The Silva Forest Foundation

Ecosystem-based Forest Use Plan for the Harrop-Procter Watersheds

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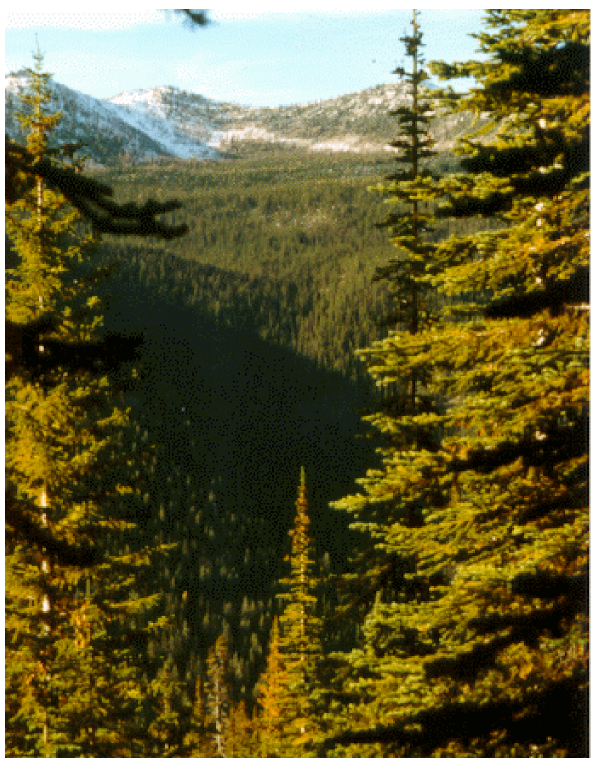
prepared by

The Silva Forest Foundation.



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1. INTRODUCTION

This report outlines the methods used and results of a reconnaissance level, ecosystem-based landscape assessment and forest use plan completed for the Harrop-Procter Watershed Protection Society (HPWPS).

The study area (outlined in Figure 1) is the series of small watersheds on the south shore of the West Arm of Kootenay Lake above the communities of Harrop and Procter. The study area runs from the west shore of Kootenay Lake in the east to the Harrop Creek drainage in the west, and includes all of the smaller watersheds along the north facing slope between.[1]

The HPWPS represents 800 people living in the communities of Harrop and Procter on the west arm of Kootenay Lake. A community survey carried out by the HPWPS showed that the watershed management priority of the community is continued production of high quality domestic water supplies. The stated watershed management objectives of the HPWPS include:

1. To achieve ecosystem-based forest management in the Harrop-Procter area which will benefit the community in perpetuity.
2. To ensure that forest use activities, particularly timber management, protect water quality, quantity, and timing of flow in both the short and long terms.
3. To promote a sustainable, community-based economy through ecosystem-based forestry planning, ecologically responsible timber management activities, the enhancement of local processing facilities, and the development of value-added wood manufacturing.
4. To develop appropriate non-timber forest uses of the Harrop-Procter watersheds. Non-timber forest uses under consideration include, but are not limited to: wildcrafting, nature interpretation, wildlife viewing, tourism, and existing trap lines.
5. To establish a water monitoring program in the Harrop-Procter watersheds in order to evaluate the results of ecosystem-based forestry, and to ensure that timber management does not degrade water supplies.

This reconnaissance level assessment is the first step in planning ecosystem-based forest use in the Harrop-Procter watersheds. An ecosystem-based approach will achieve the primary community goal of water protection. The labor-intensive requirements of ecosystem-based forestry will result in more employment per volume of timber cut than conventional approaches. Ecosystem-based forestry will result in lower timber harvest rates than conventional forestry, but will mitigate employment or revenue losses through

[1] The study area initially included the Wilson Creek watershed, the large watershed immediately south of the study area which drains into Kootenay Lake. This watershed was dropped from the study area at the request of the HPWPS in September 1998.

intensive forestry planning, through labor intensive partial cutting methods, and through the implementation of value-added wood products manufacturing. Appendix 2 contains a recent Silva publication *An Ecosystem-Based Approach to Forest Use* which expands on these points and lays out the foundations of ecologically responsible use.

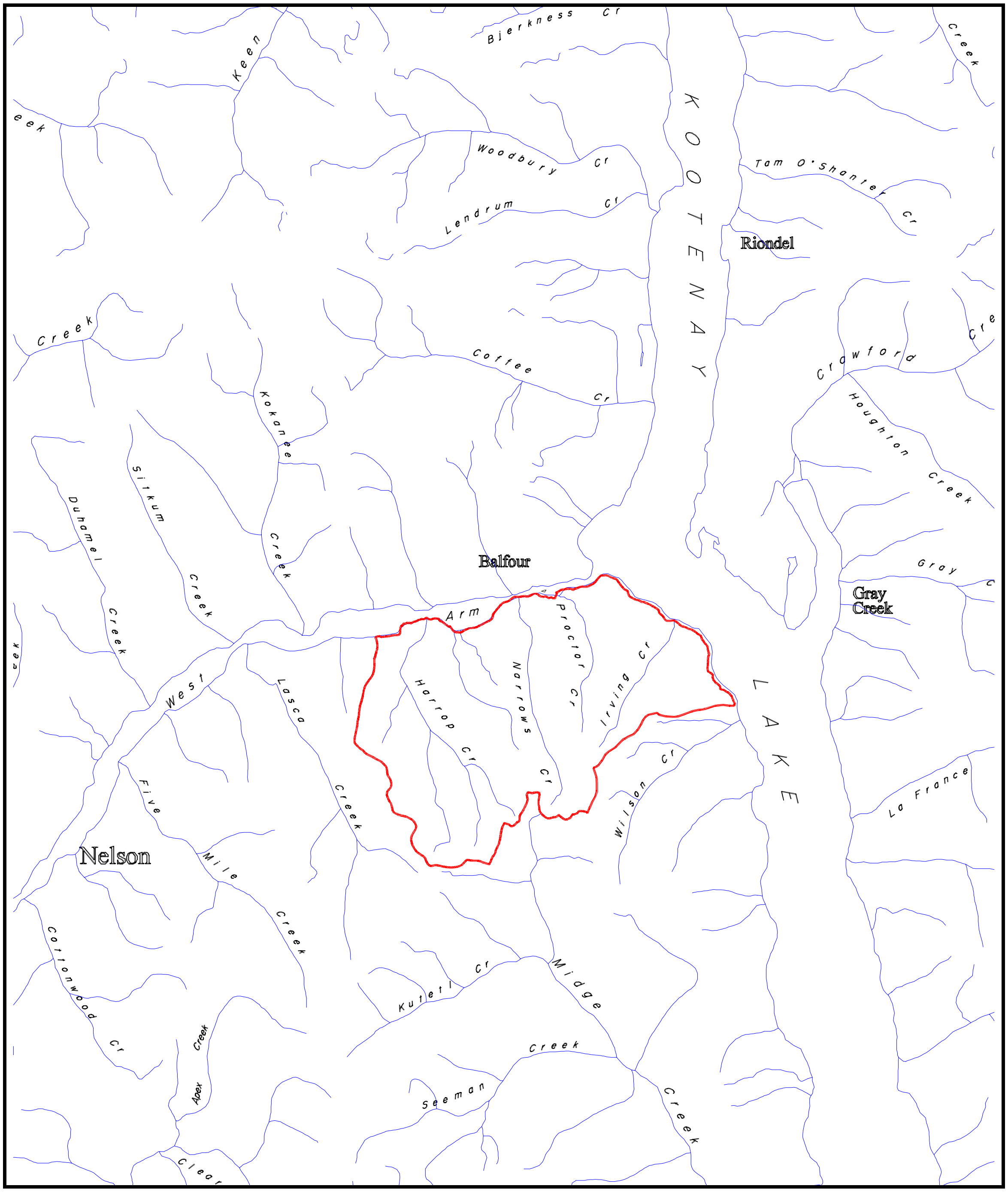

Figure 1: Map showing Harrop-Procter study area outlined in red.

This report, and the work on which it is based, is an initial estimate. The terrain stratifications and land use planning choices are based largely on air photo and map interpretation, supplemented by 6 crew days of field work. We believe that the landbase estimates are realistic, but further field assessment and planning are required to verify results. We recognize that some specific interpretations will be incorrect, but our objective is to be correct on average. For example, our interpretation might indicate that the boundary between stable terrain and ecologically sensitive steep terrain is 800 meters uphill from a creek. A field crew might identify the boundary between the two terrain classes at 650 meters, or at 950 meters. We would not regard this as a serious error, but as a reflection of the inherent uncertainty of air photo interpretation of terrain classes with limited field checking. The maps and interpretations herein should be understood to indicate, in this example, that there is likely an area of stable terrain on the lower slope, that there is likely an area of ecologically sensitive terrain further upslope, and that the boundary between the two is approximately 800 meters from the creek.

The information presented in this plan is suitable for reconnaissance level land use planning and estimating ecologically sustainable timber flows. It is not suitable for operational planning. Future work will add to and enhance this initial assessment. The current work is a starting place from which the community can move forward towards sound ecosystem-based forest management, and the more detailed and reliable planning which that will require.

Funding for this project was provided by the W. Alton Jones Foundation. The Ministry of Forests Kootenay Lake District Office kindly provided access to maps and data which greatly facilitated the GIS analysis of the study area.

This report is divided into five sections, which are listed below:

Section 1: Introduction

Section 2: Background information on the geography, geology and ecology of the study area. The information will enhance the reader's understanding of the ecological processes and the planning decisions described in the report.

Section 3: The field procedures used during the field reconnaissance and ground truthing.

Section 4: The data sources, mapping decisions and data interpretations used to develop the ecosystem-based plan maps of the study area. The methods used to combine and correlate information sources, to define the ecological limits to timber management, and to define initial watershed management choices, are outlined in this section.

Section 5: The results of the Ecosystem-based Plan, which include an initial ecologically responsible timber cutting rate and estimate of areas suitable for timber management, and recommendations for further work.

2. Geography, Geology and Ecology

2.1 Climate

The climate in the study area varies in a gradient from dry and warm beside Kootenay Lake (elevation 550 meters) to wet and cold alpine conditions at the headwaters ridge crest (elevation 2400 meters). Average monthly temperatures and temperature extremes decrease as elevation increases, while precipitation inputs increase with elevation.

At lower elevations, soil moisture deficiencies may occur during the summer growing season, although these are offset in much of the study area by downslope water movement from moister ecotypes, and by the prevalent north aspect on lower slopes. Growing seasons in upper elevations are severely curtailed by long winters, cool summers and sporadic frosts. Conditions between these two extremes vary with elevation, local slope position, soil depth and aspect.

The climatic gradient in the Harrop-Procter watersheds is of great benefit to water users. Spring snow melt occurs over a period of several months, resulting in lower peak flows and spreading the water yield from winter snow accumulations over several months. As well, the moister upper elevation climates receive precipitation inputs during periods which are quite dry in lower elevations. This results in satisfactory community water supplies year round.

2.2 Geology and Landforms

The recent Harrop - Narrows - Procter Creeks Terrain Interpretation (Wallace et al 1998) contains a good summary description of the geology of the study area. Important points are excerpted below, and the complete report is included in Appendix 4.

The main physiographical divisions within the study are:

1. The Kootenay Lake valley at the north edge of the study area. This large valley is flat bottomed, and bordered by flat terraces. This stable and biologically diverse area has been greatly impacted by human settlement, and is largely privately owned.
2. The main Kootenay Lake valley face, which rises at 40 to 60% slope gradient from the lower flats to the main valley ridge. These slopes contain much of the potential timber management landbase in the study area, but are also largely privately owned.
3. A set of long, narrow, roughly parallel valleys running south from the West Arm valley. The side valleys often have gently sloped east walls and steep west walls, due to the underlying bedrock morphology. These valleys contain the main creeks in the study area. The combination of rapid elevation change, deeply incised valleys, and sensitive sites along the side drainages makes access to upper elevations of study area in back end of side drainage channels difficult.

The bedrock in the study area is variable, including igneous intrusive, sedimentary, metamorphosed sedimentary, and metamorphosed volcanic rocks. These rock types range from hard and resistant to weathering to soft and easily weathered. Wallace et al observe:

> *Generally, dip directions in the study area are toward the northwest and west. Therefore, slopes with west-northwest aspects often have unfavorable bedrock structures. These slopes are more gentle than the east aspect slopes and are considered to contain more operable ground. Bedrock geology in the area is an important stability factor.*

To interpret, the problem is that many of the moderate side valley slopes overlie smooth planes of tilted bedrock, which run parallel to the soil surface. This results in a potential slope failure plane beneath some of the areas which we consider most promising for timber management. Redirecting natural drainage patterns and saturating soils above this failure plane will lead to slope failures at relatively low slope gradients. This does not rule out timber management activities in these areas, but stresses the need for careful engineering and hydrological impact monitoring.

The terrain and landforms which we see today in the Harrop-Procter watersheds are the result of glacial and post-glacial activity acting on the underlying bedrock, and on accumulated surficial materials. This topic is discussed by Wallace et al. In brief, during the last glaciation, the main valleys of the study area were filled with valley glaciers, which flowed north to join the main Kootenay Lake valley glacier. The moving ice plucked large quantities of bedrock away, scraped valley sides and bottoms, and deposited densely packed morainal material in many areas. As the ice melted, a wide variety of gravel, rubble and finer materials were left behind, some sorted by water, some not.

The complex interaction of bedrock geology, glaciation, and deposition of surface materials, all of which vary over the study area, has produced a complex mix of terrain and landforms. Few broad generalizations for the study area are possible, and all sites must be assessed based on their specific soil and landform attributes.

The pictures and captions on the following pages highlight terrain features in the study area.

Figure 2: Main Valley Face along West Arm of Kootenay Lake.

This picture shows the mean face of the Harrop-Procter watersheds where they abut in the central Kootenay Lake (West Arm) valley. These long slopes rise from the flat riparian plain to almost the level of the ridge crests throughout the watersheds. Precipitation input onto the slopes runs through the moderately deep soil to collect at the bottom portion of the slope, where many domestic water intakes, seeps, and springs are located. Moving up the face, the incidence of shallow soils, rock bluffs, and sensitive terrain increases as the ridge crest is neared.

While it is not highlighted from the angle of the photo, the main face is bisected by the valleys of Harrop, Slater, Narrows, and Irving Creeks. These creek valleys often occupy deeply incised canyons and present considerable obstacles to animal movement and to development of transportation networks for access to timber resources.

By far the largest continuous block of land which is potentially suitable for timber management is found on this main face overlooking the Kootenay Lake valley. However, much of this land is privately owned and not within the Crown forest which will be the basis of a community forest in the Harrop-Procter watersheds. The potential timber zones on the main face are also constrained by the importance of the domestic water sources on the lower slopes and the ecologically sensitive terrain on the upper slopes.

Figure 3: Dropoff from Upper Irving Creek to Kootenay Lake Valley.

This picture shows the varied forest types on moderate terrain in the area, and the thin shallow soils over bedrock which occur on the upper portion of the slopes throughout the study area. This picture also shows the dramatic drop-off from the upper Irving basin down towards Kootenay Lake, which appears in the background. This drop-off is accentuated by the position of the camera when the frame was taken, but the visual impression of a straight fall down to the lower elevations is reasonably accurate.

Figure 4: Upper end of Harrop Creek watershed, west fork of Harrop Creek.

This picture illustrates several features of the upper end of most of the watersheds in the study area. The lower elevations of the valley in the photograph occupy a broad, relatively flat cirque basin carved out by glaciers during the last ice age. The creek—visible in the center of the picture—is surrounded by an extensive riparian ecosystem made up of seepage areas, ponded wetlands, small streams, and other moist sensitive habitats. The riparian ecosystems and buffers mapped in these upper basins are much broader than in the lower reaches of the creeks, where the riparian ecosystem is much more confined by moderately steep valley walls.

This broad, flat cirque basin, with its extensive riparian zone, is largely occupied by old growth spruce-balsam forests, with old growth *Pinus albicaulis* forests on the upper slopes in the picture. While the valley bottom is relatively flat, it is often ecologically sensitive due to high soil moisture levels, and is best managed as a watershed protection area to maintain late season flows and quality water at all times through the year.

This photograph also shows the steep headwall cliffs which surround most of the upper watersheds in the study area. These headwalls are largely impassable to animal movement, and severely constrain the location of connecting corridors through the study area. Connecting corridors follow feasible travel routes for animals, and few feasible routes exist through this impressive array of rock walls. West Arm Provincial Park, a large protected area, is on the other side of this rock ridge.

This picture was taken in the fall, and the alpine larch forests are indicated by yellow larch trees. Most of the areas occupied by alpine larch are classed as alpine forest by the Ministry of Forests. While these areas are forested, they are occupied by very old, small trees growing in extremely harsh climatic conditions. The growing season on these upper elevations, just beneath the tree line, is short, and frosts may occur on any day of the year. Drought is also likely a problem in the height of summer in the shallow rocky soils on these upper elevations. Much of the alpine forest in the study area is "old growth" but does not contain the large diameter stem habitat associated with lower elevation old growth forests. This is an important, beautiful, and unique ecotype, but it does not contribute to meeting the habitat needs of species which depend on large diameter old growth structures.

2.3 Surficial Geology and Soils

Forest soils vary greatly across the study area, in relation to climate, slope position and parent material.

Warmer areas tend to have more strongly developed soils, with deeper nutrient enriched horizons, more active soil biota, and greater available nutrients for plant growth. Soil life forms quickly process the litter fall input into the soil ecosystem each year, and convert dead plant matter to forms readily available to growing plants.

In colder, high elevation ecosystems, organic matter tends to accumulate on the soil surface, as soil ecosystem processes digest litter inputs more slowly than they accumulate. The deep organic layers tend to insulate the soil, reducing soil warming, further slowing biological processes, and aiding further litter accumulation. Cold soils have little biological activity, and limited available nutrients for plant growth.

Soils on ridge crests, upper slopes, and knolls receive water only as direct precipitation inputs. These sites tend to be dry, as moisture rapidly drains away to downslope areas. Soils on middle slopes receive moisture inputs from precipitation, but also receive moisture and nutrient from upslope areas. Midslope soils tend to be moister, more nutrient enriched, and better suited for plant growth.

Lower slope soils continue the trend of increasing moisture. Lower slope positions are moist to very wet, as accumulated water from upslope areas rises to the surface to form seeps, springs and creeks. These areas are often nutrient rich, but may be too wet to support good tree growth. Lower slope areas are often extremely ecologically sensitive due to elevated soil moisture levels.

Parent material, or surficial geology, is also a critical consideration in soil fertility and sensitivity to disturbance. The parent material (in most cases, what the glaciers left behind) determines what climate, slope position, and biota have to work with. The most productive, stable and biologically active soils contain a mix of particle sizes (clay, silt, sand, gravel and cobbles), are over a meter deep, and are permeable to air and water to significant depth. Soils dominated by coarse, gravelly parent material or by pure water deposited sands have limited water holding capability, and few available nutrients. Soils which have been compressed by a glacier are often compact and impermeable to water or tree roots at a depth of 20 to 40 cm. While the soil parent material may be meters thick, the active part of the soil is only the narrow profile above the compressed strata. Soils dominated by fine textured silts and clays are poorly drained and poorly aerated, and inhospitable to plant growth.

The following descriptions of surficial geology and soil parent material in the study area are excerpted from Wallace et al (1998).

> ***Till:*** *Till—or moraine—is material deposited by glacial ice. Till deposited beneath the ice,* basal till, *is characteristically more consolidated, has a finer matrix and has fewer coarse fragments than* ablation till*. Ablation till is supraglacial material deposited by sliding, flowing, dumping or subsidence to the ground during melting of underlying ice. Ablation till includes material deposited as lateral moraines along the margins of melting glacial ice.*

Till deposition varies in each drainage basin. Basal till deposits in Procter Creek are derived from granitic bedrock. This till is moderately compact, has a sandy to silty sand matrix and 25-50% subrounded coarse fragments. Lower slopes in Procter Creek have till deposits that are more micaceous and as a result have a silty sand to sandy silt matrix.

Basal till in Narrows Creek is derived from less competent metamorphosed sediments and volcanics and as a result the material is fine textured. Till on the lower slopes of Narrows Creek is strongly to moderately compacted, has sandy silt and lesser amounts of clayey sand textures, with 10-25% subangular coarse fragments. Closer to the headwaters (i.e. closer to the Procter Intrusions), till has silty sand and sandy textures and 25-50% coarse fragments.

The till in Harrop Creek is derived from the Nelson Batholith. Most of the area below the upper middle to lower upper slopes is mantled by gravelly to gravelly sand ablation till. The low coarse fragment content (35%) and high sand component makes the till susceptible to gully erosion. Most of the slopes underlain by this material are extensively gullied. Strongly compacted, clayey sand textured basal till (35% coarse fragments) is exposed along the steep side-slopes and along some benches immediately above Harrop Creek. This till is extremely hard when dry (as hard as the intrusive rock fragments found within it) but flows when wet. A number of debris slides were seen that started in tree churns on the scarp faces. This material has failed extensively along the scarps above Harrop Creek.

Till based soils are common in the study area, but the nature of the soils varies considerably. Some of the till in the study area is stable and well suited to timber management. Other till based soils are prone to failure, especially when saturated. Some till soils are very sandy, with low coarse fragment content. These areas are prone to surface and gully erosion, as there are few coarse fragments in the soil matrix to armor exposed mineral soil as sand fragments wash away.

Glaciolacustrine: *Glaciolacustrine deposits are fine sands, silts and clay material deposited in or along the margins of glacial (ice dammed) lakes. Mappable glaciolacustrine silt deposits occur at two localities along Harrop Creek.*

Glaciolacustrine materials tend to form fine textured, nutrient rich soils. Soil stability is often low. Tree growth on these fine textured deposits may be limited by poor drainage. Glaciolacustrine soils are not common in the study area, but small inclusions (beneath mappable scale on initial field work) may be of concern during operation level planning.

Glaciofluvial: *Glaciofluvial materials exhibit clear evidence of having been deposited by glacial meltwater streams either directly in front of, or in contact with, glacier ice. Glaciofluvial deposits were found along the lower slopes, adjacent to the main tributaries and some smaller tributaries. Often glaciofluvial deposits have been channeled out by more recent fluvial processes, leaving steep, unstable slopes above the creeks. The deposits are generally sandy gravel and gravelly sandy textures, with 45-75% well to sub rounded coarse fragments. Much of the lower slope along Harrop is mantled with glaciofluvial materials that vary from cobble gravels to laminated sand. There is an old glaciofluvial fan*

> *located where Harrop Creek leaves the confines of the valley. Presently Harrop Creek is approximately 25 meters below the top of this fan.*

The texture and depth of glaciofluvial materials varies greatly, from thin layers of sand to deep, bedded terraces. Finer, more uniform sediments are quite unstable, and easily eroded. Glaciofluvial deposits along active creeks are prone to failure if the creek undercuts existing banks. Deep glaciofluvial terraces can be extremely dry, as soil water from upslope may flow through the site deep in permeable sediment layers, beneath the reach of tree roots.

> ***Colluvium (C):*** *Colluvium is material that has moved down slope as a result of gravity. Along the upper slopes of Harrop Creek and all along the west side of Narrows Creek there are numerous rocky cliffs and bluffs with talus slopes beneath them. Most colluvium in the area has a sandy to silty sand matrix, with blocky angular to sub-angular clasts of granitic rock and platy sub-angular pebble size clasts of less competent meta-sediments and meta-volcanics.*
>
> *Many small gullies have small colluvial cone deposits either of talus, or as the result of debris flows. These are usually too small to be designated on the map.*

Colluvial soils make up a small part of the study area. These soils are often naturally stable due to the mix of particle sizes they contain, but they are also generally located on steep slopes which offsets this favorable factor.

> ***Weathered Rock:*** *Saprolite is bedrock decomposed* in situ *by processes of mechanical and/or chemical weathering. Bedrock with high mica content in Narrows Creek is susceptible to weathering, resulting in silty textures with variable coarse fragment contents. In Harrop Creek, most of the ridge tops and much of the upper slope is underlain by saprolitic sand. This material is made up of sand with feldspar crystals (2.5 cm x 2.5 cm) and rotten rock fragments as the coarse fragment content. A typical saprolitic soil was sampled at station WH-9, where a 1.2 m pit revealed 90% sand, 10% silt with 15% coarse fragment content.*

Saprolitic deposits are generally found on the upper slopes of the study area, above the general level of glaciation or on areas which were not covered with a mantle of glacial material following the last ice age. We believe that these areas are generally outside of the timber management landbase, and are not a significant management concern. Fine soils with high sand content have a high sediment yield potential.

2.4 Fish and Wildlife

Numerous wildlife species are found within the Harrop-Procter watersheds. Large wildlife species include bald eagle, osprey, cougar, grizzly and black bear, white-tailed and mule deer. The study area is within Priority 2 and 3 grizzly bear habitat as described within the Kootenay Boundary Land Use Plan. Portions of the area are recognized as potential caribou habitat as it is adjacent to currently used areas of the last herd that travels between the United States and Canada.

The frequency of major creek valleys and deeply incised canyons present considerable obstacles to animal movement across the landscape. Maintenance of movement corridors and landscape connectivity will likely be critical to the long-term persistence of many species within the study area.

Table 1 lists the yellow, blue and red listed wildlife species in the Harrop-Procter watersheds. The table was prepared from information from the B.C. Ministry of Environment, Land and Parks web site. The color listings are defined by MELP as follows:

- **Red List:** Includes any indigenous species or subspecies (taxa) considered to be Extirpated, Endangered or Threatened in B.C.. Extirpated taxa no longer occur in the wild in BC, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Red-listed taxa include those who have been, or are being, evaluated for these designations.
- **Blue List:** Includes any indigenous species or subspecies (taxa) considered to be Vulnerable in B.C.. Vulnerable taxa are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed taxa are at risk, but are not Extirpated, Endangered or Threatened.
- **Yellow List:** Any indigenous species or subspecies (taxa) which is not at risk in B.C.. Some yellow listed species which are vulnerable during times of seasonal concentration (e.g. breeding colonies) are tracked.

Yellow Listed Species	
Long-Eared Owl	*Asio otus*
Cooper's Hawk	*Accipter cooperii*
Black-Chinned Hummingbird	*Archilochus alexandri*
Wood Duck	*Aix sponsa*
Vaux's Swift	*Chaetura vauxi*
Northern Pygmy Owl	*Glaucidium gnoma*
Northern Harrier	*Circus cyaneus*
Northern Goshawk	*Accipter gentilis*
Bald Eagle	*Haliaeetus leucocephalus*
Spotted Frog	*Rana pretiosa*
Wood Duck	*Aix sponsa*
Sharp Shinned Hawk	*Accipter striatus*
Pileated Woodpecker	*Dryocopus pileatus*
Common Goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Barrow's Goldeneye	*Bucephala islandicus*
Blue Listed Species	
Lewis' Woodpecker	*Melanerpes lewis*
Western Screech Owl	*Otus kennicotti*
Short-Eared Owl	*Asio flammeus*
Great Blue Heron	*Ardea herodias*
Rubber Boa	
Red Listed Species	
Coer d'Alene Salamander	*Plethodon idahoensis*
Red Tailed Chipmunk	*Tamias ruficaudus simulans*

Table 1: Yellow, blue and red listed wildlife species in study area.

Many of the species listed in Table 1 utilize or are dependent on large trees for nesting, roosting or denning. Amphibians are often closely related to the large fallen trees. Maintaining large diameter stems in all portions of the landscape, and maintaining old growth forests in protected areas, are critical components of long term wildlife management in the study area. The need for large lakeshore and riparian trees should be stressed. Bald eagles, herons, goldeneye and wood duck all require large stems near water for nesting and/or perching. These structures should be maintained and created within the belt of private land bordering Kootenay Lake.

Bulltrout, kokanee salmon and rainbow trout have been identified as occurring in Harrop and Narrows Creeks. Bulltrout and kokanee salmon have been observed in Procter Creek. Protection of streamside habitat and riparian ecosystems in areas frequented by fish is necessary to maintain healthy aquatic ecosystems and fish populations. Of course, maintaining water quality, quantity and timing of flow in these watersheds is also fundamental to maintaining fish populations, as well as to meeting human water needs.

2.5 Forest Ecotypes

The MoF biogeoclimatic classification system recognizes a series of descriptively named forest ecosystem subzones in the study area. Starting from the lake shore and moving uphill, these are:

- ICHdw - Dry Warm Interior Cedar Hemlock
- ICHmw2 - Columbia - Shuswap Moist Warm Interior Cedar Hemlock
- ESSFwc1 - Columbia Wet Cold Englemann Spruce - Subalpine Fir[2]
- ESSFwc4 - Selkirk Wet Cold Englemann Spruce - Subalpine Fir
- ESSFwcp - Wet Cold Parkland Englemann Spruce - Subalpine Fir
- AT - Alpine Tundra

As shown by the above list, forest ecology and tree species composition varies widely across the Harrop-Procter watersheds.

The lowest elevation zone, the ICHdw, is noted as the most diverse biogeoclimatic subzone in British Columbia in terms of tree species. It contains 14 commercial tree species, as well as rare shrubs. The ICHmw2 contains fewer tree species, as less cold tolerant species such as grand fir drop out of the species mix. Both of the ICH subzones are dominated by younger stands of Douglas-fir, western larch, and pine which originated following human caused fires in the early 1900's. In many areas, an understory of shade tolerant, long lived climax trees species (cedar, hemlock and grand fir) has developed beneath the seral conifer canopy. Over centuries, baring further fire disturbance, the shade tolerant species would tend to dominate the site. As individual members of the shade intolerant seral overstory die, the only trees available to take their place would come from within the shade tolerant understory, as larch, Douglas-fir and white pine will not regenerate successfully in the deep shade beneath a mature closed canopy forest.

On moist rich sites, forest managers have a choice between managing to retain the shade intolerant seral species through creating well lit canopy openings, or facilitating the gradual conversion to shade tolerant species by using harvest systems which maintain partial canopy closure and low light levels at ground level. A mixture of the two approaches is likely desirable.

Only scattered pockets of ICH old growth forests remain in the study area. Natural ecosystem processes and First Nations management prior to European settlement are generally believed to have resulted in lower rates of ignition and lower total burned area, and thus more old growth forest within the landscape. Observations of large old stumps, logs and snags scattered through the current young ICH forest certainly support this perception, but quantifying the extent of old growth forests prior to 1880 is beyond the scope of this study.

[2] Subalpine fir and grand fir are both commonly referred to as "balsam". The trees are somewhat similar in appearance, and have similar wood. Subalpine fir is a high altitude species well adapted to life in areas with cold winters and heavy snowloads. Grand fir is a low elevation, shade tolerant species which requires warm, moist conditions.

Figure 5: Old growth forest in Wilson Creek.

This photo shows the main stem of Wilson Creek, from the upper elevations in the watershed. The Wilson Creek drainage was originally part of the study area, but has since been added to Huscroft Lumber Ltd's chart area and is no longer part of the Harrop Community Forest proposal. However, this photo of Wilson Creek shows several interesting features which are relevant to the remaining study area.

First, one of the only large contiguous areas of interior cedar-hemlock old growth forest in Harrop-Procter watersheds is shown in the lower foreground of this picture. Likely by chance, this area was not burned by the great fires near the turn of the century, and was not burned by a more recent fire in the upper elevations of Wilson Creek. The coarse texture and variable crowns of the old growth forest show up clearly (the golden larches in the near foreground are perched on a high rock bluff overlooking the old growth forest and lower Wilson Valley). Old growth forests are a critical component of any healthy forest landscape, and are a rare forest type throughout the lower elevation Harrop-Procter watersheds. This particular patch of old growth forest was selected for protection by the Harrop-Procter water users, but we now expect it will be clearcut in the relatively near future by Huscroft Lumber.

The picture also highlights the general morphology of the Narrows, Irving, and Wilson Creek valleys. The eastern side of the valley falls in long, relatively moderate slopes from the ridge crest to the floodplain of the creek. The angle of this photograph suppresses relief. Actual slopes on the east slopes are in the 50-60% range, and exposed rock can be found throughout the walls of the valley. The western slopes of these valleys rise in jagged screes and extremely steep slopes with limited vegetation to a sharp crest. Two distinct habitat types are found in each valley: the long forested slopes and the extremely exposed steep slopes on the far side of the valley.

The photograph also highlights the relatively small size of the timber management landbase, even in the most favorable terrain in the study area. All of the areas on the left side of the creek are ecologically sensitive and not within the Ministry of Forests or the Silva timber management landbase. The upper slopes on the right side of the picture are clearly sensitive sites with thin soils over bedrock. Portions of the main forested valley are occupied by riparian zones, by gullied terrain, by old landslide scars, and by steep rock walls hidden by the trees. These are not part of the timber management landbase.

The ESSFwc1 subzone is a transitional forest zone between the lower elevation ICH zones, and the high elevation spruce and subalpine fir forests above. While dominated by spruce and subalpine fir, it also contains cedar and hemlock trees, generally as an understory.

The upper ESSF ecotypes are dominated by Englemann spruce and subalpine fir forests, tree species adapted to short growing seasons and deep winter snow. Natural fire disturbance is not common in these wet, cool ecosystems, and fires from the early 1900's did not reach the upper elevations of the study area. Therefore, the upper elevation forests ecosystems are dominated by old growth stands. The main natural disturbance processes are tree fall or group blowdown. Stand density decreases as elevation increases, eventually verging onto open parkland forests as growing conditions become more difficult and more dominated by deep, persistent snowpacks.

The Harrop-Procter watersheds contain an unusual upper elevation forest ecotype. Extensive areas of white bark pine (Pinus albicaulis) in pure stands and as dominant species in mixed stands are found on dry, rocky sites at in high elevations. (See Figure 6.) White bark pine is commonly found in small stands and patches on dry ridge crests throughout the Kootenays, but it is not often seen covering large areas. White bark pine is adapted to harsh, high altitude conditions, and grows on dry, exposed sites more successfully than the other subalpine tree species. It has an unusual, and beautiful, growth form, with several curved stems rising from a central point to form a small clump of trees.

White bark pine has a tight symbiotic relationship with a jay-sized bird, the Clark's Nutcracker. The nutcracker depends on the large pine seeds for its main food source, and in turn spreads the pine from one isolated, dry ridge habitat to another. This tightly woven piece of the ecosystem is rapidly unraveling. White pine blister rust, a tree disease introduced with white pines imported from Asia for ornamental use, is devastating the white bark pines throughout the southern interior of British Columbia. Some individual trees are likely resistant, but whether the white bark pine and the Clark's Nutcracker can survive the introduced plague, in the naturally harsh ecosystem they inhabit, is unknown.

Figure 6: High elevation forests beside Narrow Lake in Irving Creek.

The broad expanse of forest in the foreground, beside the lake, and running off along the valley bottom, is indicated by the Ministry of Forests as spruce, balsam, and white bark pine old growth. We visited this site in our field work and found the area to be reasonably well-drained with stable soils and moderate terrain, but our assessment of tree cores showed extremely slow growth rates, indicative of climatic limitations on forest growth in the area. When this picture was taken, the aircraft was flying over the Irving Creek headwall, an expanse of north-facing rock walls which would contain snow cover for much of the early part of the growing season, and likely accumulate snow early in the fall. Cold air flowing off this north-facing cirque wall would tend to pond in the valley, resulting in late frosts in spring and early frosts in fall.

The area above the lake shows typical upper elevation conditions of exposed rock and forests perched between rock bluffs. The forests on the upper ridges behind the lake are dominated by white bark pine, which is a minor component in many upper elevation forests in British Columbia, but which occurs as a dominant species throughout the upper elevations of the Harrop-Procter watersheds. These expansive white bark pine stands are an ecologically significant feature of the study area.

2.6 Human Geography

2.6.1 First Nations Use and Heritage

The HPWPS contacted the Ktunaxa Kinbasket Tribal Council and the Sinixt First Nation to request mappable information on past First Nations use and activities in the Harrop-Procter watersheds.

Material from the Ktunaxa Kinbasket Tribal Council was not available in time to be included in this report.

Robert Watt of the Sinixt delivered the information used to prepare the map shown in Figure 7 to the Silva office. Kutenai West Heritage Consulting Limited states in a December 8, 1998 letter to the Sinixt Nation:

> *...the probable areas of archeological concern will be along flat to gently sloping landforms associated with: (a) the West Arm of Kootenay Lake and Kootenay Lake proper; (b) mouths of creeks emptying into these two waterbodies; (c) subalpine and alpine lake margins; (d) subalpine and alpine meadows and parkland; and (e) areas of old growth forest (specifically western red cedar).*

A set of archeological sites have been identified along the shore of Kootenay Lake. In addition, the Sinixt identified the open alpine ridge crests and the flat lower Kootenay Lake valley slopes as areas which were important use sites. These areas are shown on the map in Figure 7.

There is little conflict between the forest management proposals in this Ecosystem-based Plan and the First Nations Uses shown. There is overlap between the high use zone along the lower slopes beside the West Arm and current settlement patterns, but settlement control is outside of the scope of this plan. The upper elevation flats noted by Kutenai West are well outside of our timber management landbase. We hope that the general principles of this ecosystem-based approach (maintaining ecological structures and functions) will minimize conflicts between ecologically responsible forest use and First Nations uses. With regard to point (e) above, there is little or no red cedar old growth left in the Harrop-Procter watersheds, and what there is will be protected under ecosystem-based management.

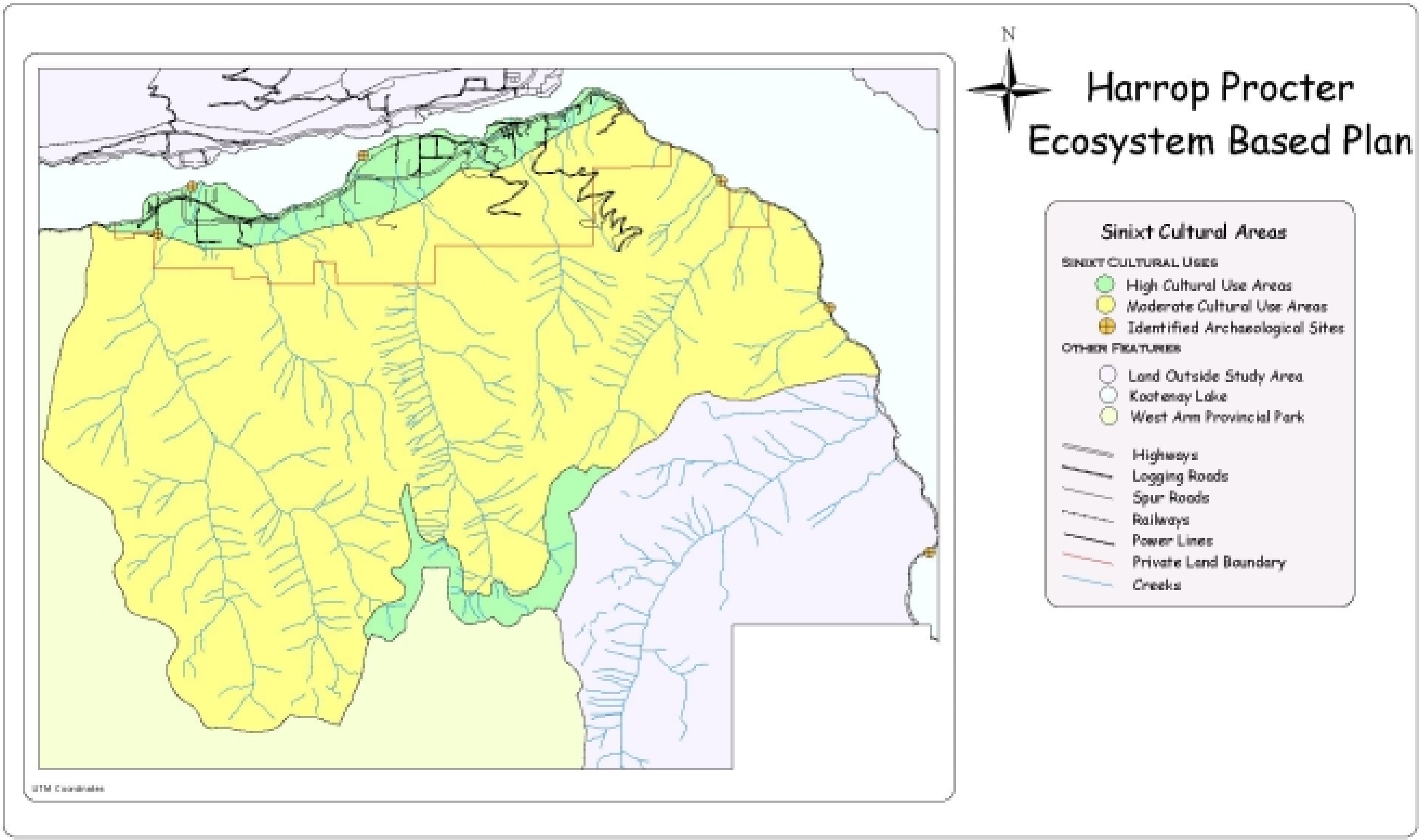

Figure 7: Map of First Nations Use Zones identified by Sinixt Nation.

2.6.2 Current Settlement Pattern

The rural communities of Harrop and Procter are located on low elevation terraces beside Kootenay lake at the north end of the study area. Human settlement density is generally low, as most residences are located on several acres of land. A great deal of green space permeates the community. The outer boundary of private land is shown on all of the maps included in this report.

A large proportion of the settled area is within the riparian zone of Kootenay Lake. Settlement naturally concentrated on the gently sloped, more arable land on the alluvial terraces and glaciofluvial terraces along the main Kootenay Lake valley, and on the broad fluvial fans at the mouths of the major creek valleys.

Figure 8: Settlement on the Kootenay Lake Floodplain.

This picture shows the flat Kootenay Lake floodplain, which is dominated by human settlement and development. Harrop is in the foreground, and Procter in the background.

The pattern of settlement has a significant impact on the potential for forest management in the Harrop-Procter watersheds. While private land occupies 18% of the study area, 48% of the area identified by Silva as stable terrain which is potentially suitable for timber management[3] falls within the private holdings. The private land includes a large proportion of the potential timber management landbase in this landscape, due to the conjunction of the tendency to settle on gently sloped terrain, and the steep and sensitive nature of much of the terrain in the study area outside of the main Kootenay Lake valley.

The boundary of private land is shown on the maps presented in this report.

[3] See Section 4.1.2 for more information.

Current Land Uses

Current land uses in the study area were identified during a series of meetings with the HPWPS.

As described above, the current land use on the lower elevation portions of the study area is human settlement.

The main current land use of the upper, backcountry portions of the Harrop-Procter watersheds is water production. The Harrop-Procter community relies on surface water from the area for domestic and agricultural water supplies.

Community members also identified areas used for wildcrafting, camping, hiking, fishing and grizzly bear viewing during this project. These areas are shown on the map in Figure 9.

Human access to most of the watershed is very limited at this time. Vehicle access is restricted to the lower slopes of the main Kootenay Valley; no roads penetrate into the side valleys. A rail grade runs along the lakeshore throughout the study area. Old mining trails and recreational trails provide foot, bicycle, horse and llama access for recreation use to the Harrop Creek drainage, to a part of Procter Creek Drainage, and along the ridge crest east of Mill Lake.

A neighboring land use also has an important impact on human uses in the study area. The areas south and west of the Harrop-Procter watersheds is part of the West Arm Provincial Park. Small protected areas are still required throughout smaller landscapes in order to maintain undisturbed habitat nodes throughout the forest landscape, but the protected area in this Class A park fulfills the need for large protected areas within a larger landscape unit.

The Harrop-Procter watersheds also form an important viewscape from the Kootenay Lake ferry, the Nelson / Kaslo highway, and the prosperous North Shore.

Timber management in the study area has been limited to private land, and a small area of crown land in the north west corner of the study area which is reached from Alexander Road. Timber management activity is likely to increase in the near future. The HPWPS is currently negotiating a form of Community Forest tenure over the crown land in the study area, and plans to implement ecologically responsible forest use in the Harrop-Procter watersheds.

Timber management will lead to an increase in road access, with attendant benefits and costs. Recreational access and activity will be increased, as will the potential for wildcrafting. However, increased access also increases the potential for undesirable impacts on domestic water supplies, increased hunting pressures, and increased noise and disturbance. The community will need to address the difficult issues and legalities of access control to crown land.

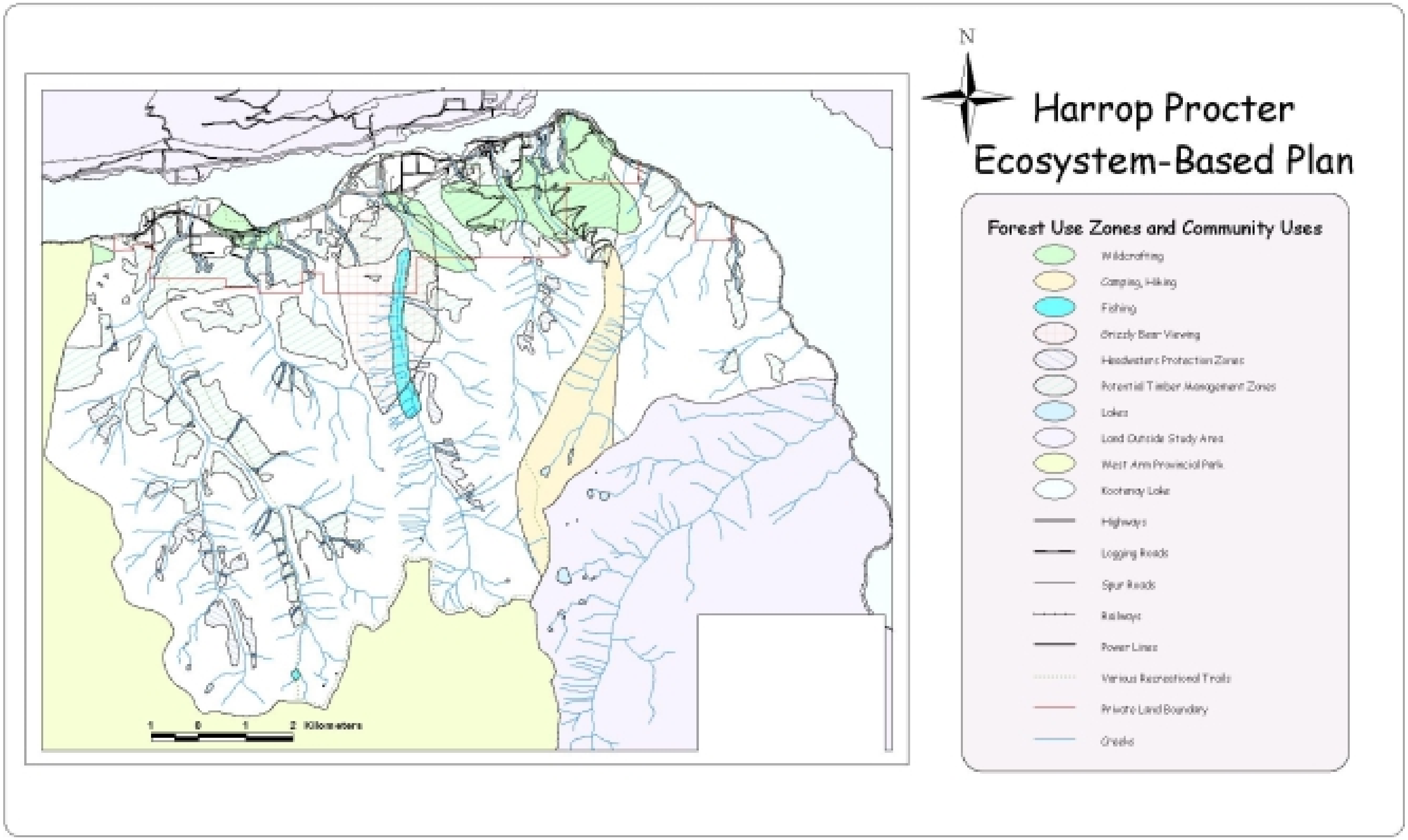

Figure 9: Map of Community Forest Uses designated by Harrop-Procter community members.

2.6.3 Impacts on Landscape Ecology

The main impacts from the current patterns of human use in the study area are on vegetation pattern and habitat availability. Impacts are caused by a combination of land clearing for settlement and alteration of natural fire frequency patterns.

The flat, moist areas beside Kootenay Lake were once a significant component of the Harrop-Procter landscape ecosystem.

The Kootenay Lake riparian ecosystem, and the riparian ecosystem of the main creeks crossing the lower terraces, likely contained old growth cottonwood, cedar, spruce, and hemlock forests prior to human settlement. Clearing and agriculture have removed the original forests and replaced them with fields, housing, and scattered small patches of younger woodland. There are few large-diameter stems left on the floodplain to provide habitat for birds and animals which would normally live on this broad riparian ecosystem. Some of the only large-diameter habitat occurs within two small patches of older cottonwood forest near the Harrop Narrows. A valuable ecological restoration project, which would have to occur almost entirely within private holdings, would be to increase the area of large-diameter forest patches on the Kootenay Lake floodplain.

The lower slopes and shoreline area would likely have been an important movement corridor through the study area. As discussed in Section 4.4.4.4, movement between the side valleys in the Harrop-Procter watersheds is difficult. The best movement corridor between valleys in most locations is along the slopes of the main Kootenay River valley, between the lower end of adjacent watersheds. This main movement corridor is now impacted, and perhaps cut for some species, by the settlement area and the pervasive human atmosphere of noise, traffic, and dogs.

The Harrop and Fraser Narrows likely once were a significant movement channel for larger terrestrial mammals across the narrowest part of the West Arm of Kootenay Lake. The Narrows are now isolated from the rest of the Harrop-Procter landscape by the settlement belt. Access to the north side of the Narrows is similarly impaired by settlement and roads. Marine traffic from small craft and ferries also likely reduces the likelihood of a successful crossing. The use of these crossing places is undoubtedly reduced by the impacts of settlement.

Due to the low settlement density and abundant small wooded areas, many small animal and bird species likely find the settled area permeable to movement and habitable. Deer also move freely through the settled area. However, other species, particularly large predators such as cougars and grizzly bears, are largely excluded from the area by human use patterns and behavior.

The mid and upper slopes of the main Kootenay Lake valley and the mid and lower reaches of the smaller side valleys have been indirectly impacted by human settlement. Forests in these areas were extensively and intensively burned, likely several times, in the period before 1910. While natural and human caused forest fires would have occurred in the study area regularly since the last ice age, the extent of the burning in the period between the start of European immigration and the start of modern fire suppression seems unnaturally high. Ignition from railroads, land clearing, logging, prospecting and other activities burned almost all of the lower elevation landscape, and greatly reduced the proportion of old, large diameter timber stands in the landscape. This alteration in vegetation cover has a significant impact on stand and landscape ecology in the study area.

Many forests in the B.C. dry interior have been severely impacted by aggressive fire suppression following the initial period of unusually extensive forest fires associated with European settlement. Dryer forest areas were adapted to thrive with frequent, low intensity ground fires. Now that all fires are suppressed, these dry site forests are suffering from an array of ecological problems. This particular ecosystem management problem does not affect the forests in the Harrop-Procter watersheds, as the north facing study area is cooler and moister than the dry forest ecotypes in question, and would likely have had a longer fire return interval.

In summary, human settlement has significantly altered the vegetation cover of a unique and exceptionally productive portion of the Harrop-Procter landscape. Settlement has directly displaced many animals, cut movement routes, and removed ecological structures required for habitat. The resources on the lower slopes which have been lost to settlement cannot be replaced from other portions of the Harrop-Procter watersheds as they do not exist in other places. Careful management of remnant ecosystems is needed to maintain current habitat levels, and restoration activities would likely help in creating and maintaining additional riparian habitat resources.

2.6.4 Community Viewpoint

The HPWPS conducted a community survey to determine local preferences for forest use in the Harrop-Procter watersheds. The survey was sent to every home in the area via Canada Post. A large majority of respondents supported an ecosystem-based forestry type of approach, a middle ground between full protection and conventional timber cutting. Ecosystem-based forest use will address and satisfy the needs and concerns of most interest groups in the community.

More than 50% of the respondents to this questionnaire favored ecosystem-based planning and management for the Harrop-Procter watersheds, while an additional 25% thought that the Harrop-Procter watersheds should be closed to any resource extraction development in order to protect water and the existing quality of rural life. Only about 25% of the respondents thought that traditional Ministry of Forests timber management was appropriate for the Harrop-Procter watersheds.

By a significant margin, protection of domestic water quality was rated as the most important function of the Harrop-Procter watersheds. Other high priority functions, in order of importance per the community questionnaire, are wildlife habitat protection, wilderness preservation, scenery, logging according to an ecosystem-based plan, closure of watersheds to industrial development, and non-logging jobs dependent on the forest. The Harrop-Procter Watershed Protection Society believes that the results of this questionnaire clearly indicate the community's desire for an ecosystem-based approach to the planning and use of the Harrop-Procter watersheds.

3. Field Work and Procedures

This reconnaissance level assessment is supported by a bare minimum of field work. Time and budget constraints, and the limited access to the study area, greatly constrained field assessments.

Prior to the field surveys, air photo interpretation of ecological sensitivity and potential timber management areas was carried out in order to familiarize ourselves with the terrain and ecotypes, and to identify areas of interest which would be visited in the field. A 1.5 hour flight over the watersheds in a fixed wing aircraft helped to verify the air photo interpretation, and to look for helicopter landing points.

Two types of areas were visited in the field survey portion of the assessment:

1. Areas which we were confident we could classify as sensitive or stable from air photo interpretation. Forested areas in this classification were checked to ensure that our confidence was not misplaced, and that the terrain and photo patterns we were interpreting from past experience were representative of the expected ecosystem types in this study area. These areas had a moderate priority for field assessment. This portion of the limited field survey was a check of interpreted information which we have a high degree of confidence in.
2. Areas which we were not able to classify as sensitive or stable from air photo interpretation. Forested areas in this classification were checked to enable us to map them properly on the Ecosystem Sensitivity to Disturbance map generated by this project. The priority of these areas for field assessment varies inversely with their frequency. Any type of unknown area which occupies a small area has a low priority, unless it was close to other field work or excellent access. We are not able to devote a substantial portion of the field budget to assessing one unusual area. However, a difficult to classify type which is extensively distributed has the highest priority for field assessment, as classifying such sites properly as sensitive or stable terrain has a significant impact on the results and reliability of the assessment.

Access to the Harrop-Procter watersheds is poor. Road access only extends for a short distance above the communities of Harrop and Procter, and the dense second growth forest in most of the middle elevations contains no helicopter landing sites. Small mid-slope wetlands are often used for helicopter access by field crews, but these are largely absent in the Harrop-Procter watersheds. There are abundant helicopter landing places on ridge crests and in alpine basins, but these sites are generally too far removed from areas of interest. The limits of feasible crew access by truck or by helicopter greatly constrained the location of our field assessments.

Tom Bradley of the SFF, accompanied variously by Jody Hoffman of the SFF, by Rami Rothkop of the HPWPS, and by other concerned citizens and SFF staff, carried out six days of field work in the study area in the fall of 1997. Two days were spent on the main West Arm valley face, working from areas accessible by truck. Three days were spent working from helicopter landing sites in the headwaters areas of Wilson, Irving, and Narrows creeks, and one day was spent working from an old MoF helicopter pad in the main stem of Harrop Creek. To reduce costs, helicopter flying time from Nelson was shared with crew members from William H. Wells Consulting Ltd., who were conducting a terrain survey of Harrop, Wilson and Narrows Creeks concurrently with our field surveys.

Field procedures consisted of traversing and mapping through the area being assessed. A minimum of a two person crew was used at all times. Distances were measured using a 75 meter nylon chain. A hand compass was used to identify azimuth of travel. Traverse lines were oriented perpendicular to the contours to ensure that the full range of ecosystem types in an area were assessed. A sketch map was drawn along the traverse route, recording soil moisture, ground slope, presence of rock, approximate soil depth, and an on site assessment of ecological sensitivity. Timber types were also mapped.

In addition, a set of site characteristics were recorded on standard forms periodically to provide a formal record of soil and site parameters. The height and age of co-dominant trees were measured within main forest types to estimate site index, or growth potential.

The field work and aerial reconnaissance were used to verify and/or improve the initial air photo interpretation. Each traverse route was identified on the relevant air photos, and areas identified as ecologically sensitive on the traverse were compared to areas identified as ecologically sensitive on the air photos. In places where the two interpretations did not agree, the air photo interpretation was modified to respect the field survey information. If, in the opinion of the interpreter, the field information indicated that an air photo pattern had been misinterpreted, all of the air photos in the set were revised to reflect the newly derived correlation between air photo pattern and site sensitivity.

3.1 Timber Yield Estimates

We used Variable Density Yield Prediction Version (VDYP) software Version 6.4, published by the Ministry of Forests, to estimate timber yield for this project. We used VDYP in the "batch" mode to estimate the yield for each forested polygon in the forest cover data file.

The estimated yield, or MAI, calculated by VDYP is an estimate of <u>net</u> timber yield in cubic meters per hectare per year. That is, allowances have been made for losses to decay and for waste and breakage during logging, using standard MoF netdowns.

VDYP was used to calculate timber yield at culmination age (age at which maximum average annual growth rate is reached), which is often significantly less than a desirable cutting age. However, a yield reduction is applied in the final stages of the summary process to allow for this. (See Table 9.)

Main variables required by VDYP include site index and crown closure of the stand. Site index is an estimate of the growing capacity of each forested site. We used the site index provided in the forest cover data files. Crown closure is an assessment of the percentage of stand area occupied by the crowns of the overstory trees in a stand. We used the VDYP defaults for each species group in the study area. We considered using the crown closure listed in the forest cover data file, but decided that basing long-term timber productivity on current crown closure, which in some cases may be more a function of recent history than site capability, was not a suitable methodology.

4. Ecosystem-based Assessment Maps

A critical component of this project is a set of maps which show:

1. Silva Ecological Sensitivity to Disturbance Rating
2. Landbase Unsuitable for Development, per the MoF and Silva
3. Old Growth Forests
4. Protected Landscape Network
5. Community Forest Uses and Proposed Protected Forest Zones

Folios of these maps at 1:22,500 and 1:40,000 scale accompany this report. Tabloid-sized reproductions of the maps are also bound into the report.[4]

The map sets were produced using PAMAP GIS, a raster-based GIS which also manipulates and presents vector information. A 10 meter raster size was used for the project, meaning that the island was represented and analyzed using a grid of 10 meter by 10 meter squares.

The map set was produced using the following spatial data sources:

- B.C. Ministry of Forests forest cover data files updated to November 1996
- B.C. Ministry of Environment, Lands and Parks terrain resource inventory mapping (TRIM) data files
- photo-interpreted information, which was transferred to paper base maps and digitized
- information from community members transferred to paper base maps and digitized

The following sections of the report describe the data source(s) and method used to create each map of the set, and explain the philosophy and science behind the maps developed specifically for this project. A tabloid-sized copy of each map is included, with a table and graph of stratification areas where appropriate.

4.1 Silva Ecological Sensitivity to Disturbance Rating

The shape of the terrain, the slope gradient, the soil depth, the soil texture, the amount of moisture available, and local climatic conditions are key factors in defining the ecological limits to human use of forest ecosystems. Technologically equipped, industrial resource exploitation virtually knows no limits. Modern industrial timber extraction seeks to mitigate ecological limits by application of different technology on more sensitive sites and/or slower removal of timber from more sensitive ecosystems. This approach is rooted in short-term economics, where the value of current returns exceeds the value of long-term productivity. Logging sensitive sites often results in impacts which exceed the capacity of an ecosystem to absorb disturbance without substantial ecological change, that is, the

[4] The tabloid sized maps are simple reproductions of the larger maps, and some small features and text may not be legible. Revising the entire map set to optimize print quality at 1:70,000 scale was beyond the scope of the project.

impacts of the disturbance exceed the ecological limits. Disturbance and change are required in ecosystems, but disturbances which exceed ecological limits result in change to the ecosystem, not fluctuations within ecosystem limits. Disturbances which exceed natural limits result in site degradation such as soil erosion and landslides. These events result in long-term ecological change, negatively impact the logging site, damage downstream water supplies, and cause population losses in wildlife populations which depended upon the resources of the undisturbed area to meet a portion of their needs.

Ecosystem-based planning and activities require that ecological limits be respected, and that human uses be designed to prevent (as opposed to mitigate) damage to ecosystem functioning. Thus, identifying ecological limits is the starting point for the development of ecosystem-based plans.

Our landscape analysis and planning methodology is based upon the principle that economies are subsets of human cultures or societies, which are subsets of ecosystems. In other words, human societies and their economies are dependent upon the natural diversity and integrity of the ecosystems they are part of. The primary objective of an ecosystem-based plan must be to maintain fully functioning ecosystems at all scales through time in the landscape being planned. To a large extent, this is achieved by respecting ecological limits through identifying and protecting ecologically sensitive areas.

4.1.1 Delineating Ecologically Sensitive Areas

Silva uses an Ecosystem Sensitivity To Disturbance (ESD) rating system to estimate the sensitivity of parts of the landscape to human uses. Map and air photo interpretation, coupled with field assessments, are used to determine the characteristics of the landscape through this rating system, which has been developed and refined by the Silva staff over the past 15 years. Further information on the Silva ESD Ratings system is contained in Appendix 1.

The ecological sensitivity to disturbance rating or classification system is based upon ecological limits as described by a group of physical factors which are:

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

Various combinations of these factors result in high or extreme ecological sensitivity to disturbance ratings. Timber management, road construction, mining, and other activities that require extensive modification of ecosystems are excluded from all but the stable and moderately stable areas. Sites which generally are rated with “high” or “extreme” sensitivity include:

- Riparian ecosystems
- Steep terrain (slopes greater than 60%)
- Wetlands
- Complex terrain

- Areas of shallow soil
- Dry sites, such as ridge tops and deep gravel soils
- Areas dominated by avalanche chutes
- High elevation transition forests

In Silva's opinion, the ecological limits indicated by high and extreme ecosystem sensitivity to disturbance ratings are such that unacceptable losses of ecosystem functioning will result if timber management, road construction, mining activities, and other consumptive resource extraction occur in these ecosystem types. Mitigation measures and high-quality conscientious operations cannot overcome or obviate the ecological limits. This assessment is based on the principle that prevention of ecosystem degradation must be placed ahead of mitigation of ecological limits. Indeed, "mitigation" of ecological limits is seldom, if ever, successful in maintaining ecosystem functioning, particularly in the long term.

Ecologically responsible timber management, road construction, mining, and other consumptive resource extraction activities are permitted within moderate and low ecosystem sensitivity to disturbance (ESD) ratings. Such activities can also be carried out in low and moderate ESD inclusions located within larger high and extreme ESD rating areas.

4.1.2 ESD Mapping

The ESD data layer was derived through a combination of air photo interpretation, field reconnaissance, existing information, and GIS modeling. Polygons of land with similar ESD status were delineated on air photos, field verified, and then imported into the GIS.

The riparian ecosystems were modeled by creating a variable width buffer around water features in the GIS, which was then added to the digitized ESD layer. Figure 10 shows a map of the final results of this process. Table 2 summarizes the areas of the stratifications shown in Figure 10 , and Figure 11 presents a chart of the stratifications.

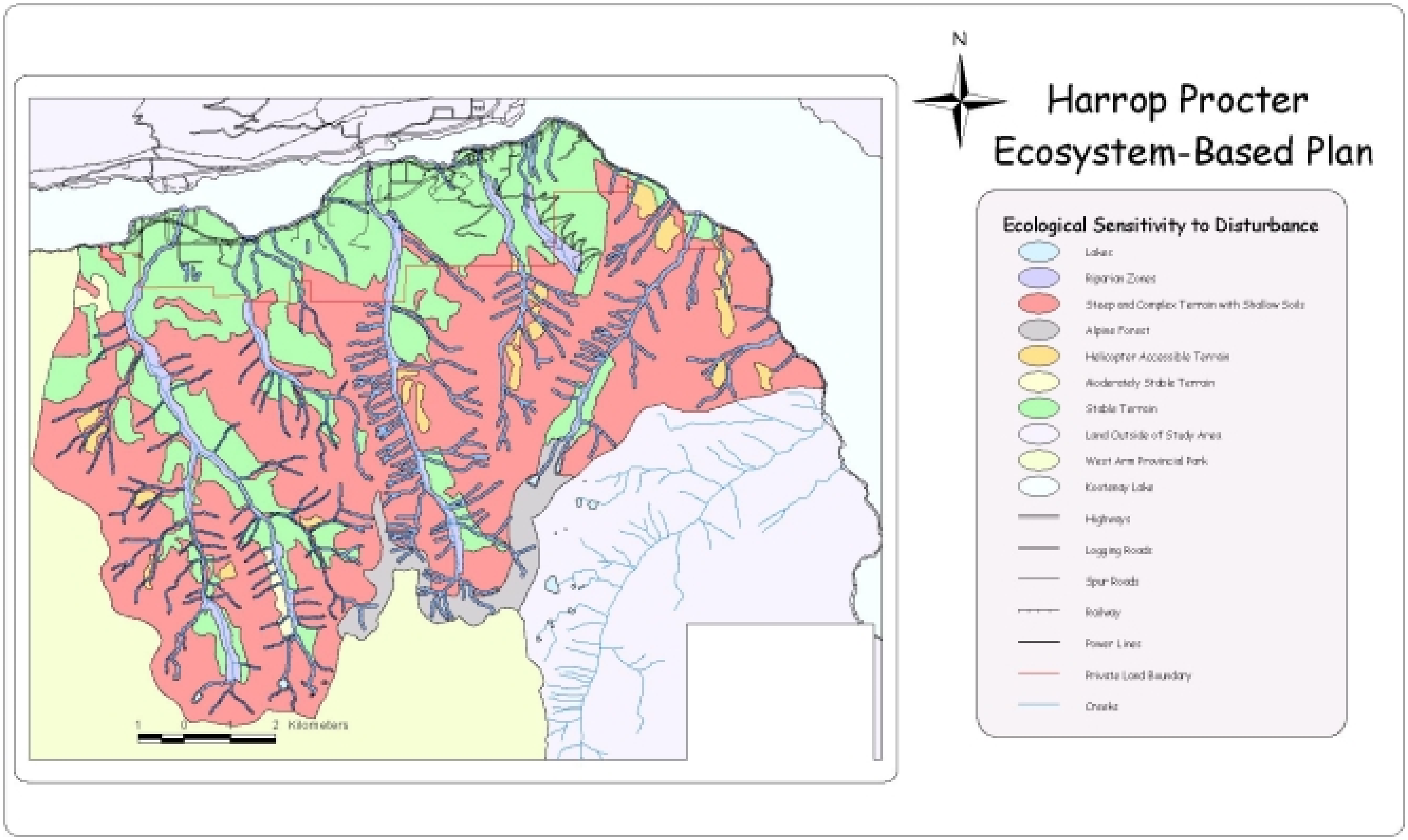

Figure 10: Map of Silva Ecological Sensitivity to Disturbance Classes in Harrop-Procter watersheds.

Silva Ecological Sensitivity to Disturbance												
Description	Crown Land				Private Land				Crown and Private Land			
	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI
Lakes	12	0.1%	0	0.0%	1	0.0%	0	0.0%	13	0.1%	0	0.0%
Ecologically Sensitive Ecotypes												
Riparian Ecosystems	1,531	11.8%	3,311	11.4%	353	2.7%	705	2.4%	1,884	14.5%	4,017	13.8%
Steep and Complex Terrain with Shallow Soils	6,510	50.2%	14,759	50.8%	209	1.6%	645	2.2%	6,719	51.8%	15,404	53.0%
Alpine Tundra and Forests	448	3.5%	343	1.2%	0	0.0%	0	0.0%	448	3.5%	343	1.2%
Subtotal:	8,489	65.5%	18,413	63.3%	562	4.3%	1,351	4.6%	9,051	69.8%	19,763	68.0%
Landbase Potentially Suitable for Development												
Helicopter Accessible Terrain	282	2.2%	745	2.6%	5	0.0%	19	0.1%	287	2.2%	764	2.6%
Moderately Stable Terrain	80	0.6%	150	0.5%	0	0.0%	0	0.0%	80	0.6%	150	0.5%
Stable Terrain	1,833	14.1%	5,042	17.3%	1,704	13.1%	3,357	11.5%	3,537	27.3%	8,400	28.9%
Subtotal:	2,195	16.9%	5,937	20.4%	1,709	13.2%	3,377	11.6%	3,904	30.1%	9,314	32.0%
Total:	**10,695**	**82.5%**	**24,350**	**83.7%**	**2,273**	**17.5%**	**4,727**	**16.3%**	**12,968**	**100.0%**	**29,077**	**100.0%**

Notes:
1) Gross MAI is net of deductions for decay only, and are not net of deductions for waste, breakage, maintenance of ecology significant structures and longer rotations. These deductions are expected to further reduce MAI by at least 30%.

Table 2: Area of Silva Ecological Sensitivity to Disturbance Classes

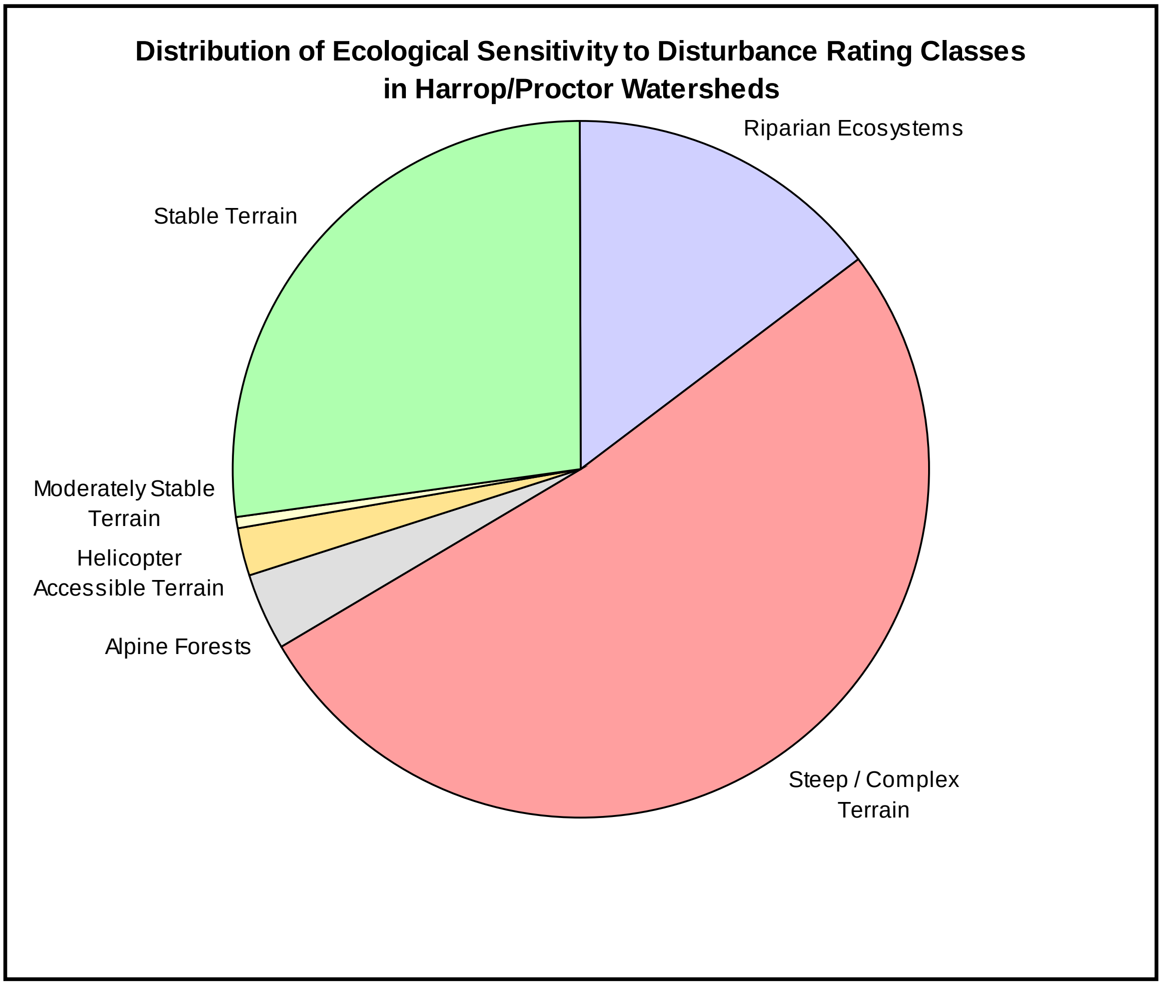

Figure 11: Graph of Ecological Sensitivity to Disturbance Classes in Harrop-Procter watersheds.

The Harrop-Procter watersheds are, as previously noted, dominated by steep terrain, rugged upper slopes, thin sensitive soils and extensive upper elevation ecosystems.

Silva ESD ratings are based on combinations of soil depth, slope, soil moisture, and terrain complexity. We used stereo pairs of 1:70,000 black and white air photos and 1:20,000 topographic maps to initially delineate sensitive areas. These 1:70,000 photographs cover large areas, allowing the interpreter to see and understand landscape level patterns, but they suffer from relatively low resolution, and greatly exaggerate relief. This makes precise identification of steep terrain difficult, as most slopes appear steep.

We used digital TRIM mapping for the area to create a digital elevation model (DEM) of the study area. The DEM was used to create a simple map showing a raster coverage of all slopes over 60%. Overlaying this map directly on our data set of various polygon levels resulted in a very pixellated final data set, dominated by square bricks of color from the steep slopes identified by the DEM. This was unattractive, and also somewhat invalid. Every single cell of steep slope read from the DEM was shown, whereas what we were most interested in were areas which the DEM indicated to be dominated by slopes over 60%. We experimented with various filtering, raster size and smoothing options, but in the end elected to interpret areas of significant steep slopes by eye, draw the selected areas on the steep slopes map, and digitize them to add them to our existing data set of photo interpreted ecologically sensitive areas.

Larger scale 1:20,000 black and white air photographs were used for a final check of all areas which had been identified as part of the potential Timber Management Landbase.. Each 1:20,000 photo covers only 30% of the land area shown on the 1:70,000 photos, so the 1:20,000 photos provide a more detailed look at terrain and landforms, although they do not show landscape level features well. Areas identified on the 1:70,000 photos as steep, rocky and/or shallow soiled were not reviewed, but all forested middle to lower slopes were carefully checked on the 1:20,000 photos. Many polygon boundaries were fine-tuned, and a series of helicopter accessible blocks were added on the east side of the study area, on the slopes above Kootenay Lake.

A reconnaissance level field check of the photo-interpreted terrain sensitivity was carried out over the fall of 1997, as discussed in Section 3.

The following ESD classes were identified in the Harrop-Procter watersheds:

- **ES 1** - Large Riparian Ecosystems and **ES** 7 - Wetlands. These ecotypes are located in valley bottom areas, near lakes, or in forested areas which contain many small perched wetlands. As computer-generated buffers were added around all mapped wetlands and streams in later steps, photo-identified riparian ecosystems were only delineated where the Silva staff believed that the computer-generated buffers would be inadequate. Large buffers were added in many upper basins where large, flat riparian ecosystems were noted, and in some lower reaches where creeks run in deeply incised valleys. In these locations, the riparian ecosystem extends from the lip of the valley to the creek.

Figure 12: The riparian ecosystem, midstem Harrop Creek.

The riparian ecosystem at this point is fairly narrow. The sides of the Harrop Creek valley drop moderately steeply to end at a small flat floodplain on the valley bottom. Moisture and seepage sites are common in the lower 100 meters or so of the valley sides. Larger trees and old growth veterans occur in the flat riparian zone which is somewhat more fire-resistant than the drier hillsides. The riparian ecosystem forms a movement corridor through this area and also provides a significantly different set of habitats than the drier upland forests which surround it. Because it contains moving water, the riparian ecosystem is also a sensitive location which should not be disturbed by extensive human uses. All riparian ecosystems, and a buffer on either side of them, are protected under the proposed ecosystem-based plan for Harrop-Procter.

- **ES 2 -** Steep Terrain. ES 2 terrain includes all areas with slopes greater than 60%[5] gradient. Steep slopes are unstable and prone to landslides and other forms of erosion, especially after logging and road construction. Steep sites can be economically logged with modern equipment, but we believe that they are too ecologically sensitive to be sustainable timber management sites. Steep slopes are common in the rugged terrain in the side drainages in the Harrop-Procter watersheds.

[5] A 60% slope rises 60 m for every 100 m of horizontal distance.

- **ES 5** - Areas of Shallow Soil. ES 5 sites have soil less than 50 cm deep over bedrock or other impermeable substrate. While soil depth cannot be measured on air photos, signs such as open, patchy forests, patches of exposed rock in the forest canopy, and complex rocky terrain all indicate areas which likely have shallow soil.

Figure 13: Upper slopes in Harrop Creek

This picture is of the ridge between Harrop and Slater Creeks, looking down into Harrop Creek. The picture clearly shows the ecologically sensitive sites found on the upper portion of the rounded ridges throughout the study area. Soils on these sites are thin and bedrock is always close to the surface. The thin soils may be due to erosion or to scraping action by glacial ice in the last ice age. Water inputs into these sites are limited. Little water flows downhill from upslope sites because there are few upslope areas and precipitation tends to drain rapidly through the shallow soils to the valley below. The result is open forests on dry, sensitive shallow soils. The area in the foreground is not a part of the potential timber management landbase. These areas have moderate slopes and are not prone to landslides or other types of major soil disturbance, but are too ecologically sensitive to be suitable for sustained yield timber management.

- **MS** - Moderately Stable Terrain. Moderately Stable sites are "in between" Ecologically Sensitive terrain and Stable terrain. In the Harrop-Procter watersheds, only a small area of MS terrain was identified near the north west corner of the study area. This area is a fine grained mixture of rocky knolls and moderately sloped terrain. Half of the MS area was removed from the potential timber management landbase, the remainder was retained.
- **S** - Stable Terrain. Stable sites are areas with moderate slopes, deep well-drained soils, and even terrain. We included 100% of the forested area of S terrain in the potential timber management landbase.
- **H** - Helicopter Accessible Terrain. Stable sites which are isolated by unstable terrain or which are not accessible by conventional means. We included 100% of the forested area of H terrain in the potential timber management landbase.

After revision, the Silva ESD lines were transferred to forest cover maps of the study area and digitized into PAMAP GIS.

The riparian ecosystems shown in Figure 10 are largely computer generated. We used the buffer generation capabilities of PAMAP to create a 30, 40, or 50 meter both sides, or 60 to 100 meter total width, buffer around all mapped creeks, lakes, marshes, and wetlands. Buffer width was selected by air photo interpretation to match the width of the riparian ecosystem along each reach. The varied buffers were combined into a single layer, and added to the final overlay map layer. Remember that under wholistic forest use, the areas outside the buffers will not be clearcut, but will be managed in an ecologically sound manner which maintains forest ecosystems on the site at all times.

The riparian buffers took precedence over the Silva photo-interpreted ESD zones. That is, where an area was classed as, for example, stable terrain, but fell within a computer-generated riparian buffer, it was classed as riparian ecosystem on the final maps and data summaries.

The final data layer combining all Ecological Sensitivity information was output as a project map, and was used as a source data layer for further map products.

4.1.3 Relationship to T.S.I.L. B Mapping

Staff members from William H. Wells Consulting were performing the field work for a Terrain Survey Intensity Level B study of Harrop, Narrows and Procter Creeks concurrently with the SFF field work fall 1997. Their report[6] was delivered in March 1998. This was unfortunately too late to be utilized as a primary data layer in our GIS analysis. We have, however, studied their report and present here a summary of our interpretations of similarities and differences.

The difference in approach to field work between this ecosystem-based plan and the TSIL B was significant. The Silva crew sampled the landscape by traversing and mapping between identifiable points, which helps us to finalize and support our air photo interpretation of divisions between ecologically sensitive terrain and potential timber management landbase. Traversing is a time consuming process, which limits the distance which can be covered in a single day. However, we rely on the data provided by the traverse to verify our photo interpreted mapping.

The W. H. Wells field crews navigated from place to place using air photos, professional ability, and dead reckoning to locate themselves. The emphasis during their field assessment was to verify that their interpretations of slope stability and erosion potential within each of the polygons they had delineated were correct. As long as they were within the polygon in question, their navigation was adequate. Their use of dead reckoning instead of traversing allowed W. H. Wells crews to cover appreciably more of each watershed than the Silva crews.

[6] Harrop - Narrows - Procter Creeks Terrain Interpretation by C. Wallace, W. H. Halleran, and W. H. Wells, March 1998.

The major interpretations of the professional geoscientists carrying out the TSIL B inventory are presented in two maps accompanying the TSIL B report which show Terrain Stability Hazard Class and Surface Erosion Hazard Class. The Terrain Stability Hazard is of great interest to us, as it uses similar parameters and criteria to the Silva Ecosystem Sensitivity to Disturbance rating system. A comparison of results is possible.

The Surface Erosion Hazard Class is interpreted from a combination of terrain and soil structure attributes, and no corresponding assessment or interpretation exists with the Silva approach. Land managers will find this information useful, however, as surface erosion hazard and water siltation are major considerations in timber management within domestic use watersheds.

Our initial comparisons of the TSIL B Terrain Stability Hazard mapping to the Silva ESD mapping of the same areas were disconcerting. Extensive areas which we had classed as "potentially suitable for timber management" in the ESD mapping were shown as "High Hazard" in the TSIL B mapping, while extensive areas we had categorized as "Ecologically Sensitive" were shown as "Low Hazard" in the TSIL B. We would expect some divergence of opinion between two reconnaissance level surveys, but the magnitude of the difference suggested systemic disagreement.

Further consideration of the matter provided some explanation. The Silva ESD mapping is used in conjunction with existing forest cover mapping and community input to delineate potential timber management zones (as discussed in Sections 4.2 and 4.5.) A substantial quantity of land which will be removed from the timber management landbase based on this additional information is still listed as "Stable" in the ESD mapping. We believe that these areas contribute much of the area to the Silva ESD "Stable"/ TSIL B "High Hazard" area.

The strict interpretation of "slope stability" used in the TSIL B work can be misleading. Many of the high alpine ridges in the study area are gently sloped landforms with very thin soil over bedrock. These areas are ecologically sensitive but have low to no potential to initiate landslides, and thus have a Terrain Stability Hazard Rating of Low. The TSIL B study is not indicating they should be part of the timber management landbase; it is simply assessing the level of risk of landslide on these sites. In the Silva assessment system, such sites are listed as ecologically sensitive, due to thin, rocky soils and the impact of high elevation climate. We believe that this is the source of most of the Silva ESD "Ecologically Sensitive"/ TSIL B "Low Hazard" area.

Table 3 provides a comparison between areas with the final Silva timber management landbase identified in Section 4.5 and the TSIL B mapping. Main interpretations of this table are:

- Sixty eight percent of the Silva timber management landbase is within Terrain Hazard Classes I to III, a reasonable level of concordance.
- Twenty Seven percent of the Silva timber landbase is within Terrain Hazard Class IV, a higher hazard class. The extent to which these high hazards areas can be safely logged using aerial systems, versus the extent to which they should be removed from the landbase, is not known at this time.

- Five percent of the timber landbase is within Terrain Hazard Class V, high hazard. These areas should be either removed from the timber management landbase, or have their hazard class modified, depending on which survey is in error.

In all, we find this to be a reasonable level of concordance between two initial studies.

	Area Within SFF Timber Management Landbase			Area Within SFF Timber Management Landbase	
Terrain Stability Hazard Class	Area (ha)	Percent of Total	Surface Erosion Hazard Class	Area (ha)	Percent of Total
I - No Significant Problems	29	3%	L - Low Hazard	107	13%
II	230	27%	M	145	17%
III	314	38%	H	412	49%
IV	226	27%	VH - Very High Hazard	172	21%
V - High Landslide Hazard	38	5%			
Total Area	**837**	**100%**		**837**	**100%**

Table 3: TSIL B Rating of land within Silva Timber Management Landbase.

As mentioned above, we did not consider erosion potential when delineating potential timber management landbase. The surface erosion hazard ratings are generally high throughout the area, due to high fine particle content in many soils. Timber management activities will have to plan to minimize erosion risk, and to mitigate erosion hazard through careful engineering, maintenance and revegetation measures throughout the timber management landbase.

4.2 Landbase Unsuitable for Development

Areas in the Harrop-Procter watersheds that are judged 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
- ecologically sensitive areas (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 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 and Non Commercial Forest Cover**

Non-forested areas include water features, 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.

Non Commercial Cover includes

- ***Alpine forest:.*** Alpine forest stands are open, snow dominated, and extremely sensitive ecosystems with very slow growth rates and short growing seasons.
- ***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:*** 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.

- **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 1993 Kootenay Lake Timber Supply Analysis:

- ***Low Site Quality*****:** Areas identified as having low growth potential by the MoF. All areas with an old site class listing of "L", or Low, were removed from the landbase.
- ***ESA 1*****:** Areas identified as environmentally sensitive by the MoF. Typically, these are areas with steep terrain and sensitive soils.
- ***Deciduous Stands*****:** 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.
- ***Low Volume Stands*****:** The TSA report identifies a matrix of stands, by species and site class, which are excluded from the landbase because their reported volume at maturity is too low to enable harvesting. A distinction is made between low volume stands on slopes over 50% as well, but we did not try to model this subtlety. All stands within the following species, site, and age groups with volumes less than 150 m3/ha were removed from the landbase:

Species	**Site**	**Age**
F, L, Py, Pw	G, M	80
F, L, Py, Pw	P	90
C, H	G, M	120
C, H	P	130
S, B	G, M	100
S, B	P	120
Pl, Pa	G, M	90
Pl, Pa	P	120

- ***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 in the forest cover data file.

- ***NSR*****:** Areas which have been logged or disturbed, and which are currently not growing commercial tree species, but which are expected to be restocked in the future.

- **SFF Ecologically Sensitive Netdowns**

  Areas identified as ecologically sensitive during the Silva analysis process described in Section 4.1.1. Two summary classes were used during the production of this map: riparian ecosystems, 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 extent and nature of the disagreement about the net timber potential of the Harrop-Procter watersheds between conventional timber management and ecologically responsible forest management.

A 1:70,000 plot of the Landbase Unsuitable for Development map is shown in Figure 14. The results of the netdown are summarized in Table 4 and Figure 15.

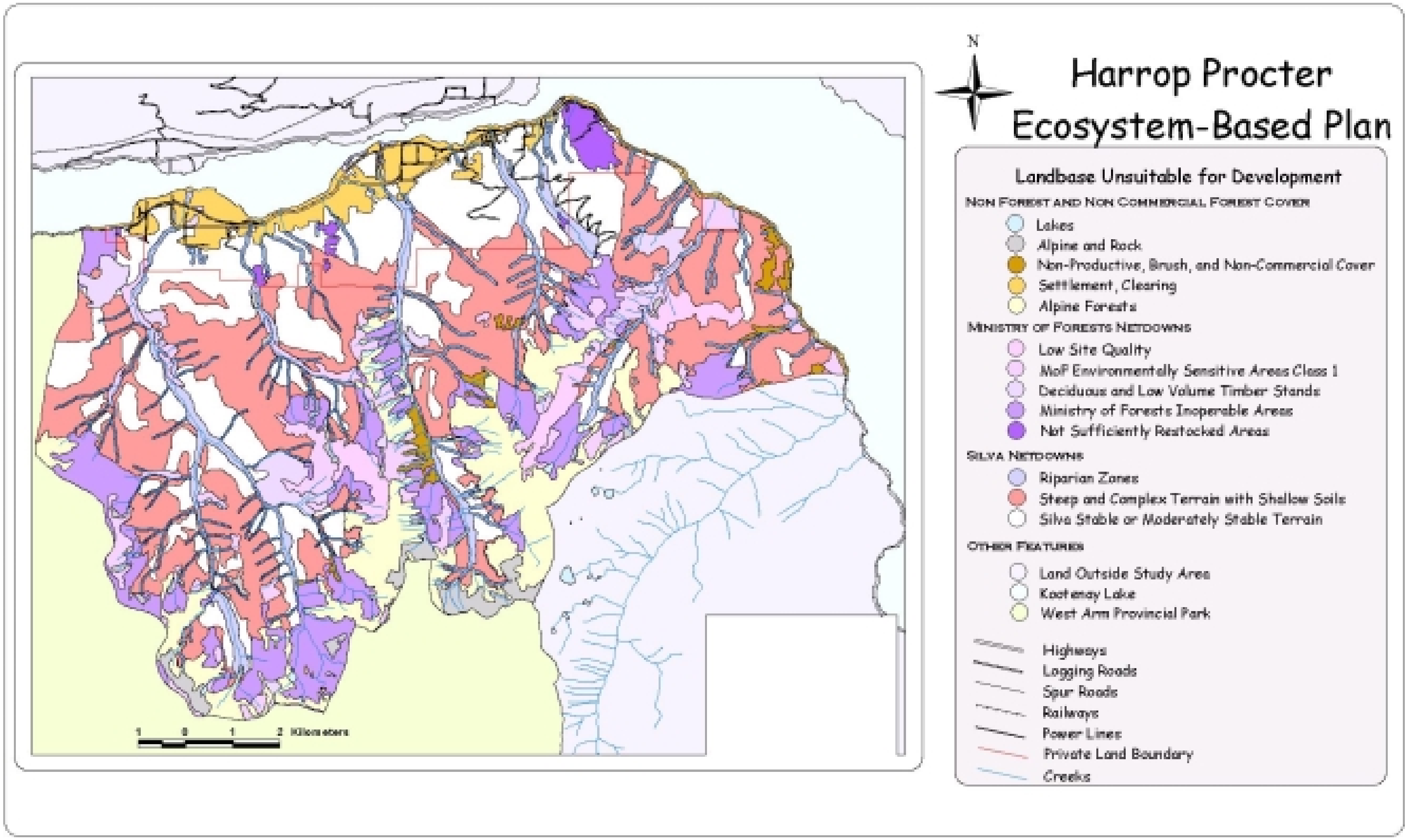

Figure 14: Map of Landbase Unsuitable for Development in Harrop-Procter watersheds.

Landbase Unsuitable For Development												
Description	**Crown Land**				**Private Land**				**Crown and Private Land**			
	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI
Non Forest and Non Commercial Forest Cover												
Lakes	12	0.1%	0	0.0%	1	0.0%	0	0.0%	13	0.1%	0	0.0%
Alpine and Rock	283	2.2%	0	0.0%	0	0.0%	0	0.0%	283	2.2%	0	0.0%
Non Productive, Brush, or Non Commercial Cover	145	1.1%	111	0.4%	0	0.0%	0	0.0%	145	1.1%	111	0.4%
Settlement or Clearing	56	0.4%	0	0.0%	588	4.5%	0	0.0%	644	5.0%	0	0.0%
Alpine Forests	1,407	10.9%	1,547	5.3%	0	0.0%	0	0.0%	1,407	10.9%	1,547	5.3%
Subtotal:	1,902	14.7%	1,658	5.7%	589	4.5%	0	0.0%	2,491	19.2%	1,658	5.7%
Ministry of Forests Netdowns												
Low Site Quality	326	2.5%	295	1.0%	0	0.0%	0	0.0%	326	2.5%	295	1.0%
Environmentally Sensitive Class 1 Areas	714	5.5%	1,520	5.2%	47	0.4%	129	0.4%	761	5.9%	1,649	5.7%
Deciduous Stands and Low Volume Stands	289	2.2%	318	1.1%	11	0.1%	25	0.1%	300	2.3%	342	1.2%
Inoperable Areas	1,458	11.2%	3,511	12.1%	6	0.0%	13	0.0%	1,464	11.3%	3,524	12.1%
Not Sufficiently Restocked Areas	0	0.0%	0	0.0%	141	1.1%	6	0.0%	141	1.1%	6	0.0%
Subtotal:	2,786	21.5%	5,644	19.4%	205	1.6%	173	0.6%	2,990	23.1%	5,817	20.0%
Silva Netdowns												
Riparian Ecosystems	801	6.2%	2,247	7.7%	214	1.6%	661	2.3%	1,014	7.8%	2,909	10.0%
Steep and Complex Terrain with Shallow Soils	3,313	25.5%	9,376	32.2%	183	1.4%	603	2.1%	3,496	27.0%	9,979	34.3%
Subtotal:	4,113	31.7%	11,624	40.0%	397	3.1%	1,264	4.3%	4,511	34.8%	12,888	44.3%
Landbase Potentially Suitable for Development												
Stable, Moderately Stable and Heli Terrain	1,894	14.6%	5,424	18.7%	1,082	8.3%	3,291	11.3%	2,975	22.9%	8,715	30.0%
Total:	**10,695**	**82.5%**	**24,350**	**83.7%**	**2,273**	**17.5%**	**4,727**	**16.3%**	**12,968**	**100%**	**29,077**	**100.0%**

Notes:
1) Gross MAI is net of deductions for decay only, and are not net of deductions for waste, breakage, maintenance of ecology significant structures and longer rotations. These deductions are expected to further reduce MAI by at least 30%.

Table 4: Summary of Landbase Unsuitable for Development strata.

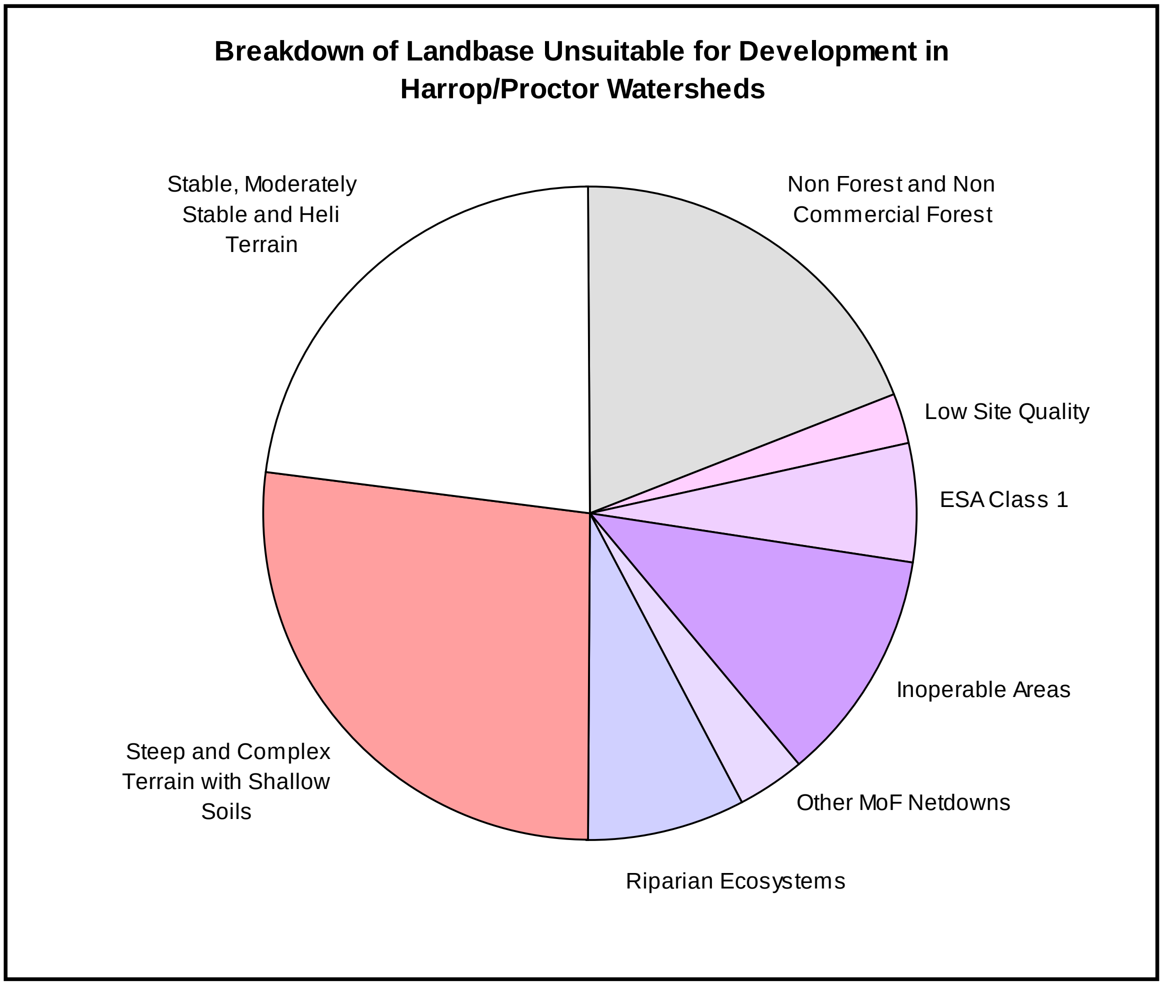

Figure 15: Graph of Landbase Unsuitable for Development strata in Harrop-Procter watersheds.

4.3 Old Growth Forests

In the last two decades, forest ecologists have come to better understand the critical importance of the old growth forest phase in maintaining healthy forest landscapes and healthy forest ecosystems.

At the stand level, the large diameter live stems and multilayered canopies common in many old growth forest types provide structures not found in younger forests. These structures support ecosystem processes which are not present in younger forests. Large diameter stems also provide habitat for cavity nesters, bark crevice dwellers and many other species which cannot easily persist in habitats without such structures. When large diameter stems die, they eventually fall to the ground and decompose to become part of the forest soil over several centuries. The sheer size of fallen old growth trees results in slow decomposition, but also results in remarkably stable temperature and humidity inside the log. This stable environment is required habitat for many species of amphibians, arthropods, fungii and bacteria. Small fallen trees do not perform similar functions, as they are, in comparison, transient structures which have very variable interior environments.

At the landscape level, patches of old growth forest often provide roosting or breeding habitat for species which may forage quite successfully within second growth forests, but which rely on old growth structures for persistence within that landscape. Woodpeckers are a good example of such a species. Old growth forests also provide seasonal refuges for ungulates in severe winter storms, as well as required habitat for old growth dependent species.

From a human use perspective, old growth forests are very valuable because their tightly interwoven ecological processes provide regulated flows of pure water. The dense biomass of an old growth forest stores water inputs well for gradual release, and the diverse soil community and complex ecosystem allows little sediment or dissolved materials to leave the ecosystem. This results in reliable supplies of high quality domestic water.

A report on old growth ecology can be obtained from the Silva Forest Foundation Web site at www.silvafor.org/docs.

We identified remaining old growth forests in the study area using Ministry of Forests forest cover data files. This is not an optimal solution, as the forest cover data is a timber management and inventory tool, not an ecological inventory. This means that:

- The only useful parameter to delineate “old growth” forests within the data base is stand age. While older stands are the most likely candidates for old growth forest status, mere stand age is not a guarantee that the forest in question has developed the structural attributes associated with old growth ecosystems.
- Listed stand ages between 100 and 250 years may or may not be accurate depending on the source of the information used for the forest cover polygon data entry.
- The MoF inventory branch favors mapping large forest cover polygons which encompass a fair amount of intra-type variation in order to keep forest cover data sets relatively small and manageable. Ecologically significant concentrations of old growth structures within a younger stand may not be mapped at all.

Despite these problems, the forest cover inventory files are the only feasible source of broad scale vegetation cover mapping for the province and the study area.

We identified old growth forests based on the stand age and species combinations shown in Table 5. Stand age was determined from the stand age class entry in the MoF forest cover data file. When more than one stand layer was listed, the age class of the most important stand layer (as identified by the MoF) was used for stand age.

Species Group	Age at Which Stands Considered Old Growth Forest for this Analysis
Cottonwood, Aspen, other Deciduous	121
Lodgepole Pine	121
White Bark Pine	121
All Other Conifers	141

Table 5: Lower cutoff ages for Old Growth Forests in this analysis.

The choice of 140 years as the lower age limit used to identify most “old growth” forests was based on two factors:

1. Coniferous forests greater than 140 years old in all biogeoclimatic zones in the study area are likely to contain the large diameter stems, multilayered crown, variable canopy and variety of large dead trees typical of old growth forests.
2. The forest cover data base specifies stand age for many stands using an age class code only. A single age class includes all stands > 141 years and < 250 years. Thus, we have no finer resolution data for many stands in the time period during which old growth forest characteristics are likely to develop.

Deciduous forests and pine forests were considered to be old growth if over 121 years of age. This reflects the rapid early growth and relatively short life span of these species. Pine forests and deciduous forests often begin to develop multi-layered canopies and a large dead stem component relatively early, compared to longer lived coniferous species.

Younger stands with veteran layers or other secondary layers of old trees noted in the forest cover data files were not considered old growth. These areas likely contain significant concentrations of ecologically valuable old growth structures, but are not likely old growth forests. Younger stands which contain old forest layers occupy 928 hectares in the study area, of which 781 hectares contain larch and fir old growth structures. Crown closure of the listed old stand layers ranges from 4 to 40%, but most stands list an old tree layer crown closure of 10 to 20%. (These generalities apply only to old forest layers within younger stands.) This conforms with our interpretation, based on air photos and field work, that there are many remaining old growth structures within the younger stands in the lower elevations of the study area, although there are few remaining old growth forest patches.

Areas identified as old forests were stratified into species groups for this analysis, using the Inventory Type Group (ITG) entry in the forest cover data files. This code is assigned by the MoF based on leading and secondary species in the stand. We further grouped the stands by leading species only, using the ITG entry. We chose not to use a biogeoclimatic zone stratification because the biogeo polygon boundaries cut through forest cover polygons. Using biogeoclimatic strata frequently leads to the counterintuitive situation where one half of a stand is stratified in one biogeoclimatic type, while the other half of the same stand is stratified into a different type, based on the dividing biogeoclimatic subzone line.

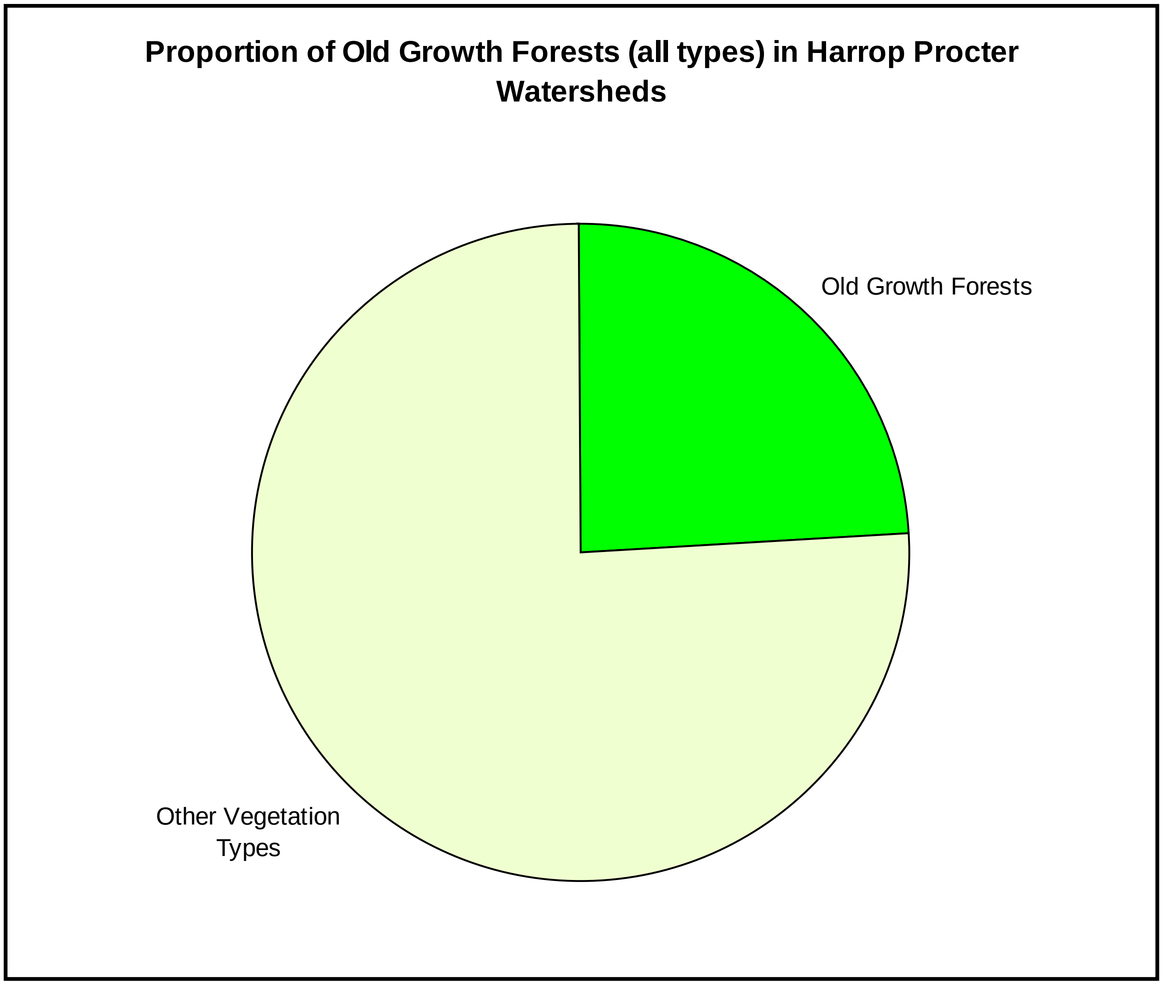

Figure 16: Graph of proportion of Harrop-Procter watersheds occupied by old forests.

As shown by Figure 19, old forests are not uncommon in the study area. Just less than 25% of the study area is within old growth forests, using a strict, age-based definition and considering all forested areas above the cutoff age as “old growth forests”. This general approach is deeply flawed, however. Different types of old forests have different characteristics, and perform different functions. The degree of representation of old forests must be assessed at least the species group level to detect distribution patterns and landscape ecology impacts, and further stratification and analysis will likely be useful as land use planning proceeds.

Figure 17 and Table 6 show the distribution of old forests in the study area by species group, and by ecological sensitivity. Figure 21 illustrates the distribution of old forest types within the 25% of the landbase which is currently occupied by old forests.

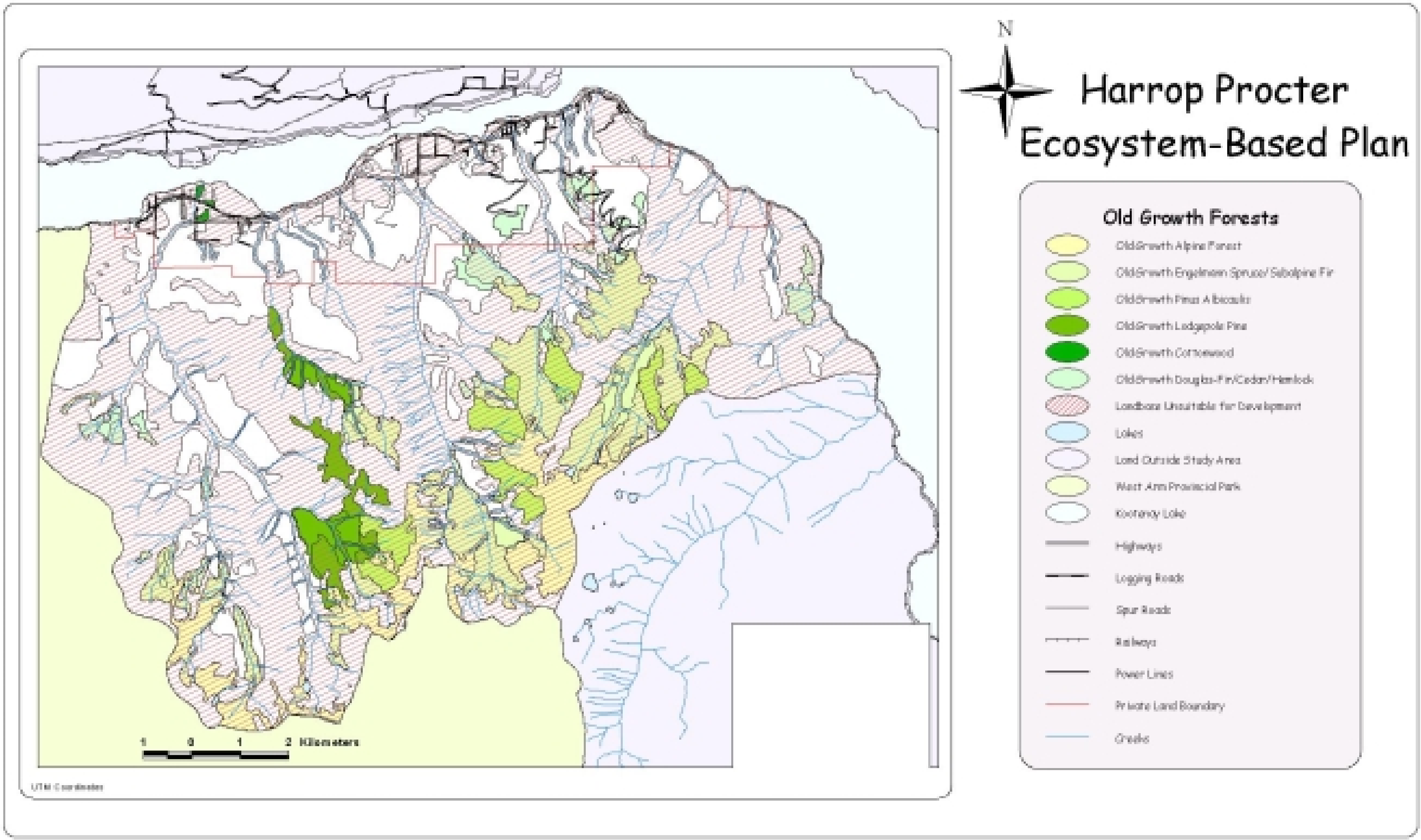

Figure 17: Map of Old Growth Forests and Landbase Unsuitable for Development in Harrop-Procter watersheds.

Old Growth Forests												
Description	On Landbase Unsuitable For Development				On Potential Timber Management Landbase				Total			
	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI
Lakes	13	0.1%	0	0.0%	0	0.0%	0	0.0%	13	0.1%	0	0.0%
Old Growth Forest Types												
Alpine Forest	783	6.0%	474	1.6%	0	0.0%	0	0.0%	783	6.0%	474	1.6%
Spruce / Sub-Alpine Fir	1,189	9.2%	2,359	8.1%	111	0.9%	198	0.7%	1,300	10.0%	2,558	8.8%
White Bark Pine	381	2.9%	746	2.6%	0	0.0%	0	0.0%	381	2.9%	746	2.6%
Lodgepole Pine	223	1.7%	526	1.8%	125	1.0%	322	1.1%	348	2.7%	848	2.9%
Cottonwood	9	0.1%	22	0.1%	0	0.0%	0	0.0%	9	0.1%	22	0.1%
Douglas-fir / Cedar / Hemlock	219	1.7%	474	1.6%	107	0.8%	248	0.9%	326	2.5%	722	2.5%
Other Vegetation Types	7,176	55.3%	15,761	54.2%	2,633	20.3%	7,947	27.3%	9,809	75.6%	23,708	81.5%
Total:	**9,993**	**77.1%**	**20,362**	**70.0%**	**2,975**	**22.9%**	**8,715**	**30.0%**	**12,968**	**100%**	**29,077**	**100%**

Table 6: Distribution of Old Forests by forest type and landbase type.

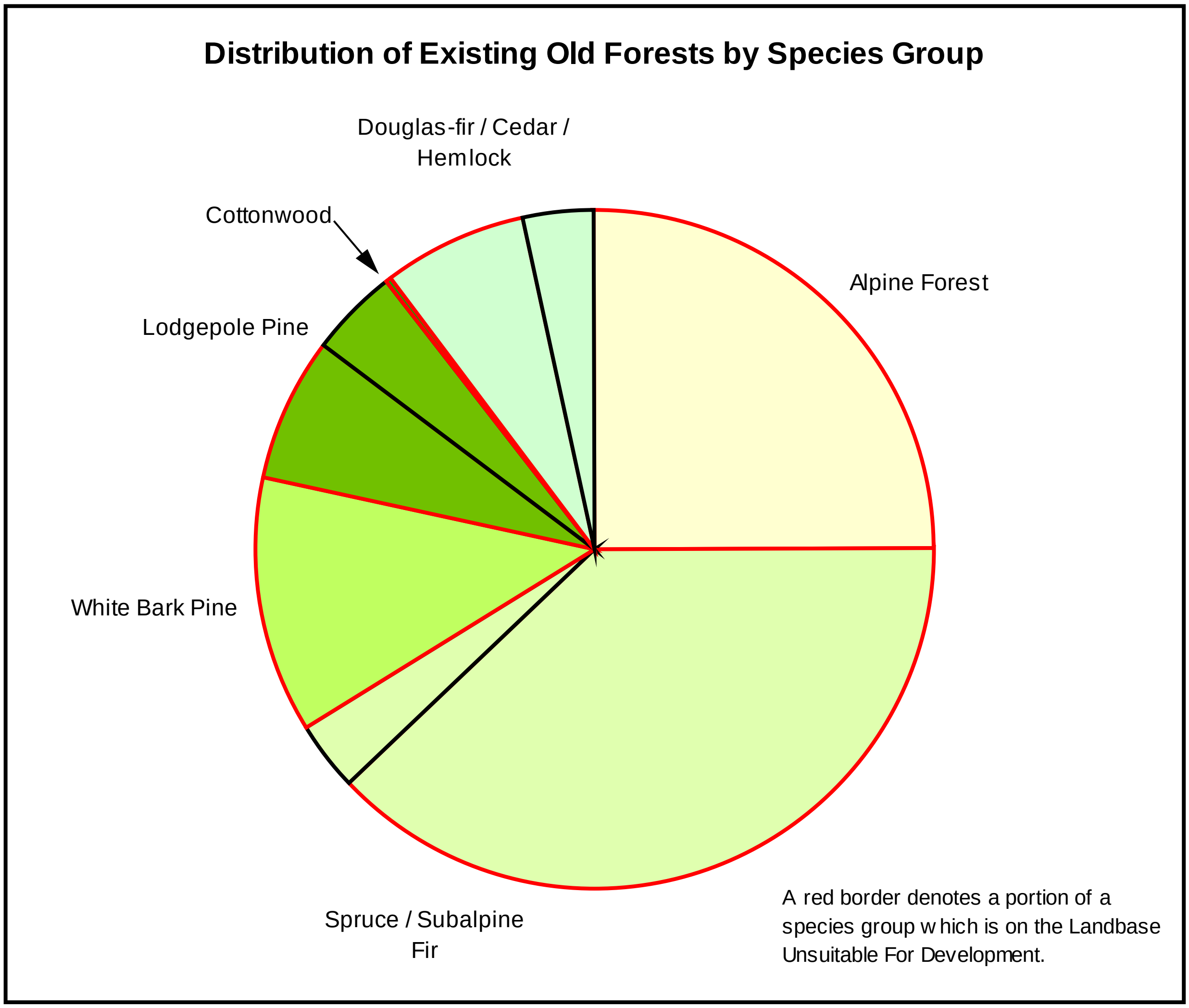

Figure 18: Graph of Distribution of Old Forests by Species Group.

As Figure 21 shows, the remaining area of old forests in the study area is not evenly distributed among species groups. Some groups are over-represented, while very little old forests remain in others. A brief discussion of each of the species groups used in the graph and table follows.

- **Alpine Forest:** 25% of the existing old forest area is within areas are identified as Alpine Forest by the MoF in the forest cover data files. Alpine forests are sparse, high elevation stands near the tree line, composed of subalpine fir, alpine larch, white bark pine and Engelmann spruce. These areas have no commercial timber values, but are high value recreation and wildlife areas. (See caption of Figure 7.)

  Many trees in alpine forests are extremely old. A natural bonsai pine less than a meter tall can be 100 years old. An alpine larch 20 meters tall can be 450 years old. These forests are "old growth", but are structurally very different from low elevation old growth forests. Old growth alpine forests are critically important to subalpine fauna, but are not a substitute for large diameter ecological structures, or the growing season environment, found in lower elevation old growth forests.

- **White Bark Pine:** 12% of the study area lies within white bark pine old forests. These high elevation ecotypes are all within the Silva Ecologically Sensitive classification. Extensive stands of white bark pine are unusual, and these forests are ecologically significant at a regional level. Again, these sparse, high elevation forests are not an ecological substitute for large diameter, low elevation, old growth forests. White bark pine is discussed in Section 2.5 above.
- **Spruce / Subalpine Fir:** 41% of the existing old forest area is within spruce and subalpine fir stands in the upper elevation ESSF biogeoclimatic zone. These stands are composed of Engelmann spruce, subalpine fir, lodgepole pine and some white bark pine on dry micro sites. The forests range from dry, sparse stands just downslope from the alpine forest ecotype to large diameter, majestic spruce stands in moist, lower elevation pockets. These high elevation stands escaped the widespread forest fires near the turn of the century.

  Due to the large area of current old spruce / fir forests, and the extensive part of the protected landscape network within the ESSF biogeoclimatic zone, maintenance of sufficient Engelmann spruce / subalpine fir old growth forest is not a management issue at this time.
- **Lodgepole Pine:** 11% of the existing old forest area is within lodgepole pine types. Based on aerial overviews, these are open, dry forest types in upper elevation areas. Lodgepole pine is a relatively short lived pioneer species which occupies sites after forest fires. Shade tolerant species (spruce and fir in upper elevations, cedar and hemlock in lower) regenerate beneath the pine canopy, and grow up through it over time. These old pine stands are likely in transition to other species mixes.

  Lodgepole pine old forests are not equivalent to large diameter, old growth. Pine seldom grows to diameters greater than 50 cm, so large trees and large fallen trees are not generated in these stands. This short lived, shade intolerant, early seral species is not generally self perpetuating, so multi-layered stands of pine do not form. When these old pine forests die off, they will not be replaced until younger pine stands in disturbed areas reach a similar age. However, this is an interesting forest type which should be maintained in the landscape through protection of much of the existing old forest, and planning to create additional old pine forest areas in the future.

  A total of 96 hectares of this old forest type are located on land within the timber management landbase. (Table 6 shows figures for Landbase Unsuitable for Development. Further deductions were made for corridors and old growth protected areas.) These areas must be managed sensitively in a manner which preserves the existing ecological structures in the stand.
- **Cottonwood:** A minute amount of old cottonwood forest is shown on the forest cover map, on private land near the mouth of Harrop Creek. As discussed in Sections 2.4 and 2.6.4, these forests are critical wildlife resources and should be protected from development. Creation of additional large diameter floodplain

forests is a high ecological restoration priority, which is complicated by the extensive private ownership of the West Arm riparian ecosystem.

- **Douglas-fir / Cedar / Hemlock:** This is likely the most important old growth forest type in the Harrop-Procter watersheds, and is the most under-represented. While the ICH biogeoclimatic zone occupies 51% of the study area, only 10% of all current old forests (2.5% of total area) are within Douglas-fir / cedar / hemlock old forests. These old stands contain the classical multi-layered canopy, diverse stand structure and extremely large diameter trees commonly associated with old growth forests. The large trees, large dead trees, and large fallen trees in these ecotypes provide wildlife habitat resources which are not duplicated in younger stands.

  As discussed above, many scattered fires survivors occur throughout the young stands in the lower elevation ICH zone which are not mapped. These will help to meet habitat needs for some species.

  Restoration of fir / cedar / hemlock old growth forests is an urgent requirement to ameliorate the impacts of extensive human caused fires in the lower elevation portion of this landscape near the turn of the century.

  The few remaining fir / cedar / hemlock old forests in the study area were protected in this ecosystem-based plan.

The conclusion from this assessment of old growth forests in the Harrop-Procter watersheds is that unnaturally low amounts of low elevation old growth forests currently exist within this landscape. Restoration of low elevation old growth forests is the urgent management need in this landscape.

We of course cannot go out and build an old growth forest. We lack sufficient understanding of the intricacies of soil, forest and wildlife ecology to accomplish such a feat, and what we do know indicates that the natural complexity, often referred to as chaos, within such systems is not reproducible by design. Issues of cost would also rule out any such attempt.

Restoration of old growth translates to “identify and leave alone”. The extensive areas included in the protected landscape network (Section 4.4) will become old growth forests over time, baring natural disturbance. As much of the landscape in the study area is occupied by 90 to 100 year old stands, the transition to abundant old growth forests will likely occur in the next century, provided people behave in a responsible manner.

Another important consideration in planning protection for old forest ecosystems is the need for large reserve areas in a landscape. Large reserves are required to maintain old growth interior forest processes and species, and to provide a source for old growth dependent species to migrate into managed landscapes. Fortunately, the Harrop-Procter watersheds are bordered to the south by a large reserve, the West Arm Provincial Park. Because of the park, reserve areas within the study area can be relatively small as long as landscape connectivity is retained. Additionally, large reserves have been effectively delineated in upper elevation ecosystems by the extensive protected landscape network defined in Section 4.4. However, no large reserves exist within the lower elevation ecosystems, except those provided by the park.

We believe it is very important to protect and maintain old growth forests on portions of the landscape outside of ecologically sensitive areas. Old forests on moderate slopes with deep soil are quite different from old forests on steep, rocky land. The protected landscape network and the forest use zoning (Sections 4.4 and 4.5) protect old growth forests on stable ecotypes by protecting areas which would otherwise be part of the timber management landbase.

The form of timber management planned for the Harrop-Procter watersheds will also retain existing old growth structures, and create more large diameter stems within timber management areas.

We recommend that a thorough inventory of existing old growth patches and structures be carried out within the lower elevations of the Harrop-Procter watersheds. The purpose would be to identify old forest resources which are not recorded on existing vegetation cover mapping. Knowing the extent of, and location of, these old forest remnants, will help future ecosystem management planning processes.

4.4 Protected Landscape Network

The Protected Landscape Network (PLN) combines the biophysical features and assessments shown on the Ecological Sensitivity to Disturbance map with proposed land management decisions to form a network of protected areas which extends across the Harrop-Procter watersheds. The purposes of the PLN are:

1. to protect ecologically sensitive sites,
2. to protect important “biodiversity hotspots” such as wetlands, riparian ecosystems and old forests,
3. to protect unique habitat areas,
4. to maintain undisturbed, representative natural areas within common habitat types,
5. to develop additional old forest habitat throughout the landscape, and
6. to maintain connections across the island at the landscape level.

A 1:70,000 plot of the proposed PLN map is shown in Figure 19. Table 7 quantifies the areas in the various PLN stratifications, and Figure 20 illustrates this breakdown graphically.

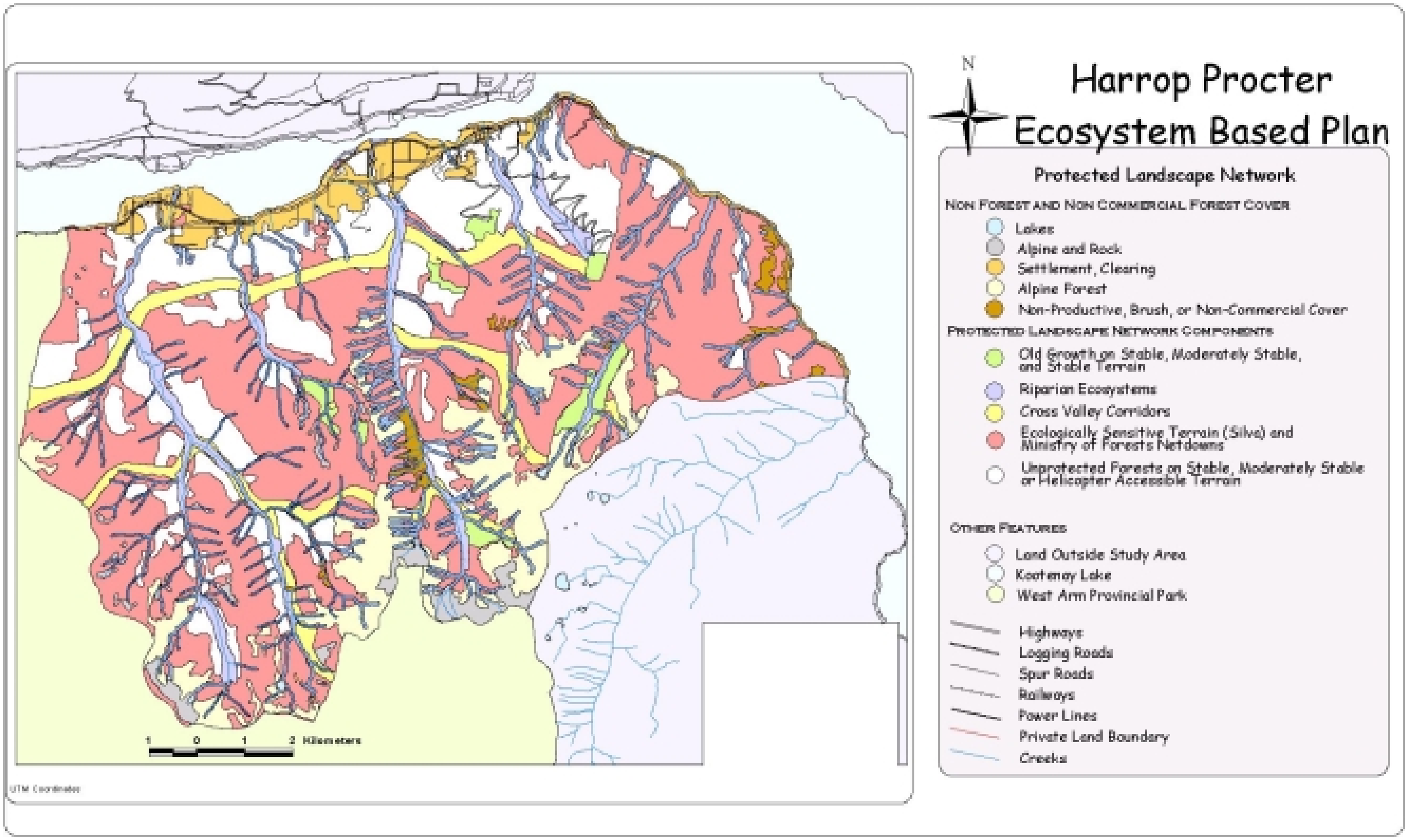

Figure 19: Map of proposed Protected Landscape Network in Harrop-Procter watersheds.

Protected Landscape Network												
Description	Crown Land				Private Land				Crown and Private Land			
	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI
Non Forest and Non Commercial Forest Cover												
Lakes	12	0.1%	0	0.0%	1	0.0%	0	0.0%	13	0.1%	0	0.0%
Alpine and Rock	283	2.2%	0	0.0%	0	0.0%	0	0.0%	283	2.2%	0	0.0%
Non Productive, Brush, or Non Commercial Cover	145	1.1%	111	0.4%	0	0.0%	0	0.0%	145	1.1%	111	0.4%
Settlement or Clearing	56	0.4%	0	0.0%	588	4.5%	0	0.0%	644	5.0%	0	0.0%
Alpine Forests, Pinus albicualis Forests	1,250	9.6%	1,462	5.0%	0	0.0%	0	0.0%	1,250	9.6%	1,462	5.0%
Subtotal:	1,745	13.5%	1,574	5.4%	589	4.5%	0	0.0%	2,334	18.0%	1,574	5.4%
Protected Landscape Network Components												
Old Growth in Potential Timber Management Zone	179	1.4%	340	1.2%	24	0.2%	79	0.3%	203	1.6%	419	1.4%
Old Growth Not in Potential Timber Management Zone	24	0.2%	40	0.1%	0	0.0%	0	0.0%	24	0.2%	40	0.1%
Riparian Ecosystems	1,398	10.8%	3,291	11.3%	237	1.8%	705	2.4%	1,634	12.6%	3,997	13.7%
Cross Valley Corridors	580	4.5%	1,497	5.1%	125	1.0%	437	1.5%	705	5.4%	1,933	6.6%
Subtotal:	2,181	16.8%	5,168	17.8%	386	3.0%	1,221	4.2%	2,567	19.8%	6,389	22.0%
Ecologically Sensitive Terrain (Silva and MoF)	5,172	39.9%	12,915	44.4%	302	2.3%	511	1.8%	5,474	42.2%	13,426	46.2%
Unprotected Forests on Stable, Moderately Stable, and Helicopter Accessible Terrain	1,598	12.3%	4,693	16.1%	995	7.7%	2,995	10.3%	2,593	20.0%	7,688	26.4%
Total:	**10,695**	**82.5%**	**24,350**	**83.7%**	**2,273**	**17.5%**	**4,727**	**16.3%**	**12,968**	**100%**	**29,077**	**100%**

Notes:
1) Gross MAI is net of deductions for decay only, and are not net of deductions for waste, breakage, maintenance of ecology significant structures and longer rotations. These deductions are expected to further reduce MAI by at least 30%.

Table 7: Area of Protected Landscape Network Strata in the Harrop-Procter watersheds.

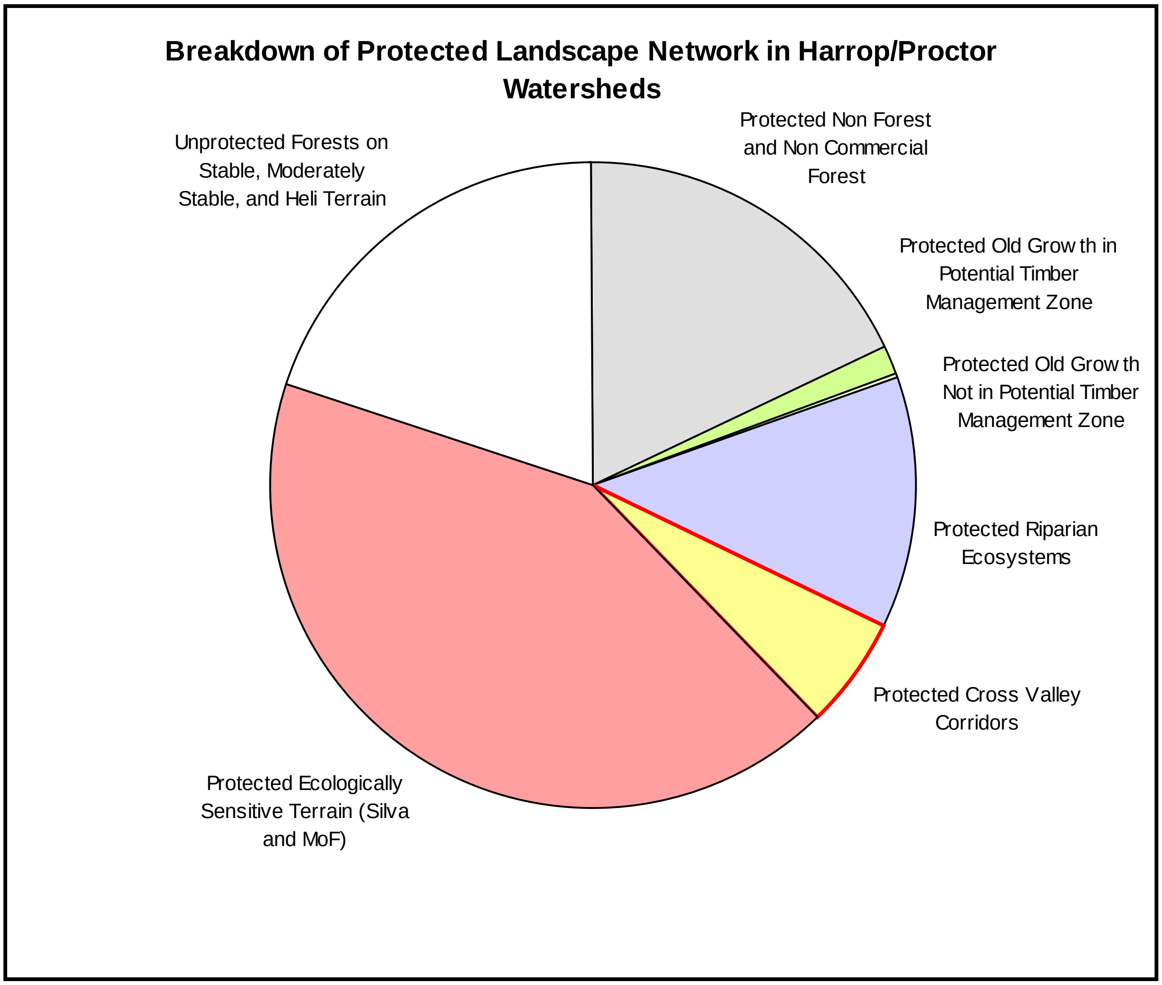

Figure 20: Graph of Protected Landscape Network strata in Harrop-Procter watersheds

4.4.1 Why is a PLN Required?

Forest landscapes and other natural landscapes contain a full array of ecosystem types, and have successional patterns that are tied to natural disturbance regimes. Such natural landscapes are fully occupied by plants and animals, and support natural flows of water, nutrients, and energy. Extensive modification of these landscapes results in degradation, in loss of ecological integrity, and, if human perturbations are persistent, in ecological collapse.

Scientists and planners now recognize the need to maintain, protect, and, where necessary, restore a framework of ecosystems throughout the landscape to ensure connectivity and ecosystem functioning at all scales. This “framework” must be an interconnected web within which natural ecosystem functioning remains intact and undisturbed by all but the softest of human interventions. It is hoped that such protected areas networks will ensure the short- and long-term health and ecological functioning of forest landscapes at all scales. Protected networks are thus necessary not only for ecological health, but also for the long-term survival of healthy human societies and economies.

The actual contents of any PLN are greatly influenced by local ecology, topography, and geography. All ecologically sensitive terrain and riparian ecosystems are by default part of the PLN: they are sensitive for biophysical reasons, their location is fixed, and they are protected. Connecting corridors and protected areas on stable terrain are identified as a management exercise. These features are located partially in response to biophysical features (linkage to sensitive terrain, linkage to important ecological resource patches, utilization of rational travel routes) and partly in response to human geography (avoidance of settled areas, avoidance of private property, reduction of resource use conflicts). Ecological factors take precedence, but human factors are not ignored.

A protected landscape network is maintained as a permanent, undisturbed network of ecosystems, and provides the basic framework for landscape level functioning through time. A protected landscape network should connect small and large protected areas to ensure ecological integrity of the landscape through time.

A protected landscape network is a permanent feature in terms of human time frames. It is theoretically possible to move components of the protected landscape network over long time periods (i.e. 250+ years), and such realignments will be required after natural disturbance in some cases. For example, a part of a cross island corridor and a timber zone could trade places, <u>provided</u> that the timber zone had developed ecosystem composition and structure similar to those in the cross island corridor to be “replaced”. In the real world, this type of switch would likely prove to be unusual, but perhaps required in less than optimal conditions following a stand replacement fire or other significant natural disturbance in the corridor.

After defining the protected landscape network, human use zones are usually designated for the areas outside of the PLN. Human use zones designate a priority use that dictates the terms of other human uses within a particular zone. However, more than one use is frequently encouraged within human use zones. Consumptive human uses, like timber and mining, are generally limited to the stable and moderately stable areas and are generally assumed to be a “sole use”.

Some human uses may also be expected to occur in selected areas within the PLN. For example, hiking trails, built and used to ecologically responsible standards, may be designated in various portions of the protected landscape network. Continued use of Provincial Parks is expected. Responsible wildcrafting may also occur. However, generally speaking, human activities are discouraged from components of the protected areas network.

If long-term studies (i.e. 150+ years of observations) demonstrate that some portions of the protected areas networks are surplus in their ecological roles, limited timber extraction and other human activities may be able to occur to ecologically responsible standards within <u>some</u> portions of the protected landscape network. However, for all intents and purposes, protected landscape networks are permanent fixtures, in human time scales, within the forest landscape. Hopefully, together with large protected reserves and the maintenance of ecological integrity in areas modified by human activities such as timber management, protected landscape networks will ensure the maintenance through time of forest landscapes that are able to withstand the spectrum of natural disturbances.

4.4.2 Cross Valley Corridors

Connecting corridors form an important part of the PLN. These corridors have several purposes:

1. to provide movement paths for plants and animals which wish or need to migrate altitudinally or across the landscape;
2. to (eventually) provide linear, connected areas of old forest habitat in readily accessible locations which extend throughout the landscape; and
3. to link specific ecological features, or ecological resources, with undisturbed forest habitat.

Questions are often raised about the concept of corridors or corridor design. We are often asked why we have delineated corridors through areas “where the deer don’t walk,” or other similar observations. We do not dispute these observations based upon local knowledge. However, corridor networks are not based upon the habitat needs of a specific wildlife or game species, but are rather an attempt to preserve ecological connections throughout the landscape. Putting corridors “where the deer walk” is usually a good thing, but placing corridors “where the deer don’t walk” is not necessarily a bad thing.

Corridors would be unnecessary if human forest use practices did not cause severe ecological impacts. No other species routinely removes many or all of the forest trees from large areas, while tearing up the ground and re-arranging the creeks. In a natural landscape without human disturbances, animals and plants can move through a variety of seral stages and old growth phases of forest ecosystems. However, typical human disturbances break natural movement corridors and create systematic patterns of disturbed areas on the landscape which do not mimic or reflect natural disturbance patterns. Because of the impacts of human use, even of wholistic timber management, we believe it is required to maintain a network of corridors or linkages throughout any landscape where human disturbances are not permitted.

Corridors, or landscape linkages, are not a perfect solution to the problem of human disturbance. Ecologists and scientists are engaged in an ongoing debate about the effectiveness of corridors, and the possible negative impacts of designing corridors in the landscape. A review of the likely benefits and negative impacts of corridors is provided in Appendix 3. In brief, ecologists fear that corridors may increase predation or lure animals into less than suitable habitat resulting in population decline, not population maintenance. However, there is solid support for corridors on the basis that they are the best option available, barring complete landscape protection.

There is also consensus that managing the landscape to provide resources for biodiversity on all portions of the land (the matrix) is greatly preferable to severely impacting some areas and relying on a corridor system to maintain plant and animal population. Ecologically responsible forest use seeks to achieve this goal by ensuring that forest structure and function remains intact on all areas, regardless of human use. However, even activities believed to be ecologically responsible may result in unanticipated ecological damage. We believe a corridor system is required in order to provide an insurance policy, or a refuge and movement system, for organisms that require resources not found in wholistic timber management zones, riparian zones, or protected ecologically sensitive terrain.

Corridors are located so as to take advantage of natural features such as:

- old growth forest patches,
- passes between hills or mountain ranges,
- 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, and to link existing protected areas within the landscape. It is important that animals and other organisms have an undisturbed movement corridor to access large protected areas.

The linkages delineated in the Harrop-Procter watersheds are generally 150 to 300 m wide. In some special locations, the corridors swell to over 800 m in order to encompass and protect an ecological feature such as a wetland complex, or to provide a protected node on unoccupied crown land. Corridors take in a mix of stable and ecologically sensitive terrain.

4.4.3 Process Used to Identify PLN

Connecting corridors form a fundamental part of the Silva ecosystem-based planning process. The purpose of the corridors is to attempt to maintain a reasonable degree of effective natural connectivity within landscape planning units. Corridors are not a replacement for maintaining connectivity through the entire landscape matrix. However, given the limitations of our current knowledge of ecosystems and landscape flows, we believe that sensibly located corridors have an important role to play in maintaining landscape level ecosystem function and movement.

Corridor location and the design of networks of corridors is a combination of art and science. Corridors are located on aerial photographs in sites which combine feasible travel routes for biota with natural connectivity, and which balance impacts on the timber management landbase with meeting ecosystem management objectives. Further study or local knowledge may indicate that some corridors should be shifted from their proposed location to other nearby locations which have a greater habitat value. This is not unexpected and is part of the process of improving this initial plan to meet the final requirements of the community.

Identifying potential corridor locations in the Harrop-Procter watersheds posed some unusual challenges. The steep rocky headwalls and scarps at the headwaters of most of the valleys, and the steep, unstable western slopes in Narrows, Harrop and Irving Creeks are effective barriers to animal movement. The series of corridors which were located through the Harrop-Procter watersheds tended to go through the only passes or movement points available which link these valleys. By and large, there are no other options for corridor locations than those which were used. Additional sites for corridors may be found in some situations, but the corridor locations selected cannot be easily moved a few hundred meters up or down the valley to reduce impact on other potential forest use activities.

Cross-valley corridors traditionally try to link the lower elevations of main drainage basins with upper elevation habitat and to provide links extending between lower elevations of drainage basins. The point is to allow for seasonal altitudinal migration of various biota and to provide a feasible movement path through forested area between lower elevations in neighboring drainage basins. The corridor network identified in Harrop-Procter varies somewhat from this model. There are portions of the network that do in fact join the lower elevation watershed areas by direct travel routes, however, at least half of the linear length of the corridor either extends along valley bottom riparian ecosystems, or runs along the midslope of the Kootenay Lake face. These unusual corridor patterns are a reflection of the topographical limits mentioned earlier, and the impact of extensive settlement and human development along the Kootenay Lake riparian zone.

4.4.4 Detailed Description of Corridors

The following subsections discuss the rationale behind the locations chosen for each of the corridors in Harrop-Procter.

4.4.4.1 West Arm Provincial Park to Wilson Creek Corridor

This corridor extends across the entire study area from west to east, starting at the boundary between the Harrop watershed and the West Arm Provincial Park, running through mid-elevation reaches of Harrop Creek, through the headwaters basin of Narrows Creek, and ending in an upper elevation pass to Wilson Creek. The corridor starts on a flat wetland basin on the boundary between the park and the study area. It follows the northern lip of a deeply incised, large meltwater gully down to the west fork of Harrop Creek. The corridor extends down onto the steep south facing slope of the gully to include some areas of more open forest and a variety of habitats and travel routes. Large animals often travel along the edge of drop-offs, which provide extensive visibility and protection from predators in at least one direction. This point of commencement for the corridor was selected because it is the first site moving north along the western boundary of the study area where the park can be reached without ascending a vertical rock face or lightly forested rocky scree, that is, this is the first good pass from the study area to West Arm Provincial Park on the west border.

At the west fork of Harrop Creek, the corridor turns north and runs in a U-shape around the junction between the west and east forks of Harrop Creek, and then runs for approximately two kilometers up the valley bottom riparian system of the east fork of Harrop Creek, also known as Mill Creek. The corridor runs along the riparian ecosystem in this location because we feel this is the most feasible travel route across the Harrop Creek valley. The only other option is a steep climb up and down the ridge which separates the east and west forks of Harrop Creek. We carried out field sampling in this area and found no evidence of extensive animal movement across this ridge and logic indicates that proceeding along the riparian corridor is a much simpler travel option than scaling and descending the ridge.

After traveling two kilometers south along the east fork of Harrop Creek, the corridor comes to the junction between the creek which flows out of Mill Lake and a branch of

Harrop Creek which runs more or less due east. The corridor follows the eastern branch, and then runs along the north bank of the eastern tributary through an area of dry open forest and sensitive shallow soils, likely over rocky areas, as it climbs towards the ridge which separates the Harrop watershed from the Narrows Creek watershed. The corridor makes a final ascent to the ridge crest, sweeping along the face of a cirque basin and rising obliquely across the terrain to a small depression in the knife edge ridge which divides the two watersheds. The link between Harrop watershed and Narrows Creek watershed could not be termed optimal or desirable, it is rather the least awful of the poor alternatives. To the south, the ridge which divides Harrop and Narrows is more open and gradual on the Harrop side, but is isolated from the main Harrop watershed by steep complex terrain and dense young forest. On the Narrows side, it drops off steeply through open forest, talus slope, and rock. North of the suggested corridor crossing is the well-known near vertical Narrows face with many deeply incised gullies, open rock screes, and extraordinarily difficult terrain. As well, the ridge is somewhat higher and more knife edged to the north of the selected crossing point.

From the ridge crossing, the corridor drops into the Narrows Creek drainage along a narrow band of sparse forest on steep slope until it reaches the bottom of a cirque basin about 150 m vertical elevation above the main stem of Narrows Creek. The corridor follows an arm of old growth spruce-balsam forest down from the cirque basin to the main stem of Narrows Creek and then turns and runs for a short distance southward along the main stem of Narrows. The headwaters of Narrows Creek are divided into a main stem and an east fork. The corridor proceeds down the east fork valley on its way to Wilson Creek. The corridor connects to a proposed protected old growth area in the headwaters of the east fork of Narrows Creek at this point. The proposed protected old growth area is a relatively small polygon of spruce balsam forest on an elevated glacial terrace (probably morainal in origin) between the main and east forks of Narrows Creek. Terrain in the area is moderately sloped to flat, and soils appear to be reasonably deep. One of our field sampling lines went directly through this area and we found it to be a rather unique ecotype in the Harrop-Procter watersheds. The area was also extensively used by at least one mature bear whose feeding areas and day beds were observed during our field work.

From the protected old growth forest area, the corridor advances up the flat upper portion of the east fork valley and climbs a low saddle into the upper elevations of the Wilson Creek watershed. The valley headwalls leading to the saddle are a mixture of open talus slopes and alpine larch forest, but again, present the most feasible movement path between these two watersheds. The join between the two watersheds is not extensive in length, and most other portions of it are significantly higher in elevation, with steeper approach and exit paths.

4.4.4.2 Mill Creek Corridor

The Mill Creek corridor runs between the main West Arm Provincial Park to Wilson Creek corridor, and the area of West Arm Provincial Park south of the Mill Creek valley. (Mill Creek is the local name for the fork of Harrop Creek, which runs to Mill Lake.) This corridor is an expansion of the riparian ecosystem protection zone on the east side of the valley. It runs through a variety of forest types, including an expanse of lodgepole pine old growth forest in the midstem of Mill Creek. The corridor moves through largely moderate terrain and climbs the moderately steeply sloped headwall of the cirque basin to the east of Mill Lake plateau, and proceeds through a gentle forested pass to join the headwaters of a fork of Midge Creek in West Arm Provincial Park. The corridor passes through one of the few places in the landscape where there is an easy travel route between the Harrop-Procter watersheds and the surrounding landscape. We understand from Hans Elias that the Harrop Creek watershed was identified as a primary movement corridor in biodiversity study work in this area. This proposed corridor along Mill Creek is designed to maintain the desired level of connectivity and specifically to link up with the low pass to Midge Creek which avoids the rocky headwalls found in most other areas.

4.4.4.3 Narrows Creek, Procter Creek, Irving Creek Corridor

This corridor was required to link the mid-reach of Narrows Creek with the headwaters of Procter and Irving Creek, with a short extension to a high altitude plateau in the Wilson Creek watershed. Procter and Irving Creeks are much shorter than Wilson and Narrows Creeks, with the result that the headwaters of the two shorter creeks are aligned with the midstem of the two longer creeks. In order to have connections between the headwaters area of Procter and Irving Creeks with the remainder of the landscape, this corridor, which extends into the midstem of Narrows and Wilson, was required.

The corridor commences midstem of Narrows Creek, just south of the potential timber management zones in the Narrows Creek watershed. The corridor rises along a moderate slope in an area of significant gullying and complex terrain, through fairly dense young forest. Near the Narrows-Procter watershed boundary, the corridor moves into a small basin occupied by a fir-spruce-balsam forest with some veteran trees. The climb to the ridge crest is short and densely forested, with slopes likely approaching 60%. However, as usual, this is the lowest and most easily accessed pass joining the two watersheds. To the south, the watershed divide is steeper on the Procter side, and the overall climb required to cross the divide is greater. To the north, higher elevations, dense forest, and steep, deeply gullied terrain on the Procter side would make passage difficult also.

Once in the Procter watershed, the corridor drops down a sharp 50% slope to the valley bottom, and then turns due south and proceeds to the most southerly point in the Procter watershed, following the course of Procter Creek. This 1.5 km run along the valley floor passes through continuous old growth spruce-balsam and Pinus albicaulis old growth forest. Forest density ranges from near closed canopy to quite open in areas of shallow soil over bedrock. At the far south end of the watershed, the corridor descends into a small cirque basin and then climbs a short steep headwall to reach the Irving Creek watershed. The headwall is forested, although avalanche or rock slide chutes are visible in the area. All of the terrain in the upper portion of the Harrop and Irving Creek watersheds is ecologically sensitive and protected from timber management or other development, so extensive areas outside of the corridor are available for animals wishing to make the passage between these two watersheds. However, there are no better passes obvious than the one which was selected.

Once in the Irving Creek watershed, the corridor drops down a steep decline over 100 or 200 meters from the ridge crest, and enters a series of stepped particle cirque basins in the headwaters of Irving Creek. The corridor passes through open forest, combined with talus slopes and wetlands perched on high elevation sites. This location is by far the most reasonable access to the Irving-Procter divide in the upper portion of Irving Creek. The corridor sweeps near Fat Lake, which is nestled in its rocky cirque basin in the upper reaches of the Irving Creek watershed, and then proceeds northward, running beside Narrow Lake for a short distance. North of Narrow Lake, the corridor joins the extensive old growth protection area which was designated in the upper portion of the Irving Creek watershed. This 100 hectare block contains a variety of spruce, balsam, and Pinus albicaulis forests, much of it on moist, lower benches, or other moderately sloped terrain.

A final small leg of the corridor joins the proposed protected old growth forest area in Irving Creek to an isolated upper elevation cirque basin in the Wilson Creek watershed. This final leg of the corridor is a somewhat hypothetical location. All of the terrain in the area is ecologically sensitive and protected from human development, and animals could use any travel route they wished to, to move between Irving Creek and Wilson Creek in this location. However, we identified this route to highlight one of the more feasible paths which could be used. From the upper reach of Irving Creek, the corridor proceeds east into a small hanging valley in the Irving Creek watershed. The corridor then moves along a lengthy talus slope, and includes the forested area between the Talus slope and the ridge crest. This route provides an opportunity for animals to climb at a gradual pace, rising across a steep slope to reach the watershed divide. From the ridge crest, a moderately steep drop through thin, Pinus albicaulis forest growing on a rocky exposed southern face leads down into the forested cirque basin. The cirque basin contains two moderately-sized lakes, and a variety of wetlands surrounded by steep rocky headwalls and sharp ridge crests. The basin is occupied by an old growth balsam and spruce forest. Terrain in the basin is a mixture of flat areas and moderate slopes.

The corridor does not link the upper elevation basin in Wilson Creek to the main stem of Wilson Creek because no feasible travel routes exist between these two locations. Animals, of course, would be able to find a way between the two, but it is dubious that a major travel route would ever be formed from the lower elevations of the Wilson Creek valley to the upper elevation cirque basin at the end of the Narrows Creek to Irving Creek corridor.

4.4.4.4 Kootenay Lake Face Corridor

The Kootenay Lake Face corridor is an unusual corridor. Rather than connecting the low elevation areas in a valley to upper elevations and to adjoining valleys, this corridor moves across the mid to upper slopes of the main Kootenay Lake valley face at more or less constant elevation. We located this corridor in an attempt to provide a movement path for biota along the main valley feature in the study area. We suspect that the main movement route prior to European settlement would have been the Kootenay Lake riparian zone. However, the Kootenay Lake riparian zone is largely occupied by settlement and clearings within the study area. Animals which wish to move through the study area in lower elevations have little choice but to move through the forested area above the settlement.

In order to minimize the potential conflicts between humans and wildlife, the Kootenay Lake Face corridor is located as far away from the settled areas as possible, while utilizing feasible creek crossings. The corridor, by and large, crosses the Harrop, Slater, Narrows, and Procter creek valleys at the approximate junction between these side drainage valleys and the main Kootenay Lake valley. In all cases, moving further upstream is impractical because the corridor would then be involved in steep, almost impassable terrain in the side drainage valleys. Moving the corridor further downhill is not desirable because this decreases the buffer distance between the corridor and the settled area and tends to increase the amount of the corridor located on private land.

A substantial part of this corridor is in fact located on private holdings. We are aware that proposing limitations on private property rights is a sensitive, and potentially divisive, political issue. In our opinion, inclusion of private holdings in the protected landscape network should be voluntary. Inclusion in the protected landscape network would not necessarily require complete ecological protection of private properties, but would require the maintenance of sufficient forest cover to allow movement of various biota through the area. We do not know if the owners of the parcels included in this proposed network are amenable to participating in this program. If not, alternative locations with less desirable levels of connectivity would have to be identified.

The Harrop Face corridor starts at the western boundary of the study area, linking to West Arm Provincial Park. The corridor then runs along the northern lip of a large, deeply incised gully or small valley down to the Harrop Creek main stem, crossing the creek at a point about 2 km upstream from the settled area. The corridor is located along the edge of the steep drop-off into the gully to incorporate a variety of habitat types and to encompass the drop-off edge movement route which is used by many animals in most situations.

The crossing of Harrop Creek is a difficult choke point in the corridor. Moving upstream, there are no better locations to cross the creek before the site used by the Harrop Irving-Wilson corridor, about 2 km upstream. Moving downstream, one enters the steep, rock-sided canyon through which the lower portion of Harrop Creek flows. The site selected requires animals to make a descent down a moderately steep slope on the west side of Harrop Creek, cross the creek, and then ascend a short, steep slope to rise out of the beginning of the Harrop Creek canyon. Further analysis of animal movement patterns in the area and of the corridor location would be desirable to ensure that the corridor is not placed in an impassable location.

Between Harrop Creek and Slater Creek, the corridor runs at more or less constant elevation across the main Kootenay Lake Valley face. The corridor is located partially within portions of the timber management landbase and partially within steep terrain which must be moved from the landbase. The corridor crosses Slater Creek, just beneath a prominent rock wall on the west bank of Slater Creek and just above the private land boundary. The crossing of Slater Creek occurs on a small flat bench and appears to present no significant obstacles to animal movement.

The passage from Slater Creek to Narrows Creek is similar. The corridor again moves across the face at more or less constant elevation through a mix of potential timber management and steep ecologically sensitive terrain. However, most of this leg of the corridor is within private land holdings. The corridor crosses Alyeo Creek on this leg, but at a point beneath the steeply gullied, deeply incised portion of Alyeo Creek.

The Narrows Creek crossing is another difficult location. The corridor first encounters the Narrows Creek valley at a place where a vertical rock face separates the upper bench occupied by the corridor from the bottom of the creek valley. In order to circumvent this impassable obstacle, the corridor moves down Narrows Creek valley to the north for half a kilometer following the edge of the drop-off into the creek valley. When the end of the rock wall is reached, the corridor turns to the east and crosses Narrows Creek. The corridor then rises up a small side drainage through continuous forest cover to the same approximate elevation it was at before it turned north and dropped down to cross Narrows Creek. The Narrows Creek crossing is entirely within private land and is the point at which the corridor comes closest to settlement and active human habitation. However, due to the extremely steep, unstable, and rugged terrain on the west side of Narrows Creek throughout the length of the Narrows Creek valley, this is the only feasible crossing place between the mouth of the creek and the headwaters area.

On the ascent from Narrows Creek to the Narrows-Procter Creek divide, the corridor runs along the north side of a proposed protected old growth area. The forest in this area is an old fir-larch-cedar stand, some of which is on terrain which is potentially suitable for timber management. Old growth fir, larch, cedar, and hemlock forests are extremely rare in the Harrop-Procter watersheds, and this area is a high priority for protection. Linking to the area with the corridor helps to ensure that the biodiversity inherent in this stand will be enhanced and protected, and will be available to spread along the maturing forest in the corridor to other parts of the landscape.

The final leg of the corridor crosses the Procter Creek valley and rises to the ridge watershed divide between Irving and Procter Creeks. The Procter Creek crossing involves a sharp drop down a long steep slope (50-65%) and up a similar slope onto the opposite valley crest. This location is far from an optimal movement corridor, but locations further to the north are impacted by existing near clearcut logging, road locations, gullies, and planned timber harvesting activity, and locations to the south are more rugged, with complex terrain, deeply incised gullies, and rock faces.

The corridor links to a small, proposed protected old growth area on the ridge crest between Procter and Irving Creeks, and stops. While animals may pick routes through the rugged terrain and deeply incised Irving Creek valley to continue along the Kootenay Lake face, we were unable to identify possible locations for corridors at this site. To the north, the way is blocked by the steep headwall of a deeply incised gully system. To the east, the west slope of the Irving Creek valley falls in a series of deep gullies, rock screes, and unstable terrain to deeply incised Irving Creek. To the south, a long knife edge ridge crest runs between Irving and Procter Creek.

4.5 Forest Use Zoning

Previous steps identified ecological framework required to protect ecosystem functioning at the landscape level, and areas which are too sensitive for aggressive human uses such as timber extraction. The end result of this process was a set of polygons of stable and moderately stable land which are potentially suitable for timber management. These areas are the white patches on the Protected Landscape Network map, shown in Figure 19.

However, the fact that we did not identify physical or ecological reasons to remove these areas from the timber management landbase does not mean that timber management is perforce the desirable land use option for all of these areas. That is why we have been careful to describe these polygons as "potential" timber management areas to this point.

Community members had earlier identified the Current Community Forest Uses shown in Figure 9. In the opinion of Silva and the HPWPS, the identified community uses are not incompatible with ecologically responsible timber management using partial cutting on the identified potential timber management landbase. At this time, we do not believe that additional reductions in the timber management landbase or harvested volumes are required to allow both timber management and the identified community uses to proceed on areas of overlap.

However, all of the watersheds in the study area are highly valued by the community as domestic and agricultural water sources. This use was not mapped on the community uses map because it extends throughout all of the watershed areas. Any disturbance or impact anywhere in the watershed which introduces fine sediment into a water supply, or which alters the flow pattern of the water supply, is of concern.

The potential conflicts between timber management and maintenance of water quality, quantity and timing of flow have been the source of an energetic debate in the Kootenays, and other portions of the western cordillera, for generations. Based on our analysis, discussions with the HPWPS, and review of the Harrop-Narrows-Procter Creeks Terrain Interpretation (Wallace et al 1998), we identified the following likely impacts to water resources from timber harvesting in upper portions of the watersheds in the study area:

1. Alteration of snowmelt patterns and spring peak flows from forest canopy alteration in the broad cirque basins in the upper reaches of Harrop Creek.
2. Risk of road induced landslides into Harrop Creek if access roads are constructed through steep, sensitive terrain to reach the upper portions of watersheds.
3. Risk of sedimentation from surface erosion of exposed soil surfaces following road and trail construction.
4. Risk of slope failure due to alteration and concentration of drainage patterns by roads and trails.

Tom Bradley and the representatives of the HPWPS met to decide forest use zoning for watershed protection in the spring of 1998. Reflecting the above concerns, broad headwaters basins and upper slope areas which are isolated above steep terrain or difficult creek crossings were zoned for watershed protection in Harrop, Narrows and Procter Creeks. The results of this meeting are illustrated on the map in Figure 22 and in Table 8. The rationale for zoning specific areas for watershed protection zones is as follows:

- **Harrop Creek - West Central:** Two small blocks on stable terrain inside a deeply incised gully system were zoned for water protection. As shown in Figure 24, these areas are isolated by deep gullies and are immediately adjacent to steep, sensitive creeks. Although possibly accessible for helicopter logging, the areas were protected to reduce risk to water supplies.

- **Harrop Creek - West Fork:** A set of five blocks in the upper West Fork watershed were zoned for water protection. Road access to these areas would have to cross a large, active gully with substantial stream flow. This crossing would present a high risk of damage to water supplies. In addition, the most southerly blocks are part of the flat, headwaters basin of the West Fork. Retaining undisturbed forest cover on this area is the best insurance policy to maintain undisturbed late season water supplies.

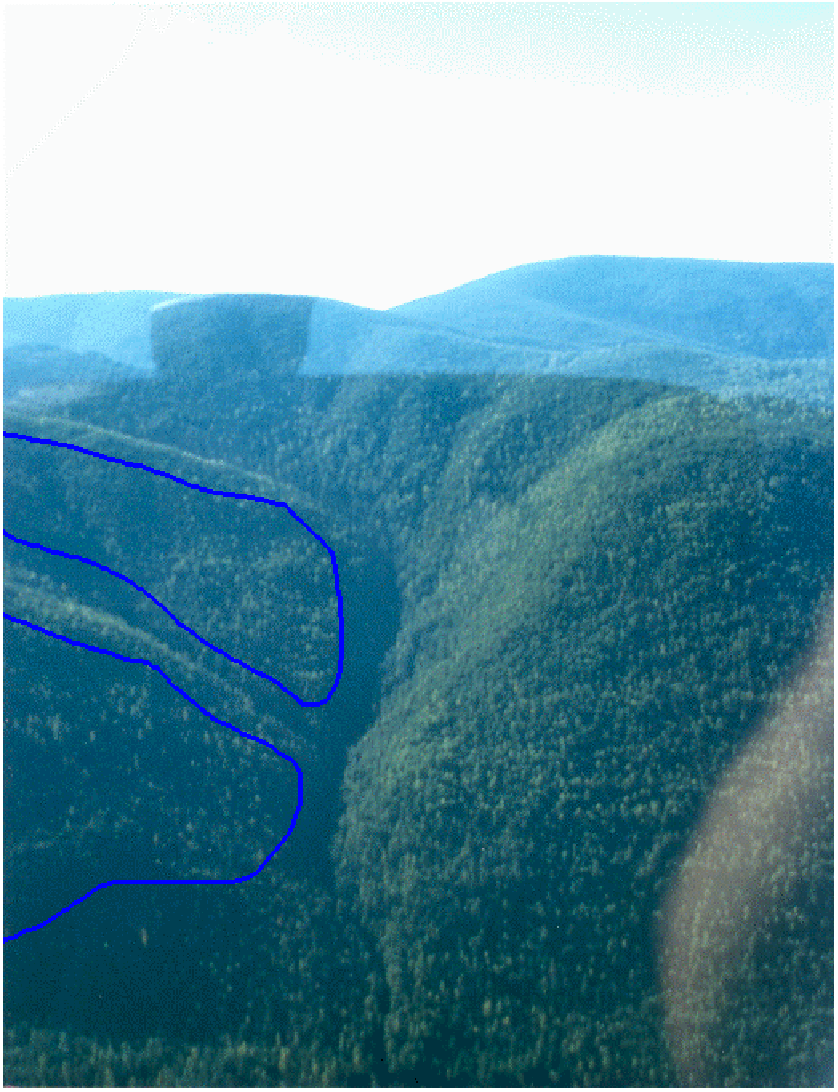

Figure 21: Areas placed in watershed protection zone in west central Harrop Creek watershed.

- Harrop Creek - East Fork: A small block in the upper watershed was zoned for water protection. This area is the furthest end of a long narrow block which extends for 2 km up the west side of the creek. The piece of the block which was zoned for water is south of a significant slide chute. The risk to water associated with crossing the slide chute with a road was not supportable.
- Narrows Creek: A set of blocks extending over 4 km in the upper watershed were zoned for water protection. Road access to these areas would have to pass through

several kilometers of area rated as Class IV terrain stability and Very High erosion potential by the TSIL B assessment of the area. We understand that the high rating in this location is due to the presence of smooth, sloped bedrock parallel to the soil surface. Several of the blocks were also within the high hazard area. All of the upper basin of Narrows Creek was therefore judged inaccessible without incurring unacceptable risks to water.

- Upper Procter Creek: A series of small blocks placed on small benches between the deeply incised multiple forks of Procter Creek were zoned for water protection. Some of these areas may be accessible for helicopter logging, but road access to the area is out of the question given steep slopes and many small drainage channels. The risk from any logging activity was felt to be to great in this sensitive domestic watershed.

This forest use zoning is an initial exercise. Zoning changes may occur as additional field based assessments of access potential and difficulties, and of terrain stability, are carried out.

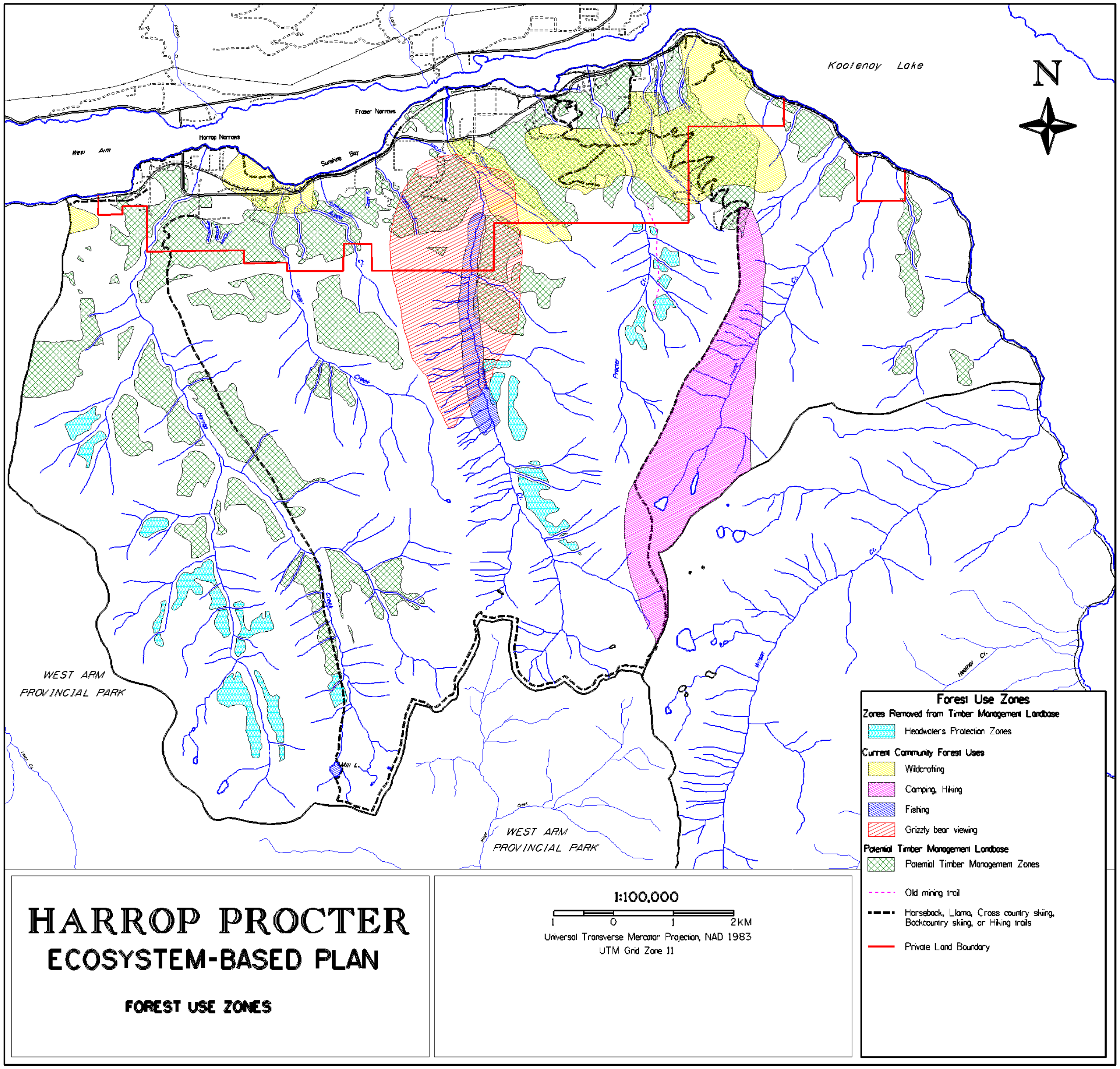

Figure 22: Map of Forest Use Zoning in Harrop-Procter watersheds.

Forest Use Zoning												
Description	**Crown Land**				**Private Land**				**Crown and Private Land**			
	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI	Area (ha)	Percent of Total Area	Gross MAI (m3/ha/yr)	Percent of Total MAI
Lakes	12	0.1%	0	0.0%	1	0.0%	0	0.0%	13	0.1%	0	0.0%
Netdowns for Ecological Reasons	9,086	70.1%	19,657	67.6%	1,276	9.8%	1,732	6.0%	10,362	79.9%	21,389	73.6%
Headwaters Protection	283	2.2%	932	3.2%	0	0.0%	0	0.0%	283	2.2%	932	3.2%
Potential Timber Management Landbase	1,315	10.1%	3,760	12.9%	995	7.7%	2,995	10.3%	2,310	17.8%	6,756	23.2%
Total:	**10,695**	**82.5%**	**24,350**	**83.7%**	**2,273**	**17.5%**	**4,727**	**16.3%**	**12,968**	**100%**	**29,077**	**100%**

Notes:

1) Netdowns for Ecological Reasons include Non Forest, Non Commercial, MoF Netdowns, Silva Ecologically Sensitive ecotypes, Cross Valley Corridors and Protected Old Growth Nodes.

2) Gross MAI is net of deductions for decay only, and are not net of deductions for waste, breakage, maintenance of ecology significant structures and longer rotations. These deductions are expected to further reduce MAI by at least 30%.

Table 8: Distribution of Area between Major Human Use Zones in Harrop-Procter watersheds

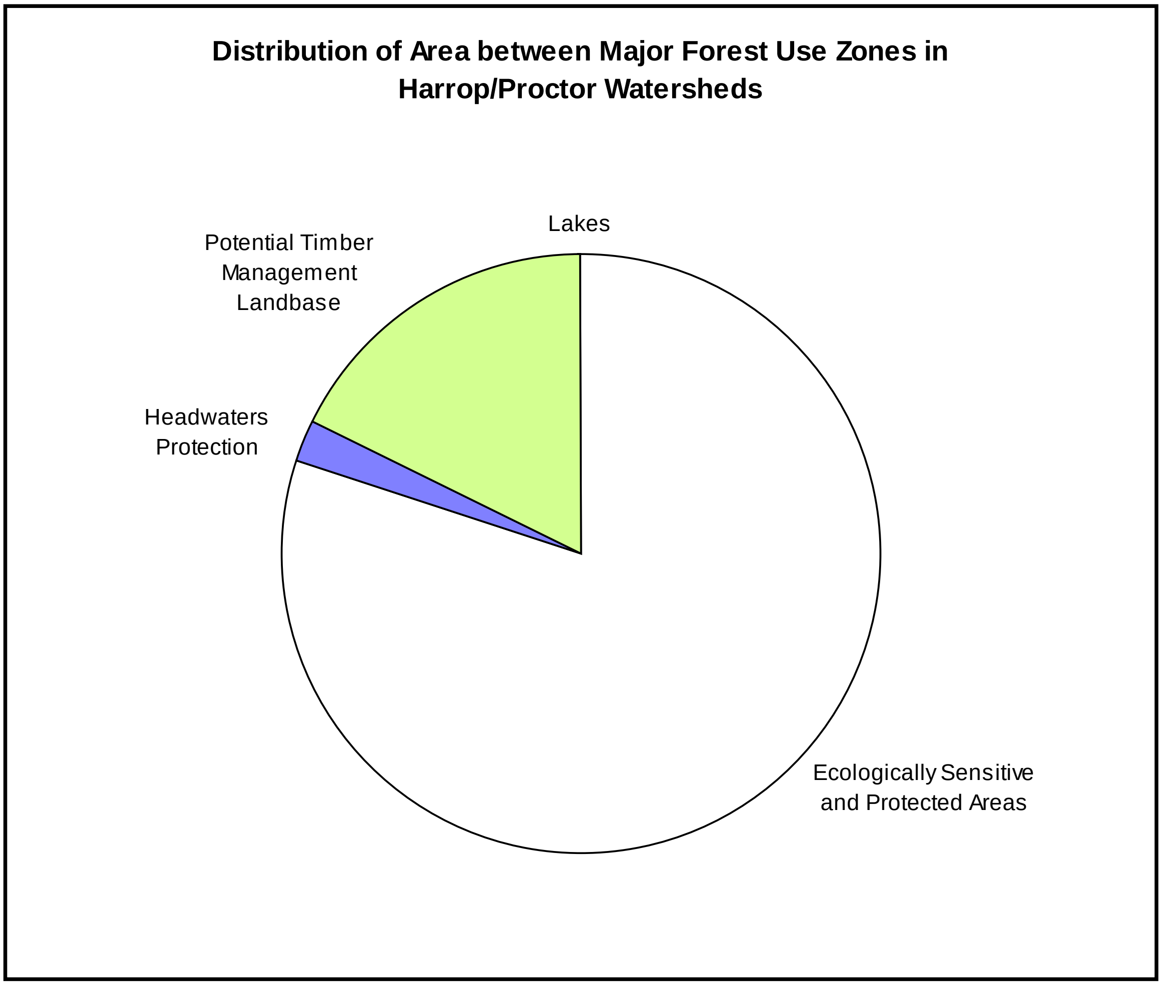

Figure 23: Graph of Distribution of Forest Use Zones in Harrop-Procter watersheds

5. Results and Recommendations

5.1 Ecologically Responsible Cutting Level

The discussion in Section 4 above has laid out the process used to identify areas in the Harrop-Procter watersheds which are not suited for timber management due to ecological limits, due to requirements to maintain landscape ecosystems, and due to the need to protect community water supplies. The end result of this process is an initial timber management landbase, shown on the map in Figure 19.

Table 9 summarizes all of the landbase netdowns developed in this process, and indicates the ecologically responsible cutting level for the Harrop-Procter watersheds. Note that the timber management landbase shown in Table 9 is 14 hectares smaller than the similar estimate in Table 8. This is because the figures in Table 9 make specific allowance for the removal of half of the 28 hectares of moderately stable terrain from the landbase.

The conclusion of this study is that the long term sustainable annual cutting rate in the Harrop-Procter watersheds is 2,603 cubic meters of timber per year, on a landbase of 1,301 hectares.

This is a relatively small cutting rate for a landscape unit of 12,967 hectares. The two main reasons for this are:

1. The pattern of ownership which places 2,271 hectares growing 3,309 m3 of timber per year in private hands.
2. The steep, rocky, and sensitive terrain in the Crown portion of the study area.

The crown portion Harrop-Procter watersheds are almost entirely un-logged and un-accessed in 1999, after close to a century of timber cutting in southern B.C. They certainly have not been bypassed for so long because they are good places to go logging, by any standard. The cutting level we have determined in this process strikes a reasonable balance between:

- the inherent difficulties of logging in rugged terrain,
- the need to protect water and other forest uses,
- the need to protect and maintain forest ecosystems, and
- community aspirations to utilize crown timber resources in a diverse local economy.

This harvest level is an initial estimate, based on reconnaissance level information. Much of the terrain classification work behind this estimate is based solely on air photo interpretation, and additional field assessments are required to verify or improve interpretations.

The type of timber management proposed for the timber management landbase in the Harrop-Procter watersheds is different from conventional forestry. The timber management landbase will not be divided into a series of smaller areas and clearcut, one at a time. The HPWPS has stated that they wish to achieve certification by the Silva Forest

Foundation as ecologically responsible timber management. A summary of the *Silva Forest Foundation Standards for Ecologically Responsible Timber Management* is contained in Appendix 5. The full document can be obtained from the SFF web site at www.silvafor.org/docs. These papers lay out the principles of ecologically responsible forest use. In addition, the SFF has recently competed a document titled *Initial Silvicultural Prescriptions for Alexander Road Forest.* This brief report uses field information gathered by the HPWPS to prepare a set of initial silvicultural prescriptions for a small part of the timber management landbase. The report contains a series of tables and diagrams which outline the type of partial cutting to be carried out, and the rationale for the choices.

The estimated long term harvesting sustainable rate of 2,603 m3/year was noted above. It is important to remember that long term forest harvesting rates are set by a combination of the net timber productivity and operable landbase, but short term harvesting rates are largely determined by the near term silvicultural objectives. The silvicultural prescriptions to be implemented will determine the volume, species composition, piece size and value of timber produced over time, and thus the funds available to pay for roads, infrastructure, logging, silviculture, and management. There can be a substantial difference between indicated long term harvesting rates and real short term rates in an ecologically responsible partial cutting regime, especially in the transition period from young stands to older forests. All of the timber management landbase in Harrop Procter watersheds is occupied by younger stands, so this is a serious concern.

The initial silvicultural assessment and modelling carried out in the *Initial Silvicultural Prescriptions for Alexander Road Forest* has been encouraging. The stands assessed can produce significant timber volumes in the near term, and the area has few if any very young stands which will contribute nothing to annual cutting rates. Further assessment and modelling of cutting rates under an ecologically responsible partial cutting regime is a high priority, however, to avoid management induced timber shortfalls in the future.

Determination of Ecologically Responsible Timber Harvesting Level in Harrop/Proctor Watersheds

	Area (ha)	Percent of Total Area	Balance	Net MAI (m3/ha/year)	Percent of Total MAI	Balance
Total Study Area Landbase:	12,967	100%	12,967	20,355	100%	20,355
Areas Not in Proposed Community Forest Landbase						
Water	12	0%		0	0%	
Private Land	2,271	18%		3,309	16%	
Subtotal:	2,283	18%	10,683	3,309	16%	17,047
Non Forested or Non Commercial Forest						
Alpine and Rock	283	2%		0	0%	
Non Productive, Non Commercial or Cleared	201	2%		78	0%	
Alpine Forests	1,407	11%		1,084	5%	
Subtotal:	1,891	15%	8,793	1,162	6%	15,885
Ministry of Forests Netdowns to Timber Management Landbase						
Low Site Quality	326	3%		207	1%	
Environmentally Sensitive Areas Class 1	714	6%		1,063	5%	
Low Stand Volume or Deciduous	289	2%		223	1%	
Inoperable Areas	1,458	11%		2,458	12%	
Subtotal:	2,786	21%	6,007	3,951	19%	11,935
Silva Netdowns to Timber Management Landbase						
Riparian Ecosystems	801	6%		1,574	8%	
Steep Terrain	3,313	26%		6,564	32%	
Sensitive Terrain in Moderately Stable Zones	14	0%		29	0%	
Subtotal:	4,128	32%	1,879	8,167	40%	3,768
Protected Landscape Network Components						
Old Growth Forests on Stable Terrain	140	1%		186	1%	
Cross Valley Corridors on Stable Terrain	156	1%		326	2%	
Subtotal:	296	2%	1,584	512	3%	3,256
Protected Forest Use Zones						
Headwaters Protection Zones	283	2%		653	3%	
			1,301			2,603
Potential Timber Management Landbase						
Helicopter Accessible Terrain	125	1%		205	1%	
Moderately Stable Terrain	14	0%		29	0%	
Stable Terrain	1,162	9%		2,369	12%	
Subtotal:	1,301	10%	0	2,603	13%	0

Notes:
1) Net MAI is net of allowances for decay, and net of a 20% allowance for the creation and maintenance of ecological structures on all management sites, and of a 10% allowance for rotations longer than culmination age.

Table 9: Estimate of Ecologically Responsible Timber Harvest Rate.

5.2 Recommendations

Based on our work in the Harrop-Procter watersheds and communication with the HPWPS, we make the following recommendations for future activities and projects:

1. Achieve a form of community forest tenure over the study area. At the time of writing, the HPWPS is applying for a Community Forest License for the Harrop-Procter watersheds. We hope they are successful, but encourage them to pursue the overall goal of community control over forest resources regardless of the outcome of this particular application.
2. Assess growing site quality in the study area. As discussed in Section 3.1, we used the default site index assessment from the forest cover data files to estimate timber yield in the study area. Our field measurements of site index raised questions about the accuracy of this information, but we did not have sufficient data to propose revision at this time. Changing site index estimates could have a significant impact in timber yield predictions and on estimates of annual cutting rates.
3. Research and model mixed stand yield. The VDYP yield model used to estimate timber productivity in this study assumes strict even aged management: clearcut, grow crop to rotation age, and clearcut again. However, we are proposing a partial cutting regime in which complex arrays of various sizes, ages, and species of trees continuously occupy forest sites. Although many people are considering the mixed stand yield problem as ecologically responsible forestry becomes mainstream, to our knowledge no one has developed suitable yield models for complex partial cutting. A combination of research, networking, computer modelling and field trials should be initiated to improve timber yield estimates under partial cutting regimes.
4. Access planning and economic feasibility. The HPWPS has carried out an initial economic feasibility study of timber management in the Alexander Road and lower Narrows Creek areas. Additional work needs to be carried out. A combination of access planning, access and logging cost estimation, and initial silvicultural planning needs to be performed for the entire proposed timber management landbase. Any areas which can not be economically accessed under reasonable silvicultural and timber value assumptions should be removed from the timber management landbase.
5. Terrain and soils mapping and field verification. All of the terrain mapping work carried out in the Harrop-Procter watersheds to date has been at a reconnaissance level, with minimal field checking. More detailed, field based inventories are required to refine the estimate of operable landbase.
6. Conduct an inventory of remnant old growth structures and patches in lower elevation ecosystems. Many individual old growth trees and patches of old growth trees occur within the young forests in the main Kootenay Lake valley, but are not currently mapped. These remnant structures are very important ecosystem resources, and should be inventoried to assist in forest use planning, and to provide baseline information about forest and landscape conditions at the time when ecologically responsible forestry began in the Harrop-Procter watersheds.
7. Research and develop a fire management plan for the study area. Fire disturbance is a natural part of forest ecosystems, and recent forest management approaches have

highlighted the negative impacts of altering the natural frequency and intensity of forest fires. Decisions regarding fire suppression versus letting areas burn, the possible use of fire as a silvicultural tool in select instances, and the management of fire in the settlement/forest interface zone, must be made. Many other agencies and tenure holders in the Kootenays and neighboring regions are considering similar problems. A combination of research, networking, community consultation, and planning is required to begin to address these issues.

8. Improve and refine ecosystem-based plan. In addition to the specific recommendations above, it is worth mentioning that any and all parts of the mapping and assessment used to develop this reconnaissance level ecosystem-based plan can be improved. The HPWPS has carried out a tremendous amount of community consultation during this process. We encourage them to continue this work, and to keep working to improve the reliability and accuracy of the maps used in this plan, and to improve the community understanding of this process.

Appendix 6

List of Common and Latin Tree Names Used in Report

Common Name	Latin Name	Abbreviation
Douglas-fir	*Pseudotsuga menziesii*	Fd
Western larch	*Larix occidenetalis*	Lw
Alpine larch	*Larix lyalli*	La
Western redcedar; Cedar	*Thuja plicata*	Cw
Hemlock	*Tsuga heterophylla*	Hw
Grand fir; Balsam	*Abies grandis*	Bg
Subalpine fir; Balsam	*Abies lasiocarpa*	Bl
Engelmann spruce	*Picea engelmannii*	Se
White pine	*Pinus monticola*	Pw
Lodgepole pine	*Pinus contorta*	Pl
Whitebark pine	*Pinus albicaulis*	Pa
Aspen	*Populus tremuloides*	At
Cottonwood	*Populus trichocarpa*	Ct
Birch	*Betula papyrifera*	Ep