trees are homes for many specialized organisms, such as carnivorous insects and lichens that fix atmospheric nitrogen. Snags are necessary for cavity nesting birds and other cavity dwelling animals such as pine marten. Fully decayed wood in rotten trees is the foundation for future forest soil and is also Nature’s water storage and filtration system. Also, large old living and decayed trees in “decadent forests” contain the highest volumes and highest valued wood of any forest phase. Conventional timber management has manipulated the concept of decadence in order to support cutting high volume, high valued old growth forests at rates that far exceed ecologically sustainable cutting rates.

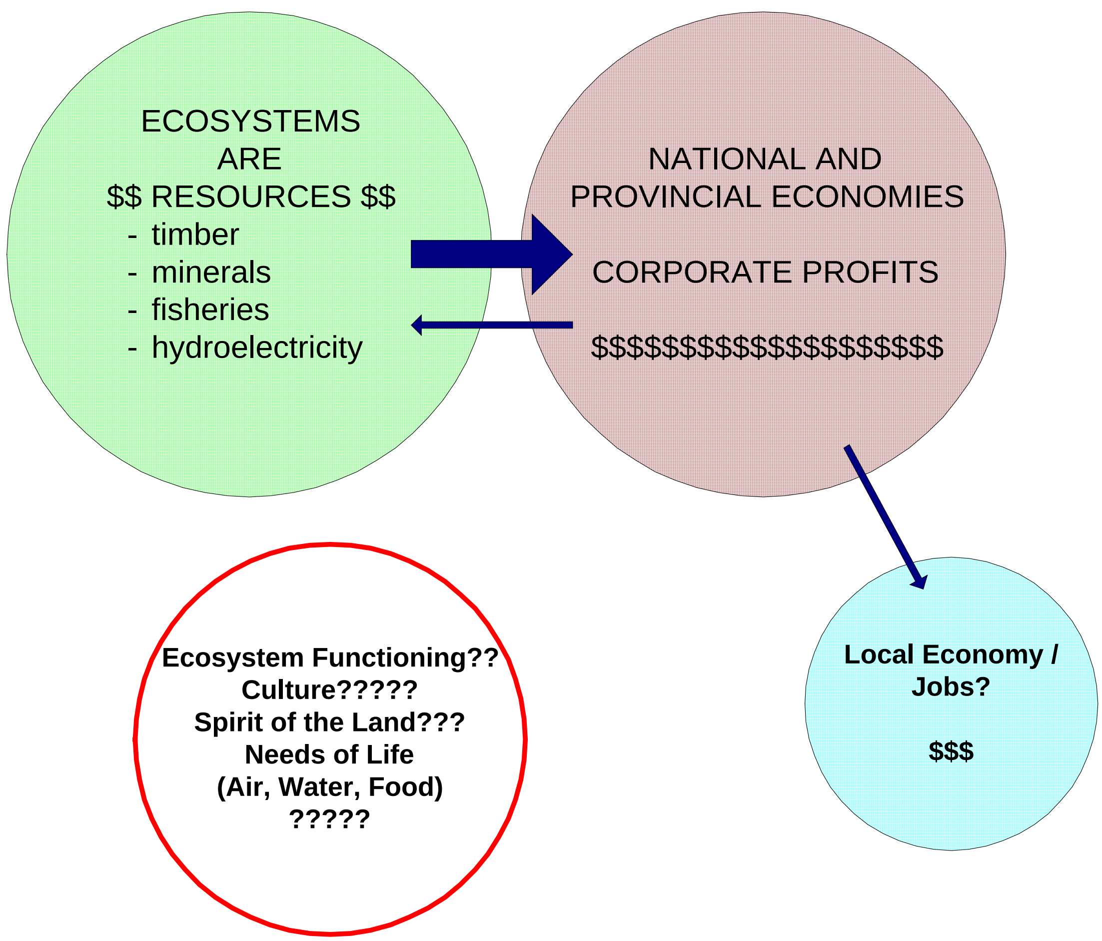
Ecologically responsible timber management understands that decadent old growth stands are critical components of any forest landscape, and old growth decadent structures (such as large, old trees, large snags, and large fallen trees) are critical to maintain at the stand level to ensure such vital forest functions as soil development, water filtration, and water storage.

2.6 Why Is an Ecosystem-based Approach Necessary?

The idea of “sustainable development” has been based on the illusion that “we can have it all.” Sustainable development is an oxymoron because it suggests that we can sustain ecosystem functioning while achieving steady economic growth. In parts of the world where poverty reduces people’s capacity to use forests and other ecosystems in ways that protect ecosystem functioning, *some* economic growth for a *limited period of time* may be necessary to avoid intensifying pressures on ecosystems. However, the affluent, consumer-based economy of much of North America and western Europe is not sustainable, because it increases degradation of ecosystems to support the goal of perpetual economic growth.

Figure 2-1 represents resource use based on the concepts of sustainable development. This approach assumes that the environment and the economy are of equal importance. However, this approach ignores the needs of ecosystems as well as the needs of Indigenous cultures and local communities.

THINK ONLY FOR TODAY
OR IN SHORT-TERM POLITICAL TIMEFRAMES.....



ONE-WAY RELATIONSHIP WITH ECOSYSTEMS....
TAKE AS MUCH AS POSSIBLE

EVENTUALLY, THE ECOSYSTEM DOES NOT WORK
AND THEN THE ECONOMY DOES NOT WORK AND CULTURE COLLAPSES

Figure 2-1: Current government and industry approach to integrated management

If we are going to sustain anything, the first priority of human use of ecosystems, including forest ecosystems, must be to protect ecosystem functioning. This priority recognizes that economies are subsets of human cultures, which are subsets of ecosystems. Thus, if human use does not sustain ecosystem functioning, it does not sustain human cultures or the economies that make up human cultures. Until recently, technologically equipped human beings have been able to temporarily avoid the consequences of ecosystem degradation by moving exploitation of ecosystems from one part of Earth to another part of Earth. As we deplete natural resources and degrade ecosystems, we also look for substitutes to previously "sustainable" resources. However, common sense tells us that this approach can only work for a short period before we have ecosystem collapse, followed by social and economic collapse.

Figure 2-2 represents an ecosystem-based approach and depicts the dependence of economies and cultures on fully functioning ecosystems.

An ecosystem-based approach protects ecosystem functioning by protecting, maintaining, and restoring (where necessary) the composition and structures that are the basis of ecosystem functioning. The composition of a forest ecosystem refers to the parts that make up a particular forest area, such as the different species of plants and animals, the type of soil, and the slope gradient of the terrain. The structures of a forest are the arrangements of the parts. Forest structures include large old trees, large snags (standing dead trees), large fallen trees, the arrangement and depth of soil organic layers, and the pattern of forest ecosystem types across large forest landscapes. Together, the composition and structures of forest ecosystems, from the largest landscape to the smallest soil microbe, are necessary to maintain fully functioning forests. This approach needs to be applied through time and to take into account natural forest disturbance types, patterns, and frequencies.

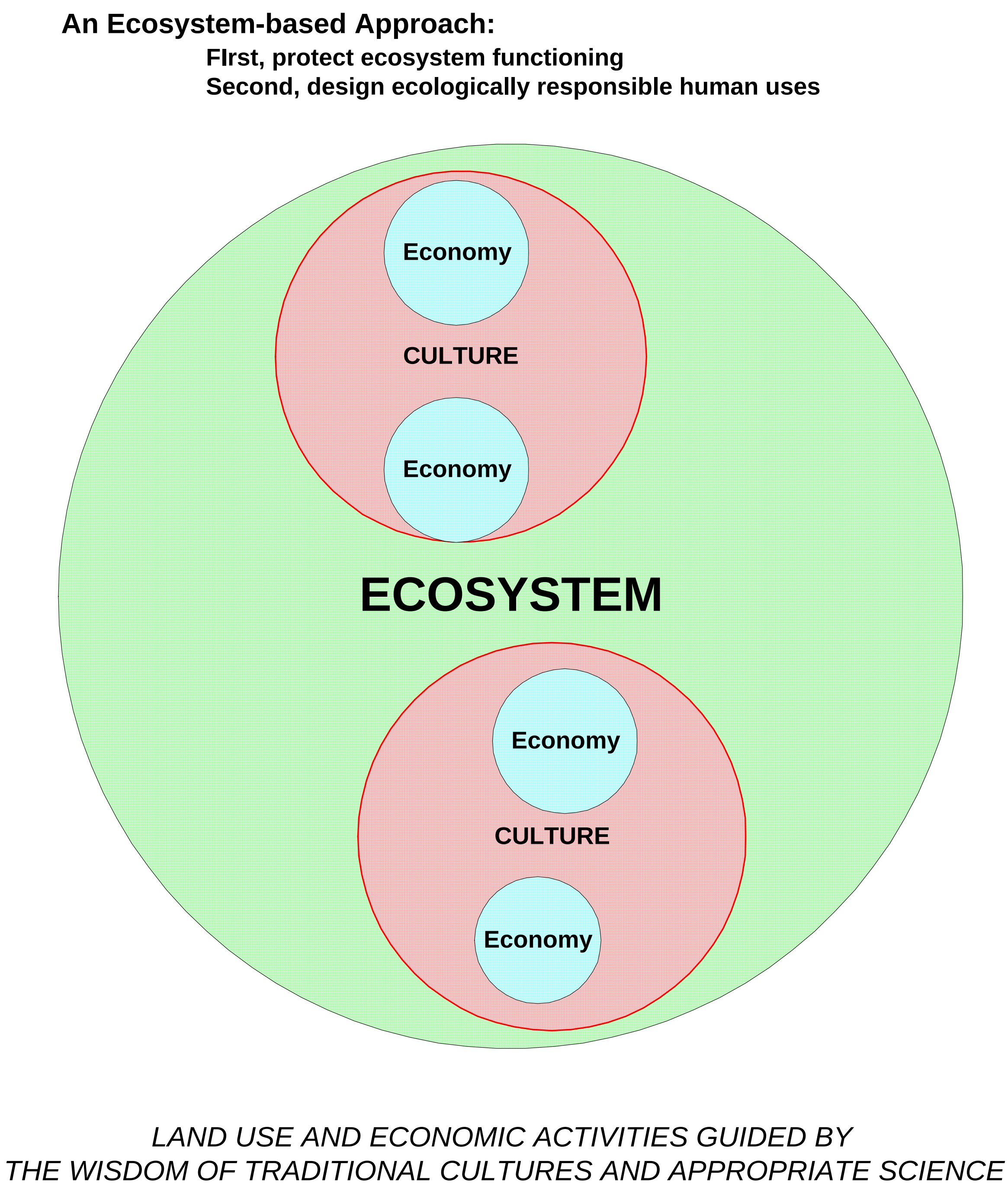


Figure 2-2: An ecosystem-based approach

Conventional timber management constantly alters and removes forest composition and structures at both landscape and stand levels throughout vast areas. Because the biological legacies of thousands of years of natural forest development support tree growth after logging in most “second growth” forests, most people think that conventional forestry works. Let’s take a look at some examples that reinforce the importance of protecting forest composition and structures to maintain forest functioning.

2.6.1 Forest landscape examples

In order to maintain forest landscape functioning, human activities must maintain connectivity. This is achieved by protecting the composition and structures of riparian ecosystems, which are the wet forests adjacent to and immediately upslope from creeks, rivers, wetlands, ponds, and lakes. As well, landscape level plans need to provide for cross-valley movement corridors, which provide travel routes for animals and plants to cross the ridges that separate one riparian ecosystem from another. Cross-valley corridors are not “natural”; before human beings began extensive modifications of forest landscapes, animals moved freely throughout, and occupied all of the landscape. However, with human modification of forests, cross-valley corridors have become a necessary component of forest landscape plans in order to provide protected travel corridors between human use zones.

Successional patterns—the stages of forest growth that follow natural disturbances—are also critical composition and structures of forest landscapes. The proportions of particular successional phases in the landscape (i.e. early successional forest, young forest, mature forest, and late successional or old growth forest) need to be maintained over a variety of time scales, from years and decades to hundreds and thousands of years, in order to maintain forest ecosystem functioning. Each successional phase, with its characteristic composition and structures, provides vital functions to maintain forest ecosystems, from the smallest patch to the largest landscape, through short and long periods of time.

For example, the only two nutrient input phases in a forest lifetime occur in the shrub-herb and late successional or old growth phases. Because the late successional or old growth phase lasts for the longest time, compared to other successional phases, old growth tends to play a dominant role in maintaining forest functioning in most forest ecosystems. Old growth forests provide the highest quality water of any forest phase, because their multi-layered forest canopies and their large amounts of decaying wood intercept and hold water. The old growth phase is also the only forest phase that contains certain specialist organisms necessary for landscape and stand level forest functioning. For example, late successional forests contain the majority of carnivorous insects that eat the herbivorous insects that feed on trees. Also, certain specialist fungi that protect tree roots and pass water and nutrients from the soil into trees are found only in late successional forests.

In contrast to natural forest functioning, conventional timber management proposes to shorten the shrub-herb phase and eliminate the old growth phase over significant parts of forest landscapes. Following this approach degrades ecosystem functioning in a variety of ways, and will eventually lead to forests that are susceptible to ecological collapse. However, conventional forestry tends to evaluate its success by how many trees are growing rather than by ensuring that all parts of the forest have been maintained. Thus, there is an illusion of healthy forests when, in reality, the forests are in serious decline.

2.6.2 Stand level examples

Trees are only a small portion of the composition and structures needed for a fully functioning forest. Nevertheless, we need forests to have trees, and we need trees to have forests. This understanding leads us to one of the most important examples of the necessity of protecting stand level composition and structures if we hope to maintain long-term forest functioning. Trees, both living and dead, are critical structural members of the forest's framework. In particular, large old trees, large snags, and large fallen trees have irreplaceable roles in forest functioning.

Large old trees are literally an ecosystem unto themselves. Some insects and small mammals live out their lifetimes solely within the confines of a single large tree. Large old trees, due to their extensive foliage area, catch large amounts of precipitation, permitting it to drip slowly through the canopy to the forest floor, thereby providing the soil with adequate time to absorb and distribute water. About 30% of the precipitation, be it snow or rain, that falls on the crown of a large old tree evaporates into the atmosphere and moves somewhere else. In a watershed dominated by large old trees, this function prevents the watershed from being overloaded with water and helps to distribute water to other parts of the landscape.

Snags, or standing dead trees, function as homes for cavity-nesting birds that eat insects that eat trees. Thus, maintaining snags throughout a forest stand is a necessary part of keeping agents of change, such as bark beetles, in balance with other parts of the forest. As snags soften, what was once a home for a woodpecker becomes, with a little expansion, a home for a pine marten.

Fallen trees, particularly large fallen trees, play myriad functions. As snow drifts over a fallen tree, it leaves a void space where the curve of the fallen tree trunk touches the ground. This provides an extremely important winter habitat niche for a number of animals, including mice, voles, and pine marten. As the fallen tree decays, it becomes the foundation for future forest soil. Trees that fall across a slope serve as natural dams to hold soil in place on steep slopes. One of the most important structural roles of fallen trees is water storage and filtration. Fully decayed wood holds about 20 times as much water as an equivalent volume of most mineral soils. Thus, fallen trees are Mother Nature's water storage and filtration system. In order to function properly, even a small watershed must contain millions of tons of decaying wood distributed throughout the drainage basin.

2.6.3 Human Examples: The benefits of an Ecosystem-based Approach

These landscape and stand level examples, illustrating the functions of some important forest composition and structures, indicate why practices such as clearcutting and elimination of old growth forests are not consistent with maintaining fully functioning forests. If the degradation caused by clearcutting and removal of old growth forests were more evident, people might be more willing to adopt ecologically responsible approaches to timber management. However, because forests operate on such long timeframes, and because, for millennia, forests have been building biological legacies through many generations of trees that have lived and died, human activities that remove composition and structures do not immediately appear to be as damaging as they actually are. However, as timber managers continue to degrade composition and structures of forests, from landscape to stand levels, damage to forest functioning becomes cumulative. Eventually this approach leads to degraded ecosystems, which provide few ecological functions, compared to the fully functioning forests they replaced. Because forest degradation occurs relatively slowly, successive generations of human beings inherit degraded forests which they assume to be natural, "healthy" ecosystems. In other words, we don't live long enough to see the results of our mistakes.

An ecosystem-based approach attempts to avoid loss of forest functioning by maintaining forest composition and structures from the smallest soil bacteria to the landscape patterns of a large forest watershed. We may not understand the functions of particular forest composition and structures; nevertheless, an ecologically responsible approach protects all composition and structures. When parts of the forest are altered during activities such as ecologically responsible timber management or tourism, provisions for the replacement of forest composition and structures are built into ecologically responsible plans and activities.

As well as providing for the protection and maintenance of forest functioning, an ecosystem-based approach fosters the development of diverse, sustainable human economies. Because an ecosystem-based approach creates the least modification to forest ecosystem composition and structures, it provides for the largest diversity of compatible forest uses. In other words, by maintaining trees on the sites where we practice timber management and by ensuring that ecologically viable old growth stands are found in each landscape, we provide an environment where the broadest spectrum of uses, from adventure tourism to timber extraction, can coexist. Such a range of activities is not possible where conventional timber management systems, such as clearcuts and tree plantations, are employed.

From a timber standpoint, because ecologically responsible timber management produces steady supplies of mature wood, the long-term economic benefits exceed those of conventional timber management practices. Mature wood—long-fibred and strong—is superior for many uses, from structural materials and pulp to furniture and fine cabinets. In comparison, short-fibred, juvenile wood is not as strong and will warp and twist easily. Mature wood is produced when the cambium layer (the single layer of cells between the wood and the bark) divides around dead branches or no branches. Obviously, increasing amounts of mature wood are produced as a tree gets larger and older.

Research indicates that old growth Douglas-fir trees contain about 80% mature wood, while 60-year-old Douglas-fir trees contain only 10-20% mature wood. Under ecologically responsible timber management, trees grow for longer periods, not only to better maintain forest functioning, but also to produce steady supplies of high-value mature wood fibre. In contrast, conventional timber management is based on cutting cycles or rotations that provide primarily low-value juvenile wood. Thus, ecologically responsible timber management maintains supplies of high-quality mature wood fibre similar to that provided by natural old growth forest ecosystems. This will ensure a healthy timber economy in perpetuity.

The elements of the Slocan Valley ecosystem-based landscape plan and the methodology used to develop the plan are further defined in Section 4-Methodology and Decisions on Important Issues: A Summary.

2.7 The Guiding Principles of an Ecosystem-Based Approach

Ten principles, which are derived from both wisdom and science, guide an ecosystem-based approach to forest protection and use.

Principle #1: Focus on what to leave, not on what to take.

An ecosystem-based approach to forest use leaves fully functioning forests at all spatial scales through time. For example, ecologically responsible timber managers identify the parts of a forest stand and forest landscape that must be protected to maintain short- and long-term forest functioning, and these decisions determine what is possible to remove for wood products and other uses.

Principle #2: Apply the precautionary principle to all plans and activities.

The precautionary principle means that plans and activities must err on the side of protecting ecosystem functioning, as opposed to erring on the side of protecting short-term monetary profits or annual timber cutting quotas. In other words, if you are not sure that an activity will protect, maintain, or restore ecosystem functioning, do not do it.

Principle #3: All plans and activities must include protection of forest functioning at all scales (time and space) and must define ecological limits of various forest ecosystem types to human disturbance.

Temporal scales refer to the need to make *forest plans* considering timeframes of 500 years and beyond, as opposed to logging development plans of 1 to 20 years. Spatial scales refer to the need to define forest landscapes as, at a minimum, small watersheds of 200 hectares (500 acres) and larger. An ecosystem-based approach requires the development of forest landscape level plans for as large a landscape as is practical, given political and ownership constraints.

"Ecological limits" are physical and biological factors which indicate that various human uses may result in unacceptable levels of modification or degradation of forest ecosystem functioning. Common ecological limits include:

- **shallow soils** (less than 30 cm/12 inches deep)
- **very dry** or **very wet sites**
- **very steep slopes** (greater than 60% slope gradient)
- **broken slopes** (abrupt slope gradient changes occur regularly across a small landscape)

- **very dry climates** (less than 25 cm/10 inches of precipitation annually)
- **cold soils** that limit biological activity, particularly soil nutrient cycling
- **snow-dominated forests** characterized by open, canopied forest stands (i.e. park land forest ecosystems)
- **riparian ecosystems**, the wet forests adjacent to and the forests immediately upslope from creeks, rivers, ponds, lakes, and wetlands.

Forest ecosystem types are relatively homogeneous forest areas delineated by their biological and physical characteristics, and by their ecological limits or lack of ecological limits. Stands or patches frequently contain several ecosystem types.

Describing a forest ecosystem type as having an ecological limit to human activities does not mean that such an ecosystem type will not grow trees following a human-induced disturbance such as logging. However, the existence of an ecological limit means that sustainable timber crops that have economically viable timber volumes and timber quality cannot be grown in reasonable periods of time. As well, both physical and biological problems, like landslides and poor regeneration of trees, result if ecological limits are not respected. If forest users attempt to ignore ecological limits, unacceptable levels of forest degradation will occur in both the short and long terms.

Principle #4: All plans and activities must protect, maintain, and, where necessary, restore biological diversity (i.e. genetic, species, and community diversity).

Maintenance and, where necessary, restoration of all types of biological diversity is necessary to sustain life as we know it in forest ecosystems. Maintaining genetic diversity means ensuring that viable natural gene pools, including the gene pools of trees logged from a site, remain on the site or, in the case of previously degraded forests, are restored (as much as possible) to the site following human use. Maintaining species diversity means that viable natural populations of plants, animals, and microorganisms must be maintained or restored, in previously degraded areas, throughout the various successional phases for each ecosystem type within a forest landscape. Maintaining community diversity means maintaining or restoring, in previously degraded areas, the variety of forest ecosystem types that result from natural disturbances at a variety of scales through short and long timeframes in a forest landscape. Protecting biological diversity must not be viewed as a frill or luxury. Instead, an ecosystem-based approach recognizes that maintaining natural biological diversity is an absolute requirement to ensure maintaining fully functioning forests through time, and thereby sustaining human cultures and economies.

Principle #5: Respect and maintain natural disturbance regimes through time and space in order to protect, maintain, and, where necessary, restore forest landscape patterns.

Natural disturbances, from the death of individual trees to large fires or windstorms, are responsible for critical composition, structures, and ecosystem functioning necessary to maintain fully functioning forests. For example, the death of an individual tree sets off a process of change: it begins with a standing snag that provides habitat for cavity-nesting birds and ends with a fully decayed fallen tree that serves as Mother Nature's water storage and filtration system. At a landscape level, natural disturbances, large and small, are responsible for diversifying habitat patterns and, therefore, maintaining a natural diversity of plants and animals. Natural disturbance regimes are also critical to the maintenance of soil nutrient cycling and adequate levels of soil nutrients. Protecting, maintaining, and, where necessary, restoring natural disturbance regimes provides for natural composition, structures, and functioning at the forest landscape level.

Principle #6: Protect, maintain, and, where necessary, restore composition, structures, and functions at the patch or stand level in all plans and activities.

Composition refers to the parts of a natural, healthy forest ecosystem, including the topography, soil, water, plants, animals, and microorganisms. **Structures** are the arrangements of the parts in a forest ecosystem, including large old trees, large snags (i.e. standing dead trees), and large fallen trees. Forest **functioning** refers to how a forest works at a full range of scales over long timeframes. Natural composition and structures must be maintained in order to maintain fully functioning forests. Many compositions, structures, and functions are beneath the surface of the ground, within the soil where human beings cannot see while planning and carrying out forest use. When implementing an ecosystem-based approach, we hope that by maintaining the forest composition, structures, and functions that we can see, we will also maintain the composition, structures, and functions that we cannot see.

Principle #7: Protect, maintain, and, where necessary, restore forest ecosystem connectivity at all scales during planning and carrying out ecologically responsible forest use.

Connectivity in forest ecosystems is maintained, in large part, by ensuring the protection of water movement patterns. This includes microscopic water movement patterns in the forest soil and in riparian ecosystems, from ephemeral streams and small wetlands to large river systems and wetland complexes. Connectivity is also maintained in forest ecosystems by protecting and, where necessary, restoring the full range of composition and structures from the large landscape level to the smallest stand or patch.

Principle #8: Recognize that the concept of landscape is relative to the forest organism or process under consideration.

Different forest organisms or forest processes operate at vastly different scales. What is a landscape to a salamander is only a small patch or small stand to a bear. Similarly, the landscape that results from a single tree falling over due to root decay and wind is much smaller than the landscape patterns created by a large fire. A forest landscape can exist at virtually any scale, depending on the organism or forest process that is used as the point of reference. Thus, applying the concept of a forest landscape, as much as possible, to all scales—from large landscape to small stand or patch level plans—is important to ensuring the maintenance and/or restoration of fully functioning forests.

Principle #9: Plan and carry out diverse, balanced activities to encourage ecological, social, and economic well-being.

In planning for a diversity of human activities in a forest landscape or forest stand, we can use as a model the natural diversity that occurs in forest composition, structures, and functioning, from the smallest forest patch to the largest forest landscape. Diversity in forest composition, structures, and functioning maintains the integrity and resilience of forests. Diversity provides for both flexibility and stability in forest ecosystem functioning. Large natural disturbances, such as fire and insect attacks, that can dramatically alter the forest are simply processes of maintaining and restoring natural diversity, and, therefore, healthy functioning in the forest.

Because natural forests depend upon diversity, a diversity of ecologically responsible human activities is most likely to maintain natural forest diversity, and, therefore, to maintain fully functioning forests. At the same time, diverse human activities best meet the needs of all interests in human society, and provide for the most stable, sustainable human economies.

Diverse forest uses also need to be *balanced* in ways that establish equitable, protected land bases for all forest users, both human and non-human. This goal is accomplished by defining ecologically responsible forest use zones within the forest landscape.

Currently, in most forests around the world, the most aggressive and consumptive forest uses are expanding, namely logging and the manufacture of a few wood products such as pulp and 2x4s. Continuing this growth of consumption is not sustainable, either biologically or economically. Ecologically responsible timber management does not intend to continue the same level of cutting as that practiced by conventional timber management. Instead, ecologically responsible timber management requires the reduction of timber cutting levels, and, therefore, a reduction in the overall use of wood. A high priority is placed upon developing and marketing recycled wood products, including paper, 2x4's, siding, paneling, windows, and doors. Reducing consumption and recycling all wood products is a first priority in ecologically responsible forest use.

As well as ensuring that timber cutting and the manufacture of wood products stays within ecological limits, an ecosystem-based approach will also limit the number and scale of such activities as tourism and ranching within forest landscapes in order to maintain fully functioning forests.

Principle #10: Evaluate the success of all forest use activities at meeting the requirements of ecological responsibility.

Important questions to ask during an evaluation include:

- Are natural landscape patterns maintained or restored?
- Are natural stand or patch composition and structures maintained or restored?
- Are water quality, quantity, and timing of flow, at all scales, unaltered from the standpoint of protecting forest functioning?
- Are soil structures and soil processes unaltered from the standpoint of protecting forest functioning?
- Have natural disturbance regimes, from the landscape to the stand or patch level, been protected and/or restored?
- Do all ecologically responsible forest users, both human and non-human, have a fair and protected landbase?

Evaluation—asking how we did—is an absolutely essential part of an ecosystem-based approach. By evaluating our plans and activities, we learn and are able to improve our relationship with forests and with each other. The questions posed above are inclusive of all aspects of forest functioning as it relates to a variety of human uses.

2.8 Scientific Rationale

An ecosystem-based approach relies on scientific concepts developed by leading-edge researchers and practitioners. Forest ecology, conservation biology, landscape ecology, and ecological economics have been synthesized in designing the methodology and products of the Slocan Valley ecosystem-based landscape plan. Some of the scientific concepts underlining an ecosystem-based approach are summarized below.

2.8.1 Scientific Panel for Clayoquot Sound

The Silva Forest Foundation's ecosystem-based approach is consistent with the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (1994) definition of sustainable ecosystem management:

> The Panel believes that forests should be managed as ecosystems, rather than as potential products, and that forest practices should not put at risk the long-term health of forest ecosystems. Sustainable ecosystem management is characterized by resource management practices that are scientifically based, ecologically sound, and socially responsible...
>
> The goal of sustainable ecosystem management is to maintain the integrity of ecosystems. Achieving this goal requires maintaining ecosystem components and ecological processes that enable the land, water, and air to sustain life, be productive, and adapt to change.
>
> The objectives of sustainable ecosystem management include: maintaining soil formation, stability, and productivity; maintaining water quality, flow, and channel integrity; and maintaining biodiversity. Failure to maintain these processes and states may lead to failure to sustain a flow of products from the forest and failure to protect cultural, scenic, recreation, and tourism values.

> Human needs are one of many considerations in designing management activities. The needs of current generations should not supersede the needs of future ones. The protection of ecosystem components and maintenance of ecosystem processes and productivity must take precedence over all other management objectives.
>
> In the long term, managing forests as ecosystems is the best way to secure a supply of timber and other products from the forest, and to sustain British Columbia's multitude of other forest values.

The Scientific Panel notes that at each level of planning, sustaining ecosystem productivity and biodiversity must take precedence over specific product outputs. Levels of resource extraction must be determined within the limits prescribed by ecosystems.

One of the primary goals of SFF's ecosystem-based approach is to protect biodiversity. The Scientific Panel states: "Conserving biodiversity is a prerequisite to sustaining ecosystem integrity, which depends on interactions among a broad range of the ecosystem's component species, both known and unknown." The Panel stresses the need to establish a system of protected areas as well as sustainable ecosystem management outside protected areas. Thus, one of the goals recommended by the Panel is "to maintain the functional integrity of ecosystems, recognizing the connections between terrestrial, freshwater, and marine ecosystems."

2.8.2 Landscape Ecology and Conservation Biology

An ecosystem-based approach represents the practical application of the concepts and findings in the sciences of landscape ecology and conservation biology. Landscape ecology is concerned with the connections and interactions between forest stands across the landscape, and with the effects of both natural and human disturbances on the landscape. The scientific discipline of landscape ecology originated as an attempt to integrate the spatial concerns of geography with the time and scale concerns of ecology. The following important principles of landscape ecology are incorporated in the Silva Forest Foundation's methodology for the ecosystem-based landscape plan for the Slocan River watershed:

<u>Time and Space</u>: Forest ecosystems are connected in time and space across the landscape. Risser (1987) summarized the interrelation of time and space over the landscape:

> Thus, the landscape is heterogeneous, that is, consists of dissimilar or diverse components or elements. In addition to the rather obvious spatial heterogeneity, the landscape is temporally heterogeneous. Ecological processes operate at different time scales. For example, forest trees have life spans of decades, annual crops grow for less than a year, and individual stream insects may last only a few days. It is this mixture of processes consisting of different spatial and temporal scales, all operating as a system, that leads to ideas of landscape ecology.

<u>Heterogeneity</u>: Landscape heterogeneity, or diversity, is essential to forest landscapes. Diversity contributes to redundancy, or the ability of ecosystems to perform important functions in more than one way. For example, after disturbance on a forest site, mycorrhizae essential to the nutrient needs of young conifers can persist in the decaying wood of fallen trees, or through association with surviving conifers, or by colonizing compatible successional plant species. This type of redundancy, maintained by landscape

diversity, is a vital function which allows ecosystems to survive stress (Bormann 1987, Franklin et al 1989) and helps organisms survive through catastrophic disturbances over time (Perry et al 1989, Amaranthus et al 1989).

Extreme diversity can result in negative effects if habitat areas become too small to be effective. As with many aspects of forest functioning, a balance is required between heterogeneity and homogeneity.

<u>Connectivity</u>: Within a forest landscape, connectivity is provided by movement corridors, which are frequently riparian ecosystems (see Principle 3 above). Riparian ecosystems serve as movement corridors for many species of plants and animals, as well as for nutrients and energy. Riparian ecosystems are connected from valley to valley by treed forest corridors (i.e. cross valley corridors) which run up and down forest slopes. Groundwater is another landscape connector that transports nutrients and energy both within forest patches and throughout the forest landscape. Riparian ecosystems, cross valley corridors, and groundwater provide connectivity in space. The importance of these connections within forested ecosystems has been articulated by Noss (1991). Connectivity in time is represented by the various stages that a forest goes through. From the shrub/herb phase through the young and mature forest phases to old growth, each stage plays an important role in maintaining a healthy and diverse forest landscape.

Human or natural impacts that reduce or break natural landscape connectors will have direct impacts on animal, plant, energy, nutrient, and water movements (Forman 1987, Forman and Godron 1983, Noss 1987).

Conservation biology has been defined by Grumbine (1992):

> Conservation biology is the science that studies biodiversity and the dynamics of extinction. Much of this work focuses on how genes, species, ecosystems, and landscapes interact, and how human activities affect changes in ecosystem components, patterns, and processes... Conservation biologists consider the entire biodiversity hierarchy at diverse scales of space and time...

Maintaining natural forest diversity is a primary goal of ecosystem-based planning. Both landscape ecology and conservation biology study ecosystem interconnections and propose management that maintains the biodiversity within ecosystems. Numerous scientists have stressed the need to maintain the natural diversity of the forest landscape when implementing management activities (Amaranthus et al 1989, Bormann 1987, Franklin et al 1989, Harris 1984, Marcot et al 1989, Maser 1988, Perry 1988, Perry et al 1989, Schowalter 1989, Wilcove 1988).

2.8.3 Silviculture Systems

Ecologically responsible timber management differs significantly from conventional practices. In his book, *Forest Ecology*, Dave Perry defines the goals of ecologically responsible silviculture systems:

> To maintain biological diversity (and along with it the health and integrity of entire ecosystems), silviculture must do two things: (a) protect species and habitats that have no market value, and (b) mimic (to the degree possible) natural

> disturbance and successional patterns at the scale of both stands and landscapes. Intensive forest management does rather poorly on both scores. A more ecologically based management will focus on what it leaves behind rather than on what it takes. Biological legacies will be protected and habitat imbalances redressed by restoring forested landscapes to a higher proportion of old growth. Early and mid-successional communities will exist as islands within an old-growth matrix rather than vice versa, producing the shifting mosaic that characterized many natural forest landscapes. Silvicultural techniques for achieving this include partial harvesting, density management, and long rotations. Ultimately, a sustainable future will only be achieved by considering the Earth and all of its inhabitants as an integrated, interdependent whole.

2.8.4 Ecological Economics

The principles of an ecosystem-based economic analysis are based on the approaches of ecological economists. Ecological economics is a transdisciplinary field of study that addresses the relationships between ecosystems and economic systems in the broadest sense, attempting to integrate and synthesize many different disciplinary perspectives (Costanza et al 1991). Ecological economics points out the need to protect the integrity of ecological systems (Norton 1991). The connections between ecosystems and economics is summarized by Costanza (1991):

> Ecological systems play a fundamental role in supporting life on earth at all hierarchical scales. They form the life-support system without which economic activity would be impossible. They are essential in global material cycles like the carbon and water cycles. They provide raw materials, food, water, recreational opportunities, and microclimate control for the entire human population. In the long run, a healthy economy can only exist in symbiosis with a healthy ecology.

Ecological economics also recognizes the need to assign value to ecological goods and services (Costanza 1991) so that humans do not consider these to be “free.” Thomas Power (1988) has studied the non-commercial qualities that contribute to a healthy economy. In examining what makes a local or community economy healthy and stable, Power discovered that people valued the quality of life in an area and would accept lower wages and a certain level of reduced services if their quality of life needs were met.

2.8.5 Ecosystem-based Approach: the Foundation for Sustainability

As noted above, an ecosystem-based approach is supported by such formerly divergent disciplines as ecology and economics. Leading thinkers in ecological economics, conservation biology, landscape ecology, and forest ecology are all telling us that maintaining fully functioning ecosystems at all scales must be our priority if we are to develop and sustain human cultures and the economies that make up human cultures. The Slocan Valley ecosystem-based landscape plan puts this knowledge and principles into a practical, realistic context. The results challenge all of us, but we must determine how to implement this type of plan if we are to ensure a healthy Earth and provide options for future generations.

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