The Silva Forest Foundation

The Forest Sustains Us, We Do Not Sustain the Forest

Initial Report on the Raush River Watershed Forest Analysis

prepared by

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Initial Report on the Raush River Watershed Forest Analysis

1. INTRODUCTION

This report describes the preliminary ecosystem-based analysis of the Raush River Watershed, located in the Robson Valley, British Columbia. The analysis was prepared by the Silva Forest Foundation for the Dunster Community Association, and includes a set of four 1:50,000 thematic maps of the Raush River Watershed. This report provides background information on the concepts, the data sources, the methods, and the interpretations used to produce the thematic maps.

The maps and the information in this report represent the first stage in developing an ecosystem-based plan for the Robson Valley. Although the Dunster Community Association (DCA) and the Silva Forest Foundation (SFF) contributed generous funding, resources were limited. This preliminary ecosystem-based analysis of the Raush River Watershed is intended to facilitate discussion among local residents, and to provide an example of how ecosystem-based analysis and planning can be applied to the entire Robson Valley.

In short, this report and the accompanying maps can be seen as a demonstration project. In the time available, SFF staff have focused their efforts on gathering biophysical information, analyzing the information, and preparing thematic maps of:

- old growth and logged areas;
- ecological sensitivity to disturbance;
- landbase unsuitable for development; and,
- a protected landscape network.

With additional time and resources, the SFF could prepare a complete ecosystem-based plan. This would require community commitment and participation, further field study, additional landscape and stand level analysis, thorough economic assessment, and operational planning. The result would be a more detailed plan to direct current activities in the watershed, and a more comprehensive set of recommendations to guide future use of the watershed and the surrounding Robson Valley landscape.

The SFF believes the ecosystem-based planning framework is a viable and practical alternative to existing approaches. Current land and resource planning practices in British Columbia typically focus either on maximizing the flow of a single output such as wood fiber, or on maximizing a mix of outputs and uses. In either case, the emphasis is on short term financial reward. In contrast, an ecosystem-based approach focuses first on protecting and maintaining ecosystem functioning, and secondly, on identifying where and when a diverse range human activities and uses can occur within those ecological constraints. This approach is based on the understanding that exploitive use of land and water can have serious and long term negative ecological, economic, and social impacts.

The report is organized into five sections. Section 2 provides a brief biophysical description of the Raush River Watershed. Biogeoclimatic zones, disturbance history, and important ecological constraints are discussed.

Section 3 introduces the reader to the concepts and principles of ecosystem-based planning. The basic scientific theories underlying ecosystem-based analysis and the philosophy that guides ecosystem-based planning are reviewed.

Section 4 discusses the analytical methods used to produce the Raush River Watershed map set. This section begins with a general overview of the technical aspects of the ecosystem-based analysis. A more detailed description of the information sources, the procedures used to assemble and organize the information, and the interpretations and judgments used to analyze the information follow.

Section 5 briefly summarizes key findings and makes recommendations for further work.

2. RAUSH RIVER WATERSHED - A BRIEF ECOLOGICAL DESCRIPTION

2.1 Biophysical Characteristics

The Raush River Watershed (RRW) contains approximately 101,000 hectares of land, water, and ice located in the Robson Valley, British Columbia. The watershed is found within the Northern Columbia Mountains ecosection, which is an area of rugged, high relief mountains running south of the Rocky Mountain Trench.

The dominant feature of the RRW landscape is steep, mountainous terrain. The main valley and its tributaries are characterized by narrow, flat valley bottoms which change abruptly to extremely steep, broken side walls. Slopes often exceed 60 percent. The steep slope gradients occur either in short pitches that repeat themselves across local topography (*i.e.* broken or strongly complex terrain), or in continuous slopes that cover much of the valley wall. Upper slopes and benches are characterized by steep, eroded bedrock, snowfields, and glaciers. Streams in the watershed are mostly high gradient.

The climate of the RRW is characterized by strong, seasonal temperature variations and severe winters. The area lies within the "interior wet belt" and annual precipitation is approximately 800 mm, with annual snowfall ranging from 250 mm in exposed portions of the valley bottom to 1500+ mm in upper elevations. Frost free days vary from about 125 in the valley bottom to approximately 70 or less in the alpine. Cold air drains down slopes and stream valleys, effectively reducing the growing season in lower elevations.

Soils in the area are highly variable due to the broken, steep topography, and narrow, rapidly eroding valley walls. In general, soils on the mid and upper slopes develop from nutrient poor sedimentary and metamorphosed sedimentary colluvium and bedrock. In valley bottoms and lower slope receiving sites, glacial and fluvial sediments, water, and nutrients collect to form soil ecosystems that are relatively rich by comparison.

The narrow valleys, steep valley walls, and exposed high elevation tundra of the RRW landscape result in a wide diversity of habitat for plants and animals. The area can be characterized as an ecological transition zone, and mixed tree forests are found on many combinations of elevation and aspect. Upper elevation forests are dominated by Engelmann spruce and subalpine fir. Douglas-fir and lodgepole pine grow in the middle and lower elevations on drier aspects and wetter slopes contain western hemlock and western red cedar. White spruce, western red cedar, Douglas-fir, black cottonwood, and paper birch are common on valley bottoms.

2.2 Ministry of Forest Ecological Classification

The Ministry of Forests (MoF) Ecological Classification System recognizes four biogeoclimatic zones within the Raush River Watershed:

- *Alpine Tundra (AT):* The rugged terrain and harsh winter climate of the RRW is reflected in the fact that almost 50% of the RRW is classified as alpine tundra. This zone is characterized by eroding rock outcrops, glaciers, and snowfields. The tundra landscape, although barren relative to lower elevations in the watershed, provides habitat for many unique plants and animals.

- *Engelmann Spruce-Subalpine Fir (ESSF):* This zone occurs on mid and upper slopes where temperatures are cooler and soils derive mostly from colluvial material. Subalpine fir and Englemann spruce are the dominant tree species. Clumped subalpine fir grows in alpine parkland in the snow dominated upper elevations.
- *Interior Cedar-Hemlock (ICH):* The ICH zone occurs on lower slopes and valley bottoms. The dominant tree species are western red cedar and western hemlock, with Douglas-fir, lodgepole pine, and trembling aspen occurring in seral stands.
- *Sub-Boreal Spruce (SBS):* This zone occurs in valley bottoms with soils composed of fine textured glaciolacustrine and fluvial sediments. The forest in this zone is dominated by western white spruce with mixture of Douglas-fir, western hemlock, lodgepole pine, and western red cedar depending on local site conditions.

2.3 Past Disturbance and Current Ecosystem Characteristics

Much of the forest cover below the point at which Kiwa Creek access road enters the watershed is a product of human disturbance. Extensive fires from early mining, railway construction, and associated settlement activities spread into the northern portion of the RRW. As a result, only remnants of late successional or old growth forest are present in the lower portions of the watershed. Most forest cover consists of younger mixed-species seral stands that continue to be impacted by recent logging and other human disturbance. Mature and old growth hemlock-cedar and subalpine fir-Engelmann spruce forests are found only on mid and upper slopes.

The RRW above the Kiwa Creek road access is relatively untouched by human disturbance. Later seral and old growth stands characteristic of the three main biogeoclimatic zones are better represented throughout the upper watershed, particularly on north facing slopes on the west side. On slopes on the east side, a high incidence of lightning induced small wildfire has created a fine-grained mosaic of younger seral stands on low and mid slopes. Due to frequent avalanche disturbance, a distinctive pattern of younger seral forests also occurs on many mid and higher slopes throughout the upper watershed.

2.4 Ecological Constraints

Biophysical characteristics that inhibit development in the RRW are a result of the shape of the terrain, the slope gradient, the soil depth and texture, the amount of moisture available, the landscape characteristics, and the history of disturbance. An ecosystem-based approach to planning requires that these characteristics be respected, and that human activities be designed to prevent damage to areas where these characteristics, or combinations of these characteristics, result in sensitive ecosystem functioning. Key ecological characteristics that inhibit development in the RRW include:

- **Steep Slopes:** With the exception of the RRW valley floor, most of the topography in the watershed is characterized by steep, often broken slopes. Soil stability on these slopes is largely dependent on tree and associated vegetative cover. Removing that cover will eliminate the root structures, the protective canopy, and the evaporative processes that work to stabilize these slopes.

- **High Elevation Forests:** Forests above 1200 m are extremely sensitive to disturbance due to low biological recover rates, the result of cold climates, deep snowpacks, cold soils, and slow nutrient cycling. Much of the soil activity in these forests occurs in the upper 5 cm of soil. This active layer is easily degraded by any kind of logging activity, and the cold conditions result in long site recovery and regeneration times.
- **Broken Topography:** Due to the steep, broken topography, localized highly sensitive sites occur throughout the RRW. These sites may contain high water tables, springs and seeps, shallow soils, or very dry moisture conditions. These sensitive sites tend to appear relatively stable when tree or vegetative cover is present; however, field inspection typically reveals perched roots, soil creep, snow press, or other indicators of site sensitivity.
- **Fire Disturbance:** As described above, much of the forest cover in the lower RRW is the product of relatively recent human disturbance. Fires set during railway construction, mining and settlement in the surrounding Robson Valley at the turn of the century spread into the lower watershed, eliminating much of the natural forest landscape pattern. Recent logging activity continues to alter the forest landscape in the lower RRW. Restoration, rather than development, should be the focus in this part of the RRW.

3. ECOSYSTEM-BASED PLANNING: CONCEPTS AND PRINCIPLES

3.1 Ecosystem-based Planning: An Introduction and Overview

The SFF and a growing number of environmental managers, ecologists, and economists worldwide believe that if human cultures and economies are to be sustained, then people must try to protect and sustain the health and integrity of the ecosystems that support those cultures and economies. An ecosystem-based plan is an important aspect of reaching this objective.

An ecosystem-based approach to analysis and planning tries to understanding and protect forest functioning at all scales through time as the first priority, and then seeks to sustain, within those ecological constraints, a diversity of human activities and uses. Ecosystem-based planning does not start with a target for production like cubic meters of timber, recreation visitor days, or animal grazing units. Instead, ecosystem-based planning begins by assessing the landscape, stand, and site level ecology of the planning area. This initial ***forest analysis*** stage focuses on identifying what parts of the forest ecosystem to need to be left to maintain fully functioning forests, rather than on identifying what parts can be taken.

Only when the important ecosystem parts have been protected is emphasis is given to what can be taken or used. During this ***forest planning*** stage, human activities are designed that will not impair ecosystem functioning. Where extractive activities are considered appropriate, ecosystem-based planning means that harvesting activities are carried out in ways that protect, maintain, and (where necessary) restore a fully functioning forest ecosystem at all scales through time.

3.2 Forest Landscapes, Stands, and Sites

An ecosystem-based forest analysis begins at the landscape scale. This involves assessing and developing an understanding of the important characteristics of forest ecosystems ranging in size from watersheds of small to moderate drainage (less than 5,000 hectares to about 50,000 hectares), to river basins and regions encompassing hundreds of thousands of hectares.

At the landscape scale, forests are shifting mosaics of interconnected, interdependent ecological communities. Each forest landscape consists of a distinctive pattern of communities that develop and move in space and time. This pattern and process of change are a function of climate, topography, ecological succession, and natural disturbance. Forests in dry, relatively flat areas that experience large, intense fires, for example, typically develop a landscape mosaic consisting of relatively uniform, similar aged forest stands that contain old growth patches and remnants. Conversely, high elevation forests in mountainous terrain that experience small scale wind or snow damage disturbances typically develop a fine-grained forest mosaic consisting of small uneven aged patches.

Landscape pattern strongly influences how forests function at the stand scale. Stands are homogeneous patches of forest with relatively uniform composition, structure, and functioning compared to adjacent patches. Forests in the dry interior of BC, for example, often contain a mosaic of young stands with a single canopy layer of similar aged lodgepole pine, interspersed with older, uneven-aged stands containing mature Douglas-fir. In contrast, forests in coastal regions have stands that contain several species and a range of tree ages. Forest use or management prescriptions can be applied evenly across all areas within these stands because they are uniform in relation to the surrounding mosaic of stands or patches.

Different forest landscapes and stands have characteristic ecological composition and structure; nevertheless, site conditions and function can vary widely. Soils underlying different trees, shrubs, and herbs in the same stand, for example, typically have quite different textures, moisture content, and nutrient concentrations. Similarly, different canopy structures allow varying levels and intensities of light to pass through, resulting in different site-specific understory shrub and herb communities.

The condition of a forest describes how human and natural disturbances have modified forest functioning from the landscape scale to the stand and site scale. Conventional timber management frequently has negative impacts at all scales, including: landscape fragmentation; loss of old growth characteristics; simplified stand composition and structure; site soil degradation; and altered water flows. An ecosystem-based approach seeks to protect forest composition, structure, and functioning at all scales, and respects the ecological sensitivity of different forest ecosystems to various human uses. By understanding and respecting ecological sensitivity, an ecosystem-based approach strives to avoid degradation of short and long term forest functioning.

3.3 Concepts in Ecosystem-based Planning

An ecosystem-based approach applies the theory and concepts of landscape ecology and conservation biology to the practice of forest analysis and planning. The science of landscape ecology examines the connections, relationships, and changes that occur across the landscape. The focus is on understanding the interaction between natural and human disturbances and the ongoing dynamics of ecological succession and change. Conservation biology, on the other hand, studies the diversity and dynamics of plant and animal individuals, populations, and communities. Research in this field centers on how different plant and animal populations interact, grow, and decline, and on how natural processes and human activities affect changes in those interactions and dynamics.

3.3.1 Forest Fragmentation

All ecosystem-based plans must deal with the impacts of past disturbance, natural and human, in the landscape. In many forested landscapes, logging, mining, and other activities typically leave a legacy of spatial fragmentation. Clearcutting, roadbuilding, and vegetation clearing for various human purposes break necessary ecological pathways, connections, and landscape patterns. The movement of plants, animals, water, nutrients, and energy is interrupted or blocked by this spatial fragmentation. Healthy landscapes require a connected mosaic of forest patches and natural successional patterns.

Conventional timber management also results in temporal fragmentation because it alters natural disturbance patterns and shortens or interrupts important successional sequences. Short rotation timber harvesting, for example, typically reduces the stand initiating phase and eliminates the old growth successional phase. The result is long term nutrient impoverishment because the stand initiating and the old growth phases are the most important nutrient input phases in the forest successional pattern. Eliminating mature and late successional phases can also remove vital animal habitat, damage aquatic ecosystems by altering groundwater and stream flow, and cause an overall reduction in ecological productivity.

3.3.2 Protected Landscape Network

Forest landscapes contain a range of ecosystem types and a successional pattern through time that are tied to natural disturbance regimes. The dynamic between succession and disturbance produces characteristic water, nutrient, and energy flows, as well as a variety of habitats that support a diverse range of plants and animals. Extensive modification of these landscapes, by altering natural flows, changing disturbance regimes, and eliminating habitat, results in degradation and loss of ecological integrity.

Scientists and planners now recognize the need to maintain, protect, and/or, where necessary, restore a connected mosaic or network of ecosystems throughout the landscape to ensure ecological functioning at all scales, from the small patch or stand to the large landscape. This network provides the landscape scale diversity within which natural ecosystem functioning remains essentially intact and undisturbed by all but the softest of human interventions.

3.3.3 Ecological Sensitivity

The pattern of the landscape, the history of disturbance, the local climate, the shape of the terrain, the slope gradient, the soil depth, the soil texture, and the amount of moisture available are key determinants of ecosystem characteristics. Conventional forestry, which emphasizes maintaining a constant flow of material outputs and uses, often ignores many of these important characteristics. Disturbance and change are required in ecosystems, but disturbance and change that is different from, or in excess of, the natural range of disturbance inevitably results in damage to the ecosystem, not change in the ecosystem. The outcome is reduced productivity, degraded forest soil, altered hydrological flows, lost wildlife habitat--in short, long term loss of ecosystem functioning.

Many forest landscapes, stands, and sites have characteristics that are easily damaged or degraded if modified by human uses. These landscapes, stands and sites are ***sensitive to disturbance.*** Certain animal species, for example, are sensitive to timber harvesting disturbance because they have specific habitat requirements that can only be provided by a particular mosaic of forest stands across the landscape. Similarly, forest soil communities on steep, wet slopes are sensitive to harvesting disturbance because they are likely to slump or slide, resulting in soil erosion and stream siltation. Forests growing on cold soils are also sensitive because nutrient cycling only occurs in the shallow organic layers that are easily damaged by many types of human activity.

3.4 Key Themes in Ecosystem-based Analysis

The following important themes drawn from landscape ecology and conservation biology are incorporated in the SFF's methodology for the Raush River Watershed ecosystem-based analysis:

- *Forest ecosystems are connected in time and space*

  Forest ecosystems are connected in time and space across the landscape. Within a natural forest landscape, connectivity is provided by linked patches, unbroken forest cover, and riparian ecosystems that serve as movement pathways for many species of plants and animals, as well as for nutrients and energy. For example, riparian ecosystems in different watersheds are connected by treed forests which traverse valley slopes. Flowing stream and groundwater is another landscape connector that transports nutrients and energy.

  While riparian ecosystems, forested slopes, and flowing water provide connectivity in space, the various phases that forests cycle through provide connectivity in time. Each phase, from the stand initiation phase and the stem exclusion phase, through the transition and shifting gap old growth phase, plays an important role in maintaining healthy and diverse forest landscapes. Human disturbances that interrupt natural ecological phases and cycles will have direct impacts on animal, plant, energy, nutrient, and water movements, and on the processes of death, renewal, and growth that contribute to healthy ecosystem functioning.

- *Forest ecosystems are heterogeneous*

  Landscape, stand, species, and genetic heterogeneity, or ecological diversity, is an essential characteristic of healthy forests. Diversity contributes to ecological resilience, or the ability of forest ecosystems to recover from disturbance by performing important functions in more than one way. Mycorrhizae essential to the nutrient needs of young conifers, for example, can persist after disturbance in the decaying wood of fallen trees, or through association with surviving conifers, or by colonizing compatible successional plant species. This type of functional redundancy, maintained by ecological diversity, is a vital part of healthy ecosystems. Resilience allows ecosystems to recover from disturbance over time.

- *Forest ecosystems are dynamic, not static*

  A forest ecosystem is not static and unchanging. Forest communities change and develop, and disturbances constantly modify the dynamics and cycles of forest succession. However, unlike the disturbances caused by clearcut logging, tree planting and other forms of conventional management, natural disturbances serve to maintain forest functioning by providing biological legacies such as snags and fallen trees that connect one forest successional phase to another. In a natural forest, the most common disturbance is the death of an individual tree or small groups of trees.

- *Knowledge about complex forest ecosystems is always uncertain*

  Past forestry research provides a rich source of knowledge about growing commercially valuable trees under relatively short rotations. Much is known, for example, about the effects that changes in temperature or soil nutrient status will have on the growth dynamics of individual trees. The questions about forest ecosystem function raised by landscape ecologists and conservation biologists, however, have caught most forest scientists and managers by surprise. The inability of traditional foresters and forest scientists to provide answers to new questions about the effects of landscape fragmentation and loss of wildlife habitat, for instance, highlights the fact that much remains to be learned about the complex, long term impacts that timber harvesting, road building, and other activities have on the overall integrity and health of forest, riparian, and aquatic ecosystems. All too frequently, management plans and activities that fail to take this lack of knowledge into account have negative and unforeseen consequences.

3.5 The Guiding Principles of Ecosystem-Based Planning

Ecosystem-based analysis and planning involves assessing and trying to understand the landscape, stand, and site ecological characteristics and conditions of the planning area. Ecosystem-based planning is the process whereby that knowledge is applied to the design of human activities which protect, maintain and, where necessary, restore ecosystem composition, structure, and functioning. Ten principles, drawn from science and wisdom, guide an ecosystem-based approach to planning:

1. Use a precautionary approach in planning

A precautionary approach means that forest plans and activities must err on the side of caution. As noted above, many of the cumulative and long term effects that timber harvesting, roadbuilding, and other human activities have on biodiversity and ecosystem functioning are not yet fully understood. However, what is clear is that the long term costs of damaged ecosystem function will be far greater than the short term cost of forgone timber cutting, mining, and other extractive activities. A tree not cut today will still be available for cutting tomorrow; degraded soil, old growth forests, and extinct salmon runs are much more difficult, if not impossible, to restore or replace. Thus, in situations where the consequences of forest use are not known, it is best to adopt plans and pursue activities which minimize the chance of causing harm.

2. Focus on what to leave, not on what to take

An ecosystem-based approach to forest use takes a precautionary approach by trying to protect and maintain fully functioning forest ecosystems at all spatial scales through time. The purpose of planning from this vantage point is to identify the parts of the forest stand and landscape that must be protected to maintain short and long term ecological functioning. These decisions determine what human uses of the forest stands and landscapes are possible.

3. ***All plans and activities must try to protect forest ecosystem function by identifying the ecological sensitivity of various forest ecosystem types to human disturbance.***

Ecological ***resilience*** describes the ability of forest ecosystems to recover from disturbance. Landscapes, stands, and sites that have low resilience are ***sensitive*** to disturbance. Inappropriate human activities often have an impact on sensitive areas, resulting in impaired forest ecosystem functioning. Common ecologically sensitive areas 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 (terrain with abrupt slope gradient changes);
- very dry climates (less than 25 cm/10 inches of precipitation annually);
- cold soils with limited biological activity, particularly soil nutrient cycling;
- snow dominated forests characterized by open canopied, patchy stands; and,
- riparian ecosystems (the wet forests adjacent to streams, ponds, lakes, and wetlands).

Describing a forest ecosystem type as being ecologically sensitive to disturbance does not mean that trees will not grow following disturbances such as logging. However, physical and biological impacts, like landslides and poor regeneration, result if ecological sensitivities are not respected. If forest users continue to ignore ecological sensitivities, unacceptable levels of forest degradation will occur in both the short and long term.

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

Maintenance and, where necessary, restoration of all types of biological diversity is necessary to sustain forest ecosystem integrity. Maintaining genetic diversity means ensuring that viable natural gene pools 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 are retained by providing representative habitat throughout the various successional phases. Maintaining community diversity means retaining and/or restoring the variety of forest stands that naturally occur in a forest landscape. Maintaining regional diversity means retaining and/or restoring the variety of forest landscapes in both time and space, that occur naturally across very large areas.

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

Natural disturbances, from the death of individual trees to large fires or windstorms, are an important part of ecosystem functioning. Disturbances maintain and create the composition and structure necessary to maintain fully functioning forests. The death of an individual tree, for example, sets off a process that begins with a standing snag providing habitat for cavity-nesting birds and ends with a fully decayed fallen tree that stores and filters water. Across the landscape, natural disturbances, large and small, are responsible for creating diverse habitat patterns and, therefore, for maintaining a natural diversity of plants and animals. Natural disturbances are also critical to the development and maintenance of soil nutrient cycles. Protecting, maintaining, and, where necessary, restoring natural disturbance patterns provides for natural composition, structures, and functioning at all scales.

6. ***Protect, maintain, and, where necessary, restore composition, structure and functioning at the patch or stand level***

Composition refers to the parts of a natural, healthy forest ecosystem, including the topography, soil, water, plants, animals, and microorganisms. ***Structure*** is the arrangements of the parts in a forest ecosystem, including large old trees, large snags, and large fallen trees. Forest ***functioning*** refers to how a forest works at a full range of scales over varying timeframes. Natural composition and structure must be maintained in order to maintain fully functioning forests. Much forest composition, structure, and functioning is found beneath the soil surface. Maintaining the forest composition, structure, and functions that are visible helps to maintain the composition, structure, and functioning that are hidden from view.

7. ***Protect, maintain, and, where necessary, restore forest ecosystem connectivity at all scales.***

   Connectivity in forest ecosystems is maintained by ensuring the protection of pathways for water flow and plant and animal movement. This includes maintaining pathways ranging in size from the microscopic water movement patterns in the forest soil, to the long range migrations of large ungulates across large landscapes. Connectivity is also maintained in forest ecosystems by protecting and, where necessary, restoring the full range of composition and structure from the smallest site to the large patches in the landscape.

8. ***Recognize that ecological processes occur across a range of scales and times.***

   Different ecological processes operate at vastly different scales. The processes that occur after a single tree falls over due to root decay or wind are very different than the landscape scale processes the occur after a large intense fire. A forest landscape can be studied at virtually any scale, depending on the point of reference. However, thinking as much as possible in terms of forest landscapes is important in ensuring the maintenance, protection, and restoration of fully functioning forests.

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

   Because natural forests are diverse, a diversity of human activities is most likely 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 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.

10. Evaluate the success of all land use activities.

   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. Important questions to ask during an evaluation include:

   - Are natural landscape patterns maintained or restored?
   - Are natural stand or patch composition and structure maintained or restored?
   - Is water quality, quantity, and timing of flow maintained unaltered?
   - Have soil structures and soil processes been protected and maintained?

- Have natural disturbance regimes, from the landscape to the stand or patch level, been protected or restored?
- Do all forest users, both human and non-human, have a fair and protected landbase?

3.6 Human Needs—Human Impacts

Human needs (not to be confused with wants) are an important component of ecosystem-based planning. In other words, people are seen as an interdependent part of whole forest ecosystems. However, an ecosystem-based approach also recognizes that modern technology gives people the power to modify or degrade ecosystems, particularly sensitive ecosystems, in ways that are not comparable with other living organisms or natural processes.

Consider the impacts of clearcut logging. At the landscape scale, clearcutting interrupts, perforates, or fragments the natural forest mosaic. This alters natural flows of energy and nutrients, and creates barriers to the migration, dispersal, and long range movements of plants and animals. Similarly, at the stand or site scale, clearcutting modifies or degrades ecosystem functioning by removing biological legacies such as dead standing trees and fallen trees. In contrast, natural disturbances such as root decay, insect feeding, wind, and fire leave a rich legacy of these important characteristics. These provide a continuity of composition and structure which maintain forest functioning.

An ecosystem-based approach that protects ecosystem functioning is consistent with the development and maintenance of stable human communities and diverse, sustainable human economies. Where timber is part of an ecosystem-based plan, timber cutting, timber management 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 also critical to developing and maintaining ecologically responsible forest use.

However, 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 attempt to 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.

3.6.1 Planning for Human Use

Human forest uses such as timber extraction are considered in ecosystem-based planning, both in the design of a ***protected landscape network*** and in the delineation of areas which are sufficiently resilient to absorb the impact of timber extraction and still retain ecological health.

After defining the protected landscape network, ***human use zones*** are distributed in appropriate locations throughout the landscape. Each zone defines a priority use that dictates the terms of other human uses within that zone. Combinations of compatible uses such as tourism and wildcrafting are encouraged within particular zones. Consumptive human uses, like timber and mining, are generally limited to the stable and moderately stable portions of the landscape.

Some human uses may also be expected to occur in selected portions of the protected landscape network. Hiking trails, for example, may be designed and constructed in appropriate locations. Likewise, ecosystem-based timber cutting can occur on stable benches within ecologically sensitive areas and on the edges of riparian ecosystems. Generally, however, consumptive human activities are discouraged from components of the protected landscape network.

The SFF believes that forest use activities, whether timber cutting, commercial tourism, watershed protection, or wildcrafting, must be carried out to high standards. This simply means that any human activity within the RRW must ensure the protection and maintenance of fully functioning ecosystems at all scales through time. Human use zones identify the priority use and the conditions under which other uses may be carried out within a particular zone. Thus, commercial tourism zones may include ecologically responsible timber extraction. However, any timber extraction that occurs within these zones must, as a first priority, protect any and all aspects of the zone that are necessary for current and future tourism activities.

Human use zones commonly incorporated in an ecosystem-based plan include:

1. **First Nations Cultural Zones*:*** These zones are identified and planned for in consultation with individual First Nations groups.

2. **Commercial Tourism Zones*:*** The priority use for these zones is commercial tourism activities. Within these zones, the exact nature and extent of any timber management and other extractive activities must respect the needs of commercial tourism operators.

3. **Ecosystem-based Timber Zones*:*** Timber cutting can occur in areas of stable or moderately stable terrain. Where this stable and moderately stable terrain is road accessible, timber zones are usually logged using ground, skidding, or cable yarding systems. Where road access is not available, wholistic timber zones are designated as “heli”, indicating that any timber extraction in these area must be carried out with aerial logging systems.

   Ecosystem-based timber management uses partial cutting systems. Approximately 30% of site growth potential is permanently set aside in well distributed (spatially and by species) overstory trees during the first and subsequent harvests. The overstory trees are allowed to die naturally, thereby replacing important stand structures like large snags and large fallen trees. The structural and compositional legacy of large, old trees, snags and fallen trees maintains ecosystem functioning.

   To protect forest functioning at landscape and stand levels, annual allowable cuts (AACs) must be determined and implemented for each small watershed with the planning area. Without this approach, timber cutting activities may overcut each watershed, resulting in localized short and long term loss of ecosystem functioning.

4. **Wildcrafting Zones*:*** Gathering of edible plants, mushrooms, medicinal herbs, and other non-timber forest products often makes substantial contributions to local

economies. Care must be taken to set sustainable limits for extraction of these wildcraft forest products. Ecosystem-based partial cutting may be compatible with wildcrafting in many areas.

5. **Restoration Zones*:*** Existing clearcuts are classed as restoration zones. Restoration requirements in older clearcuts on stable terrain may be very limited, while restoration requirements in actively eroding logged areas in steep terrain may be very high. Restoration zones are subdivided into:
   - **Restoration/Protection:** following restoration, these areas are added to the protected landscape network.
   - **Restoration/Potential Timber Zones:** clearcuts on stable and moderately stable terrain that are in areas not needed for the protected landscape network can be harvested again once composition, structure, and functioning are restored.

   The need for forest restoration is a consequence of timber exploitation. However, employment from forest restoration activities can be an important short term part of local economic development strategies.

3.7 Summary of Ecosystem-based Planning

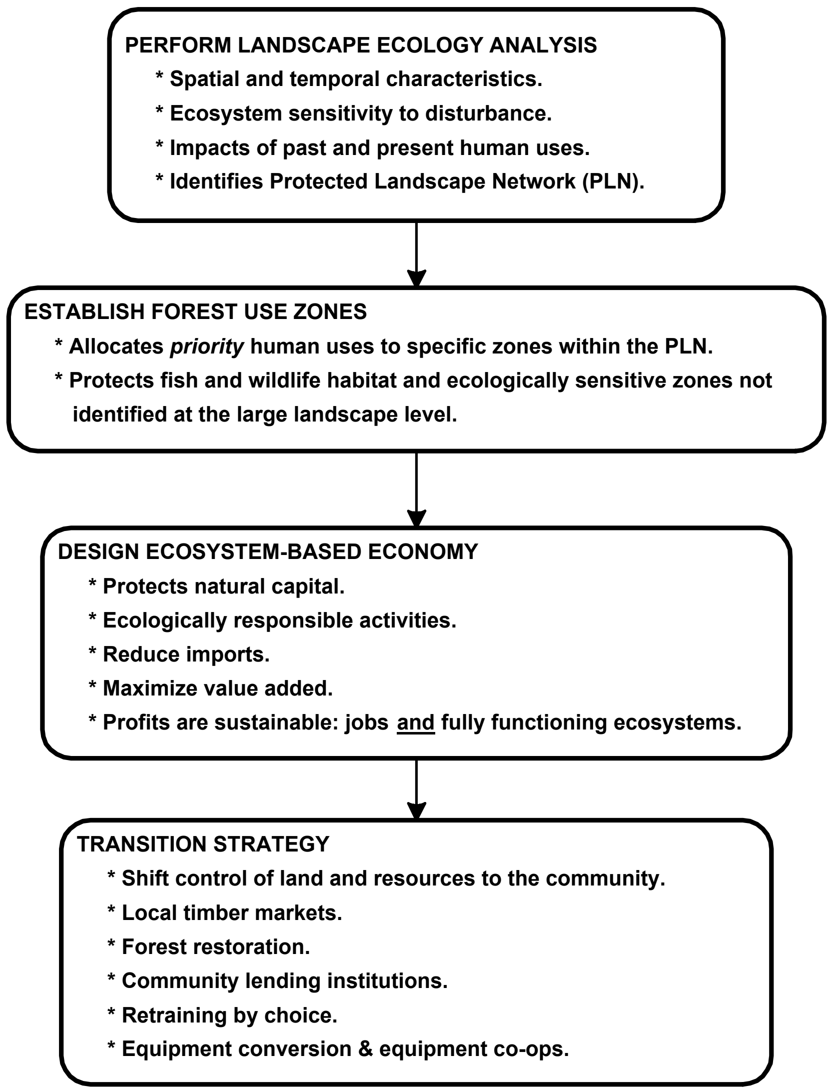
Ecosystem-based planning seeks to find a balance between the need to protect and maintain intact, healthy forest ecosystems, and the human need for forest products. This balance can only be achieved by focusing on what to leave behind in the forest to maintain ecosystem functioning, not on what to take to satisfy human wants. An ecosystem-based analysis and plan identifies areas which should be "left". These include:

- ecologically sensitive areas;
- riparian ecosystems;
- old growth patches or nodes;
- cross valley movement corridors;
- representative forest stands or patches; and,
- large protected areas

These areas form the protected landscape network. Ecosystem-based planning protects these areas from landscape, stand and site ecological degradation by providing a framework of ecological linkages and protected areas that will maintain landscape, stand and site composition, structure and functioning over time. The flow chart in Figure 1 summarizes the steps of a complete ecosystem-based plan.

Figure 1: Flow Chart of the Ecosystem-based Planning Process.

SEQUENCE OF ECOSYSTEM BASED PLANNING



The decision making process for this entire sequence is a community based consensus.
All decisions are based on:

PRIORITY ONE: All uses are ecologically responsible, requiring the protection of biological diversity at all scales, and,

PRIORITY TWO: Human and non-human uses are balanced across the landscape.

4. METHODS AND RESULTS

This section contains two parts. The first part provides a general overview of the information sources and methods used to produce the RRW thematic map set, including: air photos and map interpretation, field and aerial ground truthing, and geographic information system (GIS) analysis. The second part discusses the specific methods and decisions SFF staff used to produce the data overlays in each map. Summary tables and graphs, and a brief discussion of the results for each map are included.

4.1 General Methodology

This ecosystem-based analysis relies on a combination of: (1) air photo and map interpretation; (2) "ground truthing" and adjustment of the initial interpretation through field study and aerial assessment; and (3) GIS analysis of BC Ministry of Forests (MoF) forest cover data files and digitized SFF data.

4.1.1 Air photo and map interpretation

SFF staff developed an initial assessment of general landscape, stand, and site characteristics in the RRW from topographic maps, TRIM (Terrain and Resource Information Maps) maps, MoF forest cover maps, and 1:70000 air photos of the area. The assessment began with the identification and delineation of watershed boundaries, streams and wetlands, forest cover types, non-forest lands, and other key land categories. The subsequent assessment of landscape condition and the designation of ESD (ecological sensitivity to disturbance) types within the RRW involved careful analysis of MoF forest cover information and air photo interpretations. Slope estimates were verified with TRIM maps .

4.1.2 Field Truthing and Interpretation Revision

SFF staff and a crew from the Robson Valley including Roy Howard, Chantal Midgley, Cam Swets, Mark Aubrey, and Andy Jones, conducted field work in late August and September, 1996. The goal of the field work was to confirm air photo interpretations and to accurately determine the characteristics of areas that were difficult to classify during photo interpretation. Field work involved traverse sampling to note site, soil, and moisture conditions, to assess stand composition and structure, and to measure stand height and age. SFF staff also flew over the RRW by helicopter to verify landscape assessments and ecosystem designations for areas inaccessible by foot. The field information was used to revise the initial land cover interpretations and terrain assessments.

4.1.3 GIS Analysis

The SFF used digital forest cover data provide by the Prince George Ministry of Forests Regional Office for base mapping in this analysis. MoF forest cover mapping is designed to provide timber inventory information for extensive areas, and lacks many potentially useful interpretations and assessments of forest ecology. However, it does provide accessible and useful information on vegetation cover, non-forested areas, hydrologic features, and coarse resolution ecosystem mapping.

We utilized the data base attached to digital forest cover maps to identify old growth forest areas and areas which the MoF removed from the timber management landbase. We supplemented the forest cover map data with our own interpretations of ecological sensitivity to disturbance, and with a suggested landscape network of protected movement corridors and old growth reserves.

Terrain type and ESD boundaries were interpreted from air photos, TRIM maps, and field study. ESD polygon boundaries were transferred from air photos to forest cover maps using a "relation to visible landforms" method. Terrain features such as exposed rock outcrops, wetlands, water bodies, and some forest patches are readily visible on both the air photos and forest cover maps. The ESD polygon boundaries on the air photos were transferred to forest cover maps based on their distance from, or congruence with, these and other common features, and then digitized into the GIS.

Movement corridors were delineated on air photos. The purpose of the corridors is to join lower elevation and upper elevation ecosystems, to link protected areas, and, where possible, to link valley ecosystems across passes. Corridors were identified on air photos and drawn directly into the GIS. In the rugged terrain of the Raush, there are few potential corridor locations which join adjacent valleys—most slopes end in vertical rock walls or extensive glaciers. Choices for corridor locations were therefore heavily constrained.

Old growth reserves were photo interpreted, using species rarity mapping produced from the forest cover data base for additional information. The purpose of these reserves is to protect areas of old forest on moderate terrain outside of riparian zones, and to protect unusual old growth species groups. The Old Growth Reserves are in addition to the extensive areas of old forest which are protected on ecologically sensitive terrain.

Table 1 lists the information layers and briefly describes their contents and origin.

Table 1: GIS data layers developed for ecosystem-based analysis.

Data Layer	Data Contained and Source of Data
Forest Cover	Ministry of Forests standard forest cover information, listing tree species, age, height, site index, MoF environmental sensitivity (where applicable), and information about non-forested and non-productive sites.
SFF ESD Types	Derived from SFF photo and map interpretation and ground truthing. Indicates areas which are too sensitive for resource extraction, and areas which are ecologically stable enough for timber management.
Old Growth Forest Areas	Stands and remnant areas containing old growth. Divided into two age classes (141 - 250, 250+). Derived from MoF forest cover mapping.
Riparian Buffers	Protected areas surrounding watercourses, wetlands, and lakes. Some photo interpreted, but most computer-generated by GIS.
Cross Valley Corridors and Old Growth Reserves	Connecting corridors which provide habitat and connectivity among components of the protected landscape network, and selected areas of old growth forest on stable terrain which should be protected to maintain biodiversity. The corridors were located by air photo interpretation. Old growth reserves were selected using a combination of MoF forest cover mapping, air photo interpretation and Silva ESD mapping.

SFF staff combined the layers listed in Table 2 in various ways to produce the attached map set and the summary tables and graphs contained in this report.

4.2 Methodology by Map Data Layer

This part of section 4 provides details about the source, interpretations, and procedures used to produce the information layers in each of the following maps:

- the ecological sensitivity of the RRW landscape;
- old growth and logged areas within the RRW;
- areas in the RRW that are unsuitable for development; and
- a system of protected areas and corridors.

Data summaries from each map are also provided below.

4.2.1 Ecological Sensitivity to Disturbance in the Raush River Watershed

Ecosystem-based planning seeks to identify and understand the important ecological characteristics of an area, and then to restrain human uses to prevent damage to ecosystem functioning. This approach is based on the understanding that human economies, communities, and societies are dependent upon the natural diversity and integrity of the ecosystems they are part of. In other words, healthy ecosystems are the basic foundation of healthy economies and communities. A fundamental step in the development of ecosystem-based plans which sustain protect and maintain healthy economies and communities is to identify the characteristics and conditions that indicate ecological sensitivity within the planning area.

The SFF uses an “Ecological Sensitivity To Disturbance” (ESD) rating system to estimate the possibility that timber harvesting, road construction, and other activities will damage or impair the ecological integrity of forest ecosystems. The concepts underlying the SFF ESD rating system are discussed above in section 3.2.3 (see also Appendix 1). Briefly, map and air photo interpretation, field assessments, and GIS analysis are used to identify the sites and stands that are sensitive to disturbance. The ESD rating or classification system is based upon a group of physical factors:

- slope gradient;
- slope shape or complexity;
- soil depth to a water impermeable layer; and
- site moisture conditions.

Various combinations of these factors result in ESD ratings ranging from low (L) to extreme (E4). Timber management, road construction, mining, and other activities that extensively modify ecosystems are excluded from all but the low to medium risk areas. Sites which generally receive a “high” or “extreme” sensitivity rating include:

- riparian ecosystems
- steep terrain (slopes greater than 60%)
- complex, highly variable terrain
- wetlands
- areas of shallow, poorly developed soil
- dry sites, such as ridge tops and deep gravel soils

- areas dominated by avalanche chutes
- high elevation transition forests

In SFF's opinion, there is a high possibility that timber management and other resource extraction activities will cause a serious loss of ecosystem functioning if allowed in areas with high and extreme ESD ratings. This assessment is based on experience gained by foresters in a wide range of forest landscapes in BC and around the world. Land use activities that ignore or that try to manipulate the natural ecological characteristics of an area may produce short-term financial rewards, but inevitably the end result is long-term loss of ecosystem integrity. Ignoring ecological characteristics and conditions is seldom, if ever, successful in maintaining ecosystem functioning, particularly in the long term.

Ecosystem-based timber management, road construction, mining, and other consumptive resource extraction activities are permitted in areas of moderately stable and stable terrain and moderate to low ESD ratings. Such activities can also be carried out in small areas of stable terrain that are located within larger areas with high and extreme ESD ratings, provided roads are not constructed through areas with high and extreme ESD ratings. These areas require aerial logging systems and are generally referred to as "helicopter accessible" terrain.

Ecological sensitivity types are delineated through a combination of air photo interpretation, ground truthing, and GIS analysis. The ESD types are delineated on topographic maps, then digitized into a GIS. The riparian zones are modeled by creating a variable width buffer around water features in the GIS, which is then added to the digitized ESD layer.

ESD polygons were delineated on air photos, using photo interpretation, TRIM topographic maps, and field study for data sources. The TRIM mapping was used to check ground slope in the many portions of the Raush watershed which have slopes in the 50 to 70% range. Areas with slopes over 60% are designated as Ecologically Sensitive - Steep Terrain areas. Differentiating between areas which are steep but potentially suitable for careful timber extraction (e.g. 55% slopes) and areas which are steep and ecologically sensitive (e.g. 65% slopes) is very difficult using air photos alone. The TRIM topographic maps were used to measure slopes and class the land appropriately.

The ESD polygon boundaries were transferred from air photos to forest cover maps using a "relation to visible landforms" method. Terrain features such as exposed rock outcrops, wetlands, water bodies, and some forest patches are readily visible on both the air photos and forest cover maps. The ESD polygon boundaries on the air photos were transferred to forest cover maps based on their distance from, or congruence with, these and other common features, and then digitized into the GIS.

A small scale plot of the Ecological Sensitivity to Disturbance map is shown in Figure 2. Figure 3 shows a graph of the final results of this process. Table 2 summarizes the areas of the ESD stratifications shown in Figure 2.

Figure 2: Map of Ecological Sensitivity to Disturbance classes.

Raush: Ecological Sensitivity to Disturbance Classifications	Area (ha)	Percent of Total
Water	819	1%
Riparian Ecosystems	12,379	12%
Alpine Ecosystems	53,994	53%
Avalanche Chutes	3,870	4%
Steep Terrain/Shallow Soils/Complex Terrain	25,973	26%
Helicopter Accessible Terrain	958	1%
Moderately Stable Terrain	2,129	2%
Stable Terrain	895	1%
Totals:	101,018	100%

Table 2: Summary of Ecological Sensitivity to Disturbance classes.

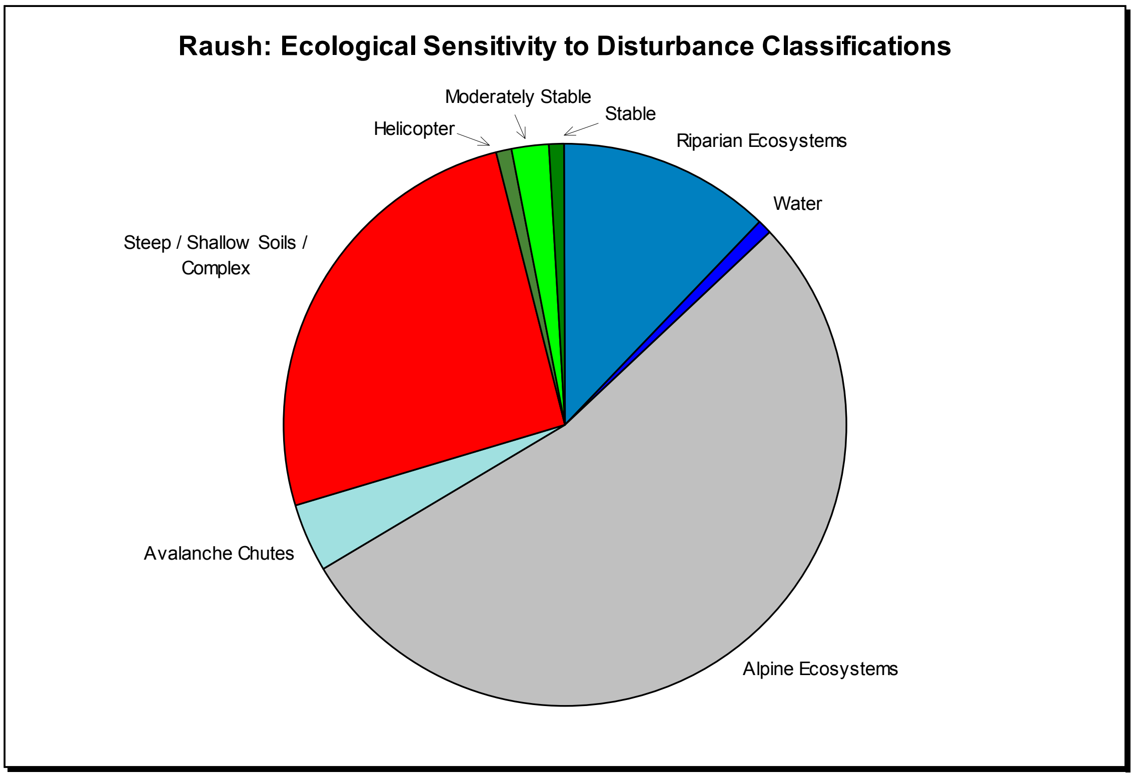


Figure 3: Graph of Ecological Sensitivity to Disturbance classes.

Combinations of codes—for example, areas having both steep terrain and shallow soils/complex terrain—are common in the RRW. The main ESD classes identified in the RRW are:

- **Large Riparian Ecosystems (ES 1)**

  Large riparian areas are dominant in the valley bottom. Only larger riparian ecosystems and wetland complexes were identified on air photos. Riparian buffers around smaller wetlands and streams were created by GIS modeling. These riparian buffers are given greater weight than other ESD zones. For example, areas classed as stable terrain during photo interpretation which are within a computer generated riparian zone are classed as riparian ecosystem on the final maps and data summaries.

- **Steep Terrain (>60% slope) (ES 2)**

  Steep terrain includes all areas with slopes greater than 60%. Such slopes are unstable and prone to mass wasting, slumping and other forms of erosion, especially after logging and road construction. Due to root decay, soils on these slopes may become increasingly unstable for many years after logging.

- **Complex Terrain (ES 4)**

  These sites contain broken, hilly terrain and gullies. While the overall slope gradient of the area may be moderate, the micro slope gradient on gully sides or hillock sides is often over 60%. As a result, complex terrain contains many small, extremely dry ridge and hill crests with shallow or poorly developed soil. The combination of small steep slopes, dry moisture conditions, and shallow soils makes these sites unsuitable for timber management.

- **Avalanche Zones (ES 3)**

  Avalanche zones have steep slopes that experience frequent snow avalanche disturbance.

- **Shallow Soil or Bedrock (ES 4)**

  These sites have soil less than 50 cm deep over bedrock or an impermeable layer. Soil depth cannot be measured on air photos; however, open forests, patches of exposed rock in the forest canopy, and complex rocky terrain all indicate areas likely to have shallow soil. SFF staff confirmed air photo interpretations of shallow soil areas during field sampling, where possible.

- **Snow Dominated (ES 4)**

  The ecology of these areas is governed by deep, heavy winter snow packs. Snow dominated forests are patchy, with slow regeneration following disturbance and natural openings which are maintained in a treeless state by snow damage to coniferous regeneration.

- **Moderately Stable Terrain (MS)**

  Moderately stable sites are "in between" ES terrain and Stable terrain. These areas generally contain continuous slopes in the 30% to 60% range, and are usually fine grained mixtures of stable and ecologically sensitive sites. A proportion of these areas are suitable for ecologically responsible timber management. During this initial work, we assume that 50% of the MS terrain is available for timber management. Additional field assessment is required to refine this estimate.

- **Stable Terrain (S)**

  Stable sites are areas with moderate slopes, deep well drained soils and even terrain. These areas are suitable for ecosystem-based timber management.

4.2.2 Old Growth and Logged Area in the Raush River Watershed

This map and data set compares the area of recent logging or disturbance with the area of old growth forests in the RRW.

To ensure long-term landscape health, old growth forest nodes or patches must be maintained throughout the RRW landscape. To ensure stand level ecosystem functioning, old growth structures such as large old trees, snags, and fallen trees also need to be retained within logged areas. Late successional or old growth forests provide a variety of specialized functions and benefits not found in other successional phases, including:

- water interception, storage, filtration, and release;
- habitat for insect carnivores that regulate herbivorous "pest" insects;
- a high level of carbon storage;
- production of the highest quality, highest value, and highest volumes of wood;
- production and storage of soil nutrients necessary for other forest successional phases, particularly the young and early mature forest phases;
- provision of the unique habitat characteristics required by many plants and animals;
- maintenance of healthy populations of specialized species which include the soil flora, fauna, and microorganisms that other forest successional phases rely on; and
- the greatest species diversity of any successional phase.

Only a small portion of the RRW is currently logged, although industrial timber management plans to advance into the valley in the near future. Logged areas were easily identified on air photos and MoF forest cover maps. They consist of two industrial clearcuts in the Kiwa Pass area, and the cleared areas of the Peterson Ranch in or near the riparian zone of the Raush River in the lower portion of the watershed.

Old growth stands were delineated based on age class from the forest cover data files. This is not an optimal method for identifying old growth, but it is the only practical method given available data sources and funding. "Old Growth" has many possible definitions. The more appropriate definitions are based on ecologically significant structural parameters, such as tree size, quantity and size of coarse woody debris and canopy structure. Such ecological information is not available from the MoF forest cover data files, which are designed for the purpose of maintaining an inventory of timber resources, not of ecological attributes. However, while structural attributes and composition can vary, all old growth forests are old forests. Moir (1992)[1] states:

> Old growth forests differ structurally and successionally from younger forests only after sufficient time has elapsed. In a word, old growth forest are "old" forests

[1] Moir, W. H. 1992. Ecological concepts in old growth definition. In: Old growth forests in the southwest and rocky mountain regions: Proceedings of a workshop. USDA Forest Service. Fort Collins, Colorado. GTR-RM-213.

> ...Although structure and age may help to characterize old growth forests, forest age is the essential feature.

The indicated level of certainty of the photo interpreted age estimates recorded in the forest cover data files is ± 20% (MoF 1988)[2], but our experience indicates that the variation is often greater. Four factors contribute to the error level of the MoF forest inventory age data:

1. Many of the age estimates are derived from air photo interpretation without limited ground checking. The growth rings of a tree cannot be counted on an air photo.
2. Old growth forests tend to be all aged. Field measurement of similar trees may reveal ages that are different by hundreds of years. The population selected for measurement may have significant, but unassessed, impacts on stand age estimates.
3. In the MoF system, old forests are divided into two large age classes of 140 to 250 years (age class 8) and >250 years (age class 9). These extremely large strata may be satisfactory for timber volume estimation, but are imprecise from the standpoint of old growth ecology. The point of division between the two strata (250 years) is arbitrary and may not be significant in forest growth and development in many ecotypes.
4. The Ministry of Forests favors the use of relatively large forest types which combine noticeably different forest conditions. The criteria used to stratify the forest into types are sufficiently broad that any type may actually contain a wide range of distinct forest ecosystems or age classes. This method is acceptable for the timber inventory purposes of the MoF, but tends to obscure details which would be of interest in a study of old growth forests.

Despite these known problems, stand age is the only feasible variable to use for identifying old growth forests at this initial planning level. We distinguished four classes of old forests in the watershed:

- **Old growth aged 141-240 years on sensitive terrain**: These are mostly intact stands of Engelmann spruce and subalpine fir on steep middle to upper slopes adjacent to alpine areas.
- **Old growth age 250 plus years on sensitive terrain**: For the most part these are stands of subalpine fir and western hemlock on steep middle slopes directly adjacent to and below the younger old growth on the upper slopes.
- **Old growth aged 141-250 years on stable terrain**: These stands of western hemlock and Douglas-fir comprised only a small percentage of old growth in the watershed, and are found on lower, valley-bottom slopes adjacent to riparian ecosystems.
- **Old growth aged 250 plus years on stable terrain**: These stands also represented only a small fraction of forest cover, and are found distributed throughout the watershed embedded within stands of younger forests near the valley bottom .

[2] Ministry of Forests. 1988. Forest classification. Chapter 3 in the Forest Inventory Manual. B.C. Ministry of Forests and Lands, Inventory Branch. Victoria.

A small scale print of the project map showing logged and old growth features in the RRW is shown in Figure 4. The total area and percentages of logged and old growth forest in the RRW are summarized in Table 3 and Figure 5. While the table and the graph provide a useful overview of forest cover in the RRW landscape (only ≈ 30% is forested), the old-growth and logged area map better conveys the character of the forest cover. The recent history of fire disturbance in the watershed has eliminated much of the old growth forest along the valley bottom and lower slopes in the lower portion of the watershed. A critically important feature of the RRW is the fact that 66% of the landscape is either alpine or glacier. From a landscape viewpoint, closed canopy forests are relatively rare, are limited by a snowy, cold climate, and require a high degree of protection to maintain ecosystem functioning.

Figure 4: Map of Logged and Old Growth areas in Raush River Watershed.

Raush: Logged and Old Growth Areas	Area (ha)	Percent of Total
Water	819	1%
Glacier	17,012	17%
Wetland	841	1%
Alpine Tundra and Alpine Forests	51,216	51%
Other Non-Forest	665	1%
Logged Areas	133	0%
Older Forest on Sensitive Terrain	13,041	13%
Old Growth on Sensitive Terrain	2,901	3%
Older Forest on Stable Terrain	1,044	1%
Old Growth on Stable Terrain	1,061	1%
Younger Forest	12,287	12%
Totals:	101,018	100%

The following age classes are used in this table:
- Older Forest: Stands aged 141 to 250 years.
- Old Growth: Stands aged 251+ years.
- Younger Forest: Stands aged 1 to 140 years.

Table 3: Summary of Old Growth strata by Terrain Sensitivity and Age Class.

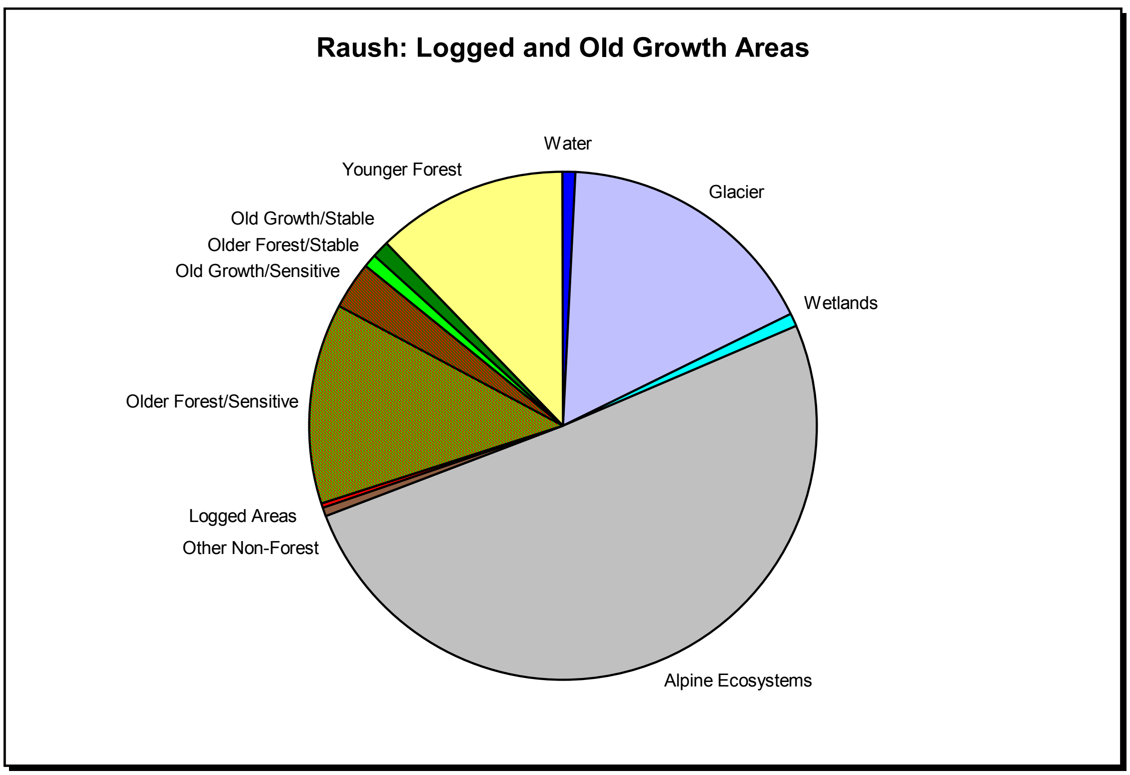


Figure 5: Graph of Logged and Old Growth areas.

4.2.3 Areas in the Raush River Watershed that are Unsuitable for Development

Areas in the RRW that are unsuitable for timber management consist of:

- non-forested areas (per MoF);
- non-productive and non-merchantable forested areas (per MoF);
- environmentally sensitive areas (per MoF); and
- additional areas classed as highly ecologically sensitive (per Silva).

These areas are identified and delineated using MoF forest cover maps, air photo interpretation, field assessment, and GIS analysis. Note that while some of the classifications (e.g. MoF ESA1 and Non-Productive Forest) may overlap, each hectare of land can only be filed in one category. Thus, the hierarchy of the netdown process is very important. Changing the order of the netdowns will change the total area shown for each class, as well as the patterns shown on the map. The following list is in the hierarchical order used for the netdowns:

- **Non-forested areas**

  Non-forested areas include water features, glaciers, rock outcrops, alpine tundra, wetlands, and settlement clearings. These areas were identified from information contained in the MoF forest cover data files and removed, or netted out of, the potential forest management landbase.

- **Ministry of Forests Forested Area Netdowns**

  The following classes were identified and removed from the timber management landbase using the MoF forest cover data files and the stratifications supplied in the 1994 Robson Valley Timber Supply:

  - ***Alpine forest*****:** Alpine forest stands are open, snow dominated, and extremely sensitive ecosystems with very slow growth rates and short growing seasons.
  - ***ESA 1*****:** Areas identified as environmentally sensitive by the MoF. Typically, these are areas with steep terrain, sensitive soils, or expected regeneration problems.
  - ***Non-productive brush:*** Non forested sites which contain an ecologically stable community of brush species, usually willow or slide alder, with little or no potential for conversion to productive forest land. May include 6 to 10 % forest cover. May include sites with permanently high water tables, snow chutes, and high elevation sites with persistent snow cover.
  - ***Non-productive forest:*** Forested areas with very low timber productivity. Includes forests bordering swamps and forests on rocky and/or steep terrain. This class also includes all forest cover polygons with a site class of “Low”.
  - ***Non-Commercial Brush and Deciduous:*** These two types were grouped together in the mapping and analysis. Non Commercial brush areas are denuded but potentially productive forest lands which are currently occupied by non-commercial brush species. Commercial trees species may be present in low densities. Deciduous stands are forest stands dominated by aspen, birch, or cottonwood. These tree species are marginally merchantable, and are not generally included in estimates of commercial timber productivity at this time.

- ***Inoperable area*:** These areas are considered uneconomic to harvest due to poor accessibility, high elevation, low stand volume, and/or poor timber quality. These were identified from operability mapping provided by the MoF, and from the forest cover data file.

- **SFF Ecologically Sensitive Netdowns**

  Areas identified as ecologically sensitive during the SFF analysis process described in Section 4.2.1. Three summary classes were used during the production of this map: riparian ecosystems, upper elevation forest, and steep and/or complex terrain. These codes are only applied to areas which were not netted out by the MoF netdowns.

  The areas in these classes highlight the extend and nature of the disagreement about the net timber potential of the Raush between conventional timber management and ecologically responsible forest management.

A small scale plot of the Landbase Unsuitable For Development map is shown in Figure 6. The results of the netdown are summarized in Table 4 and Figure 7. Fully 70% of the landbase is not forested, and MoF timber netdowns remove another 20% from the potential timber management landbase. SFF ESD netdowns subtract another 7%, leaving only 3% of the landbase that is potentially suitable for timber management. Some parts of this remaining 3% will be protected in order to ensure adequate representation of all ecosystem types and connectivity within the protected landscape network, discussed in Section 4.2.4.

Figure 6: Map of Landbase Unsuitable for Development.

Raush: Landbase Unsuitable for Development	**Area (ha)**	**Percent of Total**
Non Forested Areas		
Water	819	1%
Glacier	17,012	17%
Rock and Alpine	51,631	51%
Wetland / Clearings	859	1%
MoF Netdowns		
Alpine Forest	5,088	5%
MoF High Environmental Sensitivity	13,562	13%
Non-Productive Brush	250	0%
Non-Productive Forest	185	0%
Deciduous Forest	413	0%
Inoperable Area	997	1%
SFF Ecologically Sensitive Areas		
Riparian Ecosystems	2,095	2%
Upper Elevation Forest	6	0%
Steep / Shallow Soil / Complex	4,943	5%
Landbase Potentially Suitable For Development		
Mod. Stable / Stable / Helicopter Terrain	3,159	3%
Totals:	101,018	100%

Table 4: Summary of Landbase Unsuitable for Development strata.

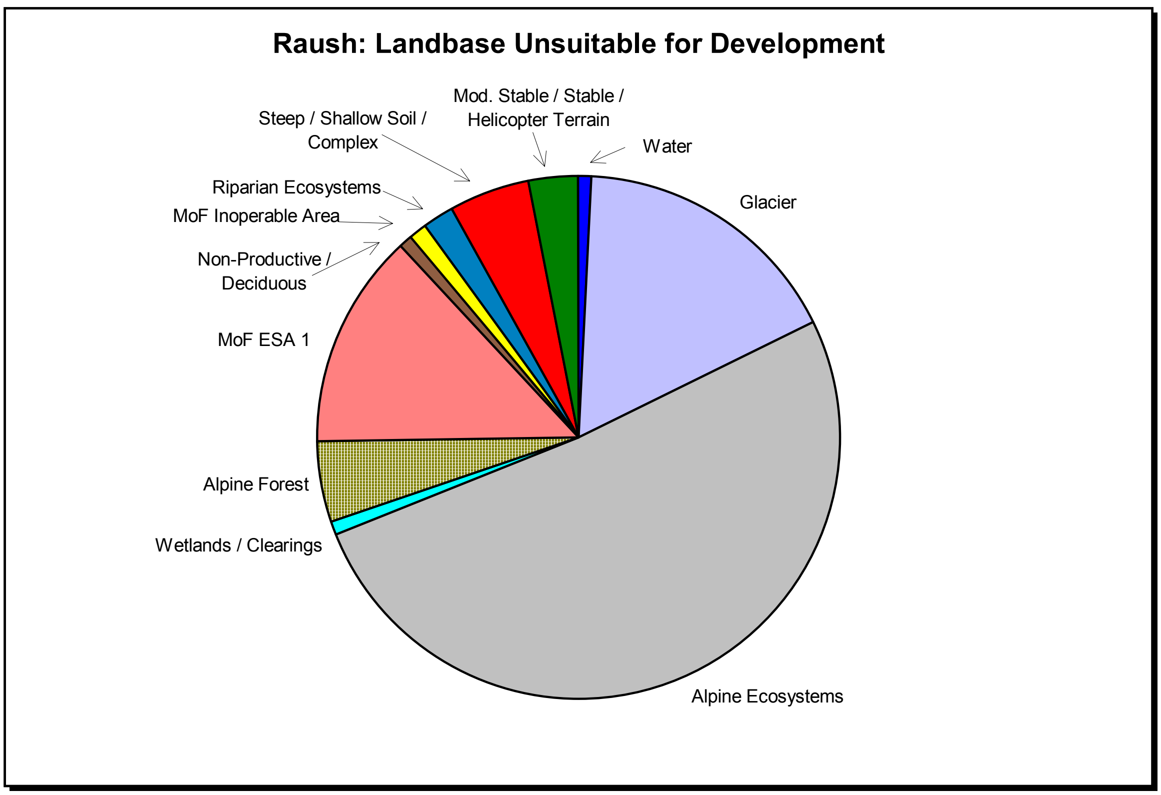


Figure 7: Graph of Land Unsuitable for Development strata.

4.2.4 Protected Landscape Network for the Raush River Watershed

As discussed in Section 3, there is widespread agreement on the need to protect, maintain and, where necessary, restore a network of connected ecosystems throughout the landscape to ensure ecological functioning at all scales, from the small patch or stand to the large landscape. A protected landscape network in the RRW needs to include:

- riparian ecosystems;
- old growth reserves;
- ecologically sensitive areas;
- cross valley corridors;
- some natural younger stands on moderately stable terrain;
- some natural younger stands on stable terrain; and,
- representative ecosystem types.

A protected landscape network with these components becomes an undisturbed pattern of patches and pathways that maintains important ecosystem composition, structure, and functioning at all scales. Components of the protected landscape network may be moved over long time periods. A cross valley corridor can become a timber zone, for example, provided that another timber zone in an appropriate location has developed the necessary composition and structure to replace the corridor. This type of exchange may require periods in excess of 250 years following logging to allow former timber zones to develop old growth characteristics. Terrain constraints in the Raush Valley, where many upper elevation sites are vertical rock faces or glaciers, severely limit flexibility of corridor location. Thus, although the components of a protected landscape network will change and shift over time, they will be relatively permanent features in human terms.

Elements of a protected landscape network should not be confused with large parks or wilderness reserves. Large protected areas are also required throughout the larger regional landscape in order to provide an ecological "blueprint" which can guide efforts to restore ecosystem functioning in landscapes and stands degraded by human activities. The protected landscape network is the ecological fabric that connects large reserves and ensures long-term ecological functioning within modified landscapes. The entire Raush River watershed is a potential site of a large protected area reserve.

As part of the protected landscape network, the SFF identified a number of cross valley linkages throughout the RRW. In conjunction with the riparian ecosystem network, these protected network components provide:

- movement pathways for animal migration and plant seed dispersion;
- a network that connects old growth habitat within the watershed; and
- a source of ecological resources, with undisturbed forest habitat.

Cross valley corridors are located so as to take advantage of natural features such as:

- old growth forest patches;
- lower elevation passes joining main valleys;
- wetland ecosystems;
- riparian ecosystems; and
- undisturbed areas of the landscape.

While corridors are not specifically designed to mimic large animal movement routes, they are designed to avoid barriers to movement between the other components of the landscape network.

A small scale map of the Protected Landscape Network is shown in Figure 8. The corridors and other components of the protected landscape network identified in the Raush River Watershed by the SFF staff are summarized in Table 5 and Figure 9.

The corridors delineated in the RRW are generally 200 to 400 m wide. Some corridors swell to over 500 m in order to encompass unusual forest stands. Corridors include a mix of stable, moderately stable, and ecologically sensitive terrain. In many locations in the RRW, the designated corridors travel from the valley bottom to the alpine uplands. This provides a diversity of habitats within the corridor and increases the value of the corridors as pathways for plant and animal movement.

The cross valley corridors in the RRW generally follow watercourses, and in fact are expansions of riparian zones. This is not our general practice when locating corridors. We normally try to locate corridors which start at mainstem riparian ecosystems, climb over the watershed divide in a passable location for animal movement, and then descend to the mainstem riparian zone in the next valley. The rugged terrain in the Raush Valley, where most watershed divides can only be reached by passing through vertical rock faces or glaciers, severely constrains corridor location. We hypothesized that most plant and animal species would not have natural movement paths which traversed icefields or vertical cliffs, but would in fact move through this landscape parallel to main valley bottoms. The corridor locations seek to enhance these travel routes, as well as providing connections to neighboring landscape units where physically possible.

Corridor location at the landscape planning level is an inexact science. Further study or local knowledge may indicate that some corridors should be shifted from their proposed location to other nearby locations which have greater ecological value. This is not unexpected and is part of the process of turning this preliminary analysis into a long-term forest plan that will meet the goals of the Robson Valley community.

Figure 8: Map of Protected Landscape Network.

Raush: Protected Landscape Network	Area (ha)	Percent of Total
Non Forested Areas		
Water	819	1%
Glacier	17,012	17%
Alpine	51,216	51%
Wetlands	841	1%
Other Non-Forested	682	1%
Protected Landscape Network		
Riparian Ecosystems	4,573	5%
Cross Valley Corridors	1,090	1%
Old Growth Reserves	558	1%
Ecologically Sensitive Terrain	21,559	21%
Unprotected Areas		
Unprotected Forest	2,668	3%
Totals:	101,018	100%
Total Area of Protected Old Growth(1) Forest (All terrain classes combined)	16,448	16%

(1) Old Growth defined in this case as all forests older than 141 year of age.

Table 5: Summary of strata in Protected Landscape Network.

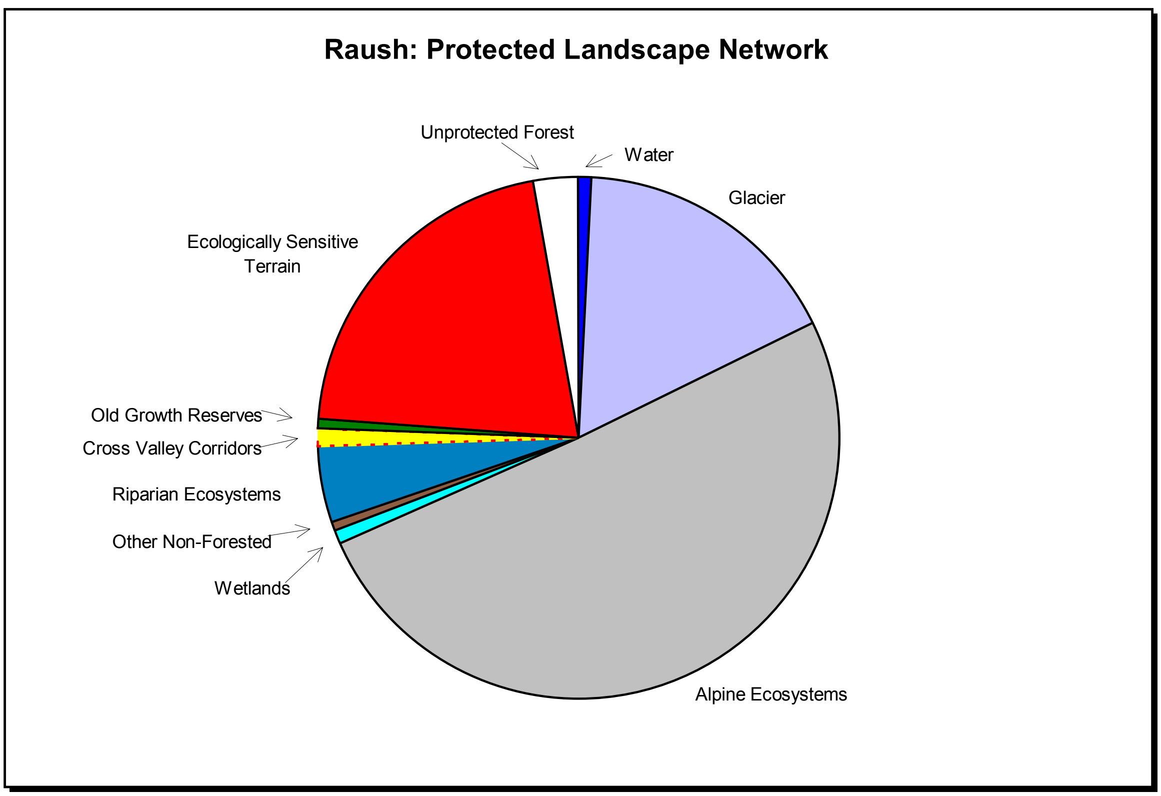


Figure 9: Graph of Protected Landscape Network strata.

5. RECOMMENDATIONS

The results in this report are preliminary and are not meant as a definitive ecosystem-based analysis of the Raush River Watershed. Rather, they are meant to provide an interpretation of current conditions in the watershed, and to suggest a different approach to the design of forest plans that will guide future development. The intention is to provide a broader knowledge base to enhance local debate, and thereby to create an opportunity for informed community decision making. The SFF hopes that these goals are at least partially met in this report and through the accompanying maps.

This preliminary ecosystem-based analysis shows that the Raush River Watershed is an ecologically sensitive landscape. The watershed and immediate surrounding area can be described as a mosaic of ecosystem types with characteristics that indicate high sensitivity to human disturbance. High elevation, cold temperatures, highly variable and steep terrain, poorly developed soils, and a high incidence of natural disturbances provide clear indication of low resilience and ecological constraints. The limited area that is sufficiently stable for timber management lies near the valley bottom in the lower watershed. Much of this area has already been impacted by fire, settlement, logging, and other human disturbance.

Developing and implementing plans that will protect, maintain, and, where necessary, restore the ecological integrity of the RRW will require additional community commitment, further analysis, and careful planning. In particular, the RRW needs to be considered within the context of the larger Robson Valley landscape. Completion of an ecosystem-based plan for the Robson Valley landscape may indicate that the RRW is an important large protected area.

The following recommendations for further work are based on insights gained in this and other projects. These tasks could be accomplished as joint endeavors between the SFF and the Dunster Community Association.

1. Hold a community workshop to explain:
   - the findings of the RRW preliminary ecosystem-based analysis and maps;
   - how an ecosystem-based plan may be prepared for the Robson Valley landscape; and
   - how an ecosystem-based plan could lead to a more stable, diverse, and sustainable economy in the Robson Valley.
2. Develop a workplan, timetable, and budget for an ecosystem-based plan for the Robson Valley landscape. This workplan would describe how Silva and the Dunster Community Association can cooperatively develop the plan.
3. Develop an ecosystem-based plan for the Robson Valley.