Restoration Plan for District Lot 63 of the Pebble Beach Nature Reserve, Galiano Island

Prepared by:
Nathan Gaylor
Odin Scholz
Keith Erickson

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GALIANO CONSERVANCY ASSOCIATION

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Context

Up until 150 years ago, over 75% of the forest landscape of East Vancouver Island and the adjacent Gulf Islands was dominated by trees greater than 100 years of age. Today only 2.6% or 10,605 hectares of the same landscape is characterized by older forest (McPhee et al., 2000). Regenerating forests, agricultural lands, roads and urban development have replaced and fragmented old forest making ecosystems of the Coastal Douglas-fir Biogeoclimatic Zone (CDF) some of the most endangered in British Columbia. All old-growth forest types that are either dominated or co-dominated by Douglas-fir within the CDF are currently on the province's list of rare and endangered ecosystems (Flynn, 1999).

Fragmentation of the forested landscape due to human land-use has resulted in:

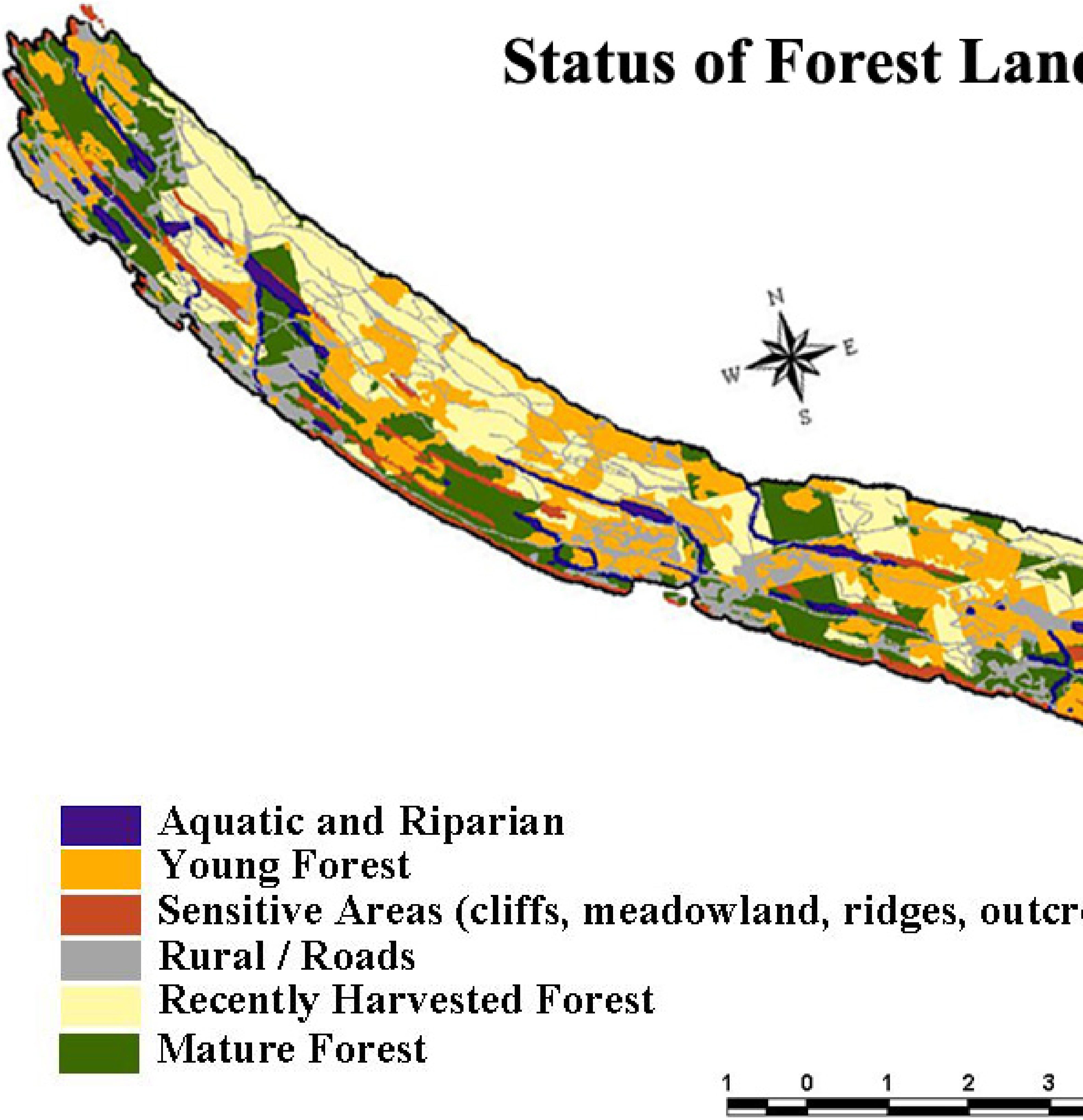
- extensive loss of original habitat
- reduced habitat patch size
- increased edge and decreased interior habitats
- increased isolation of habitat patches
- modification of natural disturbance regimes and successional patterns
- spread of exotic vegetation (including plantation stock from off-island)

Addressing these existing impacts requires that conservation efforts be focussed on land protection and ecosystem restoration. Preserving the few remaining parcels of land that exhibit in-tact natural ecosystems is of utmost importance. However, the sheer rarity of these opportunities within the CDF dictates that the protection and subsequent restoration of degraded land will also play a vital role.

Planning and analysis at a landscape level are necessary to ensure that efforts are focussed in the most effective and beneficial manner. Activities such as ecosystem and land-use mapping identify opportunities for habitat connectivity and highlight natural linkages between existing protected areas. This provides insight into prioritizing land for restoration and protection by indicating where efforts might achieve the most benefit for wildlife, establishment of native vegetation, or maximizing the extent of interior habitat.

Galiano Island presents a landscape characteristic of the Coastal Douglas-fir Zone. It has undergone extensive timber removal over the past 100 years. Virtually no lot, across the near 6000ha landbase has been left untouched. Roughly one third of the Islands forest land-base (4,500 hectares) is now less than 30 years old, another third is between the ages of 30 and 80, and the final third is older than 80 years (Map 1). Most of the mature forest is scattered amongst residential developments in protected areas, on crown land, on large privately owned residential lots, and on ridges or bluffs that are difficult to access. In contrast, recently harvested and young forests dominate the entire eastern side of the island from top to bottom.

The existing protected areas network on Galiano encompasses over 13% of the Island's land-base including aquatic, cliff, ridge, bluff, meadowland, bog and forest ecosystems. Opportunities for landscape level linkages between these areas have been identified. One of the highest priorities involves the connection of the Pebble Beach Nature Reserve, Laughlin Lake, Bodega Ridge Reserve, the proposed Trincomali Marine Protected Area, and Wallace Island Provincial Marine Park (Map 2). This cross-island linkage features a range of ecosystem types including a 65 hectare clear-cut plantation that falls between land parcels characterized by mature forest. Due to its protected status, its proximity to older forest ecosystems, its role in a landscape level linkage, and its legacy of human impact, the plantation known as District Lot 63 (DL 63) has been identified as a high priority for ecological restoration.



Status of Forest
N
E
W
S
Aquatic and Riparian
Young Forest
Sensitive Areas (cliffs, meadowland, ridges,
Rural / Roads
Recently Harvested Forest
Mature Forest
1 0 1 2 3

Proposed Trincomali
Marine Protected Area
Wallace Island

Setting

The focus area of this report is District Lot 63 (DL63), part of the Pebble Beach Nature Reserve on Galiano Island. The management goal of DL 63 is "To preserve the forest, aquatic and foreshore ecosystems in perpetuity, while allowing local and regional educational and research use along with the continuation of traditional low impact recreational activities." One of the specific objectives is "To facilitate environmental restoration when and where it is required in order to maintain the natural integrity of the ecological systems within the Reserve." DL 63 also has a designation of Forest under section II, 3 of the Galiano Island Official Community Plan (1995). Objectives of the Forest designation include 1) to preserve a forest land base; 2) to protect the aesthetic value of forest land,…; and, 4) to protect riparian zones, sensitive ecosystems, watersheds and biodiversity.

The registered owner in fee simple is the Galiano Conservancy Association. Easements across DL 63 have been provided to several landowners holding title to lands beyond. There is a Statutory Right of Way stretching from the southern boundary to the northern boundary of the property that is held by Telus Communications. The land is bound by a Section 219 covenant held by the Islands Trust Fund and the Province of British Columbia. The covenant states that any restoration or alteration to the land must be consistent with the lot's management plan and that the management plan must be approved by the covenant holders. A draft management plan currently exists. It has been accepted by the membership of the Galiano Conservancy Association but has not yet received approval by the covenant holders. The plan outlines procedures and guidelines for conducting restoration activities on areas that have been subject to human disturbance. In order to meet these requirements, this restoration plan will be presented to both the Pebble Beach Management Committee and to the Galiano Conservancy Association Board of Directors for their approvals. In addition, before restoration activities commence on DL 63, the management plan or the specific section of the plan pertaining to restoration must be approved by the covenant holders.

Goal and Objectives

Goal: To assess the restoration needs of District Lot 63 and determine appropriate restoration treatments. For the purposes of this project restoration will be defined as follows:

"Restoration is assisting natural processes to mend, replace, and develop:

- Natural Composition (the parts)
- Natural Structures (the arrangement of the parts)
- Natural Functions (how it works)"

(Hammond, 1999)

Objectives:

1. Identify and analyse human and natural history of the site.
2. Identify and describe current ecological conditions of the site.
3. Evaluate ecological impacts incurred by industrial logging of the site.
4. Develop appropriate restoration strategy.

SECTION II: Physical, Ecological and Cultural History

Climate

The rainshadow effect of the Olympic and Vancouver Island mountains and the moderating effects of the ocean are the dominant influences on the climate of Galiano Island. Kerr (1951) describes the Island as having a "Transitional, Cool Mediterranean Climate". Galiano exhibits a pattern of warm dry summers and mild wet winters with an average of approximately 1,900 to 2,000 hours of sunshine (Ronneseth and Barr, 1982) and 254 frost free days (Agriculture Canada, 1989) per annum. The average annual rainfall recorded at the North Galiano Atmospheric Environment Service station is 920 mm (from 1977 to 1988). Annual rainfall ranges from 597.3 mm to 1152.6 mm (Harrison, 1994). Over 75% of the total annual precipitation falls during the winter months (November through February), with less than 10% falling as snow.

The months of January and February produce the coldest mean temperatures of 4° to 5° Celsius, while July and August are the warmest months with mean temperatures of 17° to 19° Celsius. The combined effects of low precipitation, warm temperatures, and high number of sunshine hours often result in an annual moisture deficit on Galiano Island from mid-June to early October (Harrison, 1994). This deficit can often reach drought conditions in areas of recent clearcuts, such as District Lot 63, and can result in an extreme forest fire hazard.

Geology and landforms

Galiano Island lies within the Nanaimo Basin, a large depression at the southern end of the Georgia Strait. Clark (1977) describes Galiano Island as structurally simple; it is part of the Northeastern edge of the Trincomali Anticline. The Islands strata form a simple homocline that dips northeast into the Georgia Basin. Eleven Sedimentary rock formations dominate the Basin stratigraphy, termed the Nanaimo group. Three of the Nanaimo group's sedimentary clastic rock formations form the bedrock of Galiano Island

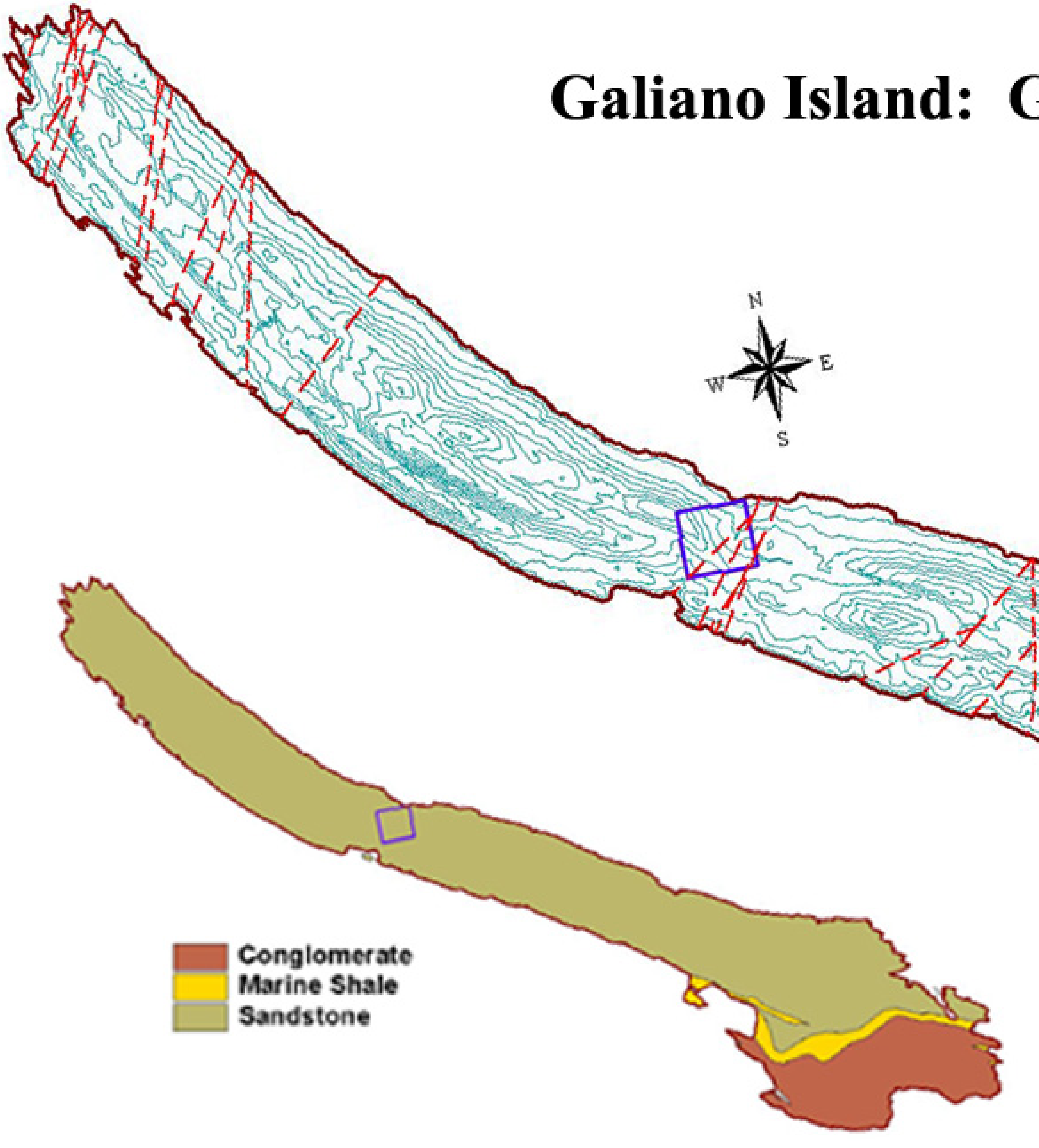
(Muller and Jeletzky, 1970) (Map 3). These formations date to the Upper Cretaceous (65-100 million years ago) and, along with Tertiary sediments, form the fill of the Georgia Basin (Mustard, 1993).

The Gabriola formation is the name of the surface layer of the Nanaimo group. This stratigraphic layer is over 500m deep and occupies 75% of Galiano Island, including the study area (Map 3) (Harrison, 1994). Provenance for Gabriola sandstone particles points to the Coast Range mountains as well as the Eastern Cordillera via a Fraser River scale fluvial system (Mustard ,1993). The Gabriola formation is over 90% arkosic arenite sandstone ranging in texture from medium to coarse grained. This young sandstone is hard and has a relative resistance to weathering. Thin Layers of shale stone co-form the Gabriola formation. Galiano Island's valleys have been carved out of these softer, more erosive sedimentary layers (Green et al., 1989).

Landform expression on Galiano Island is a result of late Cretaceous and subsequent Tertiary differential uplift of Vancouver Island and the concurrent depression of the Georgia Basin (Muller and Jeletzky,1970). These historic shifts gave Galiano Island its backbone, the vertebrae being ridges and cuestas running northwest-southeast paralleling the Georgia Strait. The linear relief pattern of Galiano Island is repeatedly bisected by fractures and faults (Map 3) (Carter, 1977). These weaknesses have been exploited by moving water, as over time v-shaped valleys have been carved allowing the islands streams out to the ocean. Two fractures pass directly through the study area (Map 3), both having steep sided valley components. Carter (1977) postulates the fractures are the tail end of faults originating on Vancouver and Saltspring Islands.

Three successive glacial events have altered the surface expression within the Nanaimo Basin, the most recent, the Fraser glaciation, occurred between 10 and 15,000 years ago (Halstead, 1967). Glaciers advanced on the region, first from Vancouver Island via the Cowichan Ice tongue, and second, from the Georgia strait lobe (ibid.). Glacial forces scraped the islands landforms leaving a more subdued terrain. The legacy of glaciation endowed Galiano Island with a thin (<1m deep) mantle of drift. The force of the glacial

Galiano Island: G



ice mechanically weathered the bedrock and deposited a cemented horizon of sand, silt and rock. On top of the weathered horizon was deposited a layer of unsorted gravelly, sandy, loamy till generated from glacial outwashing (Henderson, 1998). The weight of the ice depressed the land 75-90m relative to the ocean (Eis and Craigdallie, 1980). Depressed land and encroaching seas indicate that all low land in the Georgia Basin was submerged, following glacial retreat. Marine deposits found on the valley floors of the island confirm this aspect of the Island's history. Isostatic rebound following the Fraser Glaciation continues to this day (Halstead, 1967).

SOILS

Four ingredients are required for forest growth and development: sunlight, water, nutrients and air. The soil storehouse contains two of these ingredients: water and nutrients. Water is stored in and moves through soil. The roots of plants and their symbiotic relationship with mycorrhizal fungi draw water out of the soil. Nutrients are also found in the forest soil. Through the decomposition of organic material by microorganisms and through chemical and physical weathering, elements are made available to vegetative communities. These nutrients become water-soluble and are taken up for use by plants (Hammond, 1991).

The symbiotic relationship between higher plants and fungi is extremely important. The fungus supplies the higher plant partner with mineral nutrients and plant growth hormones, and protects the roots against pathogens; the higher plant provides the fungus with energy substrates. Virtually all-higher plants depend on mycorrhizal association (Lavender, 1990). The mycorrhizal populations in turn rely upon the characteristics of soil and water regimes.
The soils of DL63 as described by Green, Vliet, and Kenney in the Agriculture Canada 1989 publication Soils of the Gulf Island of British Columbia are composed of three major types, the Saturna soils, the Brigantine soils, and the Metchosin soils.

Saturna soils constitute 3599.4 ha of the 5787 ha of Galiano. These soils are the most common soils found in DL63. They are classified as an Orthic Dystric Brunisol and are formed on top of sandstone. These well drained loamy sand to sandy loam soils occur at depths of less than 200cm with an underlying restrictive layer of consolidated bedrock. The course fragment content is extremely variable, ranging from 20 to 80%, consisting of both colluvial and glacial material in variable amounts depending on specific location. A variation of the Saturna soil type is evident within DL63. A weathered ridge feature protruding from the N.W. corner of the lot (Map 4) predominantly consists of glacial till and is separated from the rest of the Saturna soil type in this area by a restrictive layer (bedrock) within 50cm of the surface.

Brigantine soils constitute 386.2 ha of Galiano's 5787 ha. This soil type is only located on gentle slopes in the Southeast corner of DL63. They are classified as a Glayed Dystric Brunisol and are formed on fine textured subsoils, often massive in structure with a seasonally fluctuating water table that is saturated to about 60cm from the surface during winter. Brigantine soils are imperfectly drained soils that have a layer of loamy sand to sandy loam of marine or fluvial origin overlying deep silty clay loam to silty clay marine deposits that are usually stone free. The course fragment content is usually between 5-10% and angular gravel in composition. The Brigantine soils in DL63 occur adjacent to the upper reach of Beaver Creek.

Metchosin soils constitute 46.4 ha of Galiano's 5787 ha. This soil type consists of the organic soils found in wetlands and is classified as a Typic Humisol. A shallower form of this type known as a Terric Humisol is identified as occurring in DL63. These are very poorly drained organic stone-free soils. The Metchosin soil type occurs in a swamp that has been delineated on Map 4 as well as in seasonally flooded flat areas located along Beaver Creek.

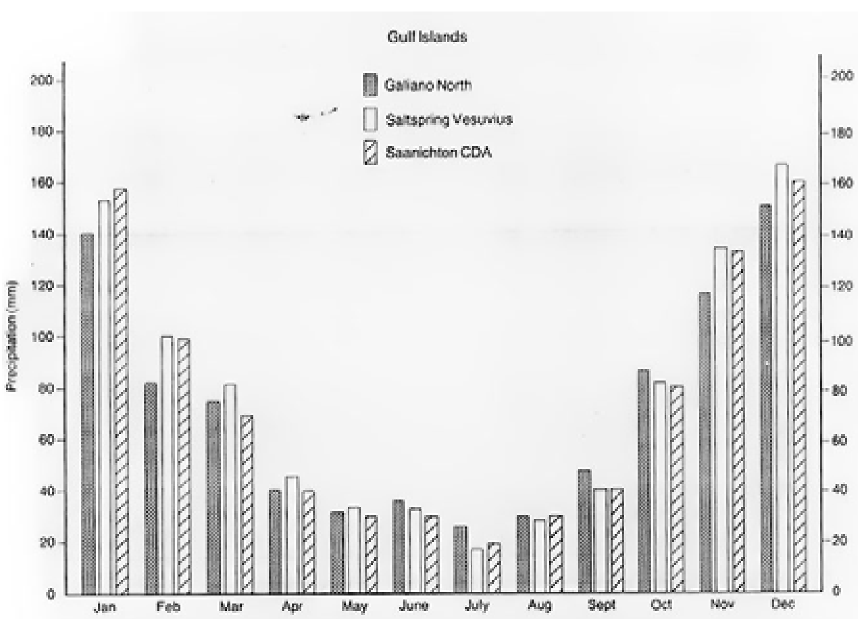
Hydrology

Precipitation is the main source of freshwater into Galiano Island. In general, water input to the island ecosystem returns to the sea via above or below ground flow. Water inputs

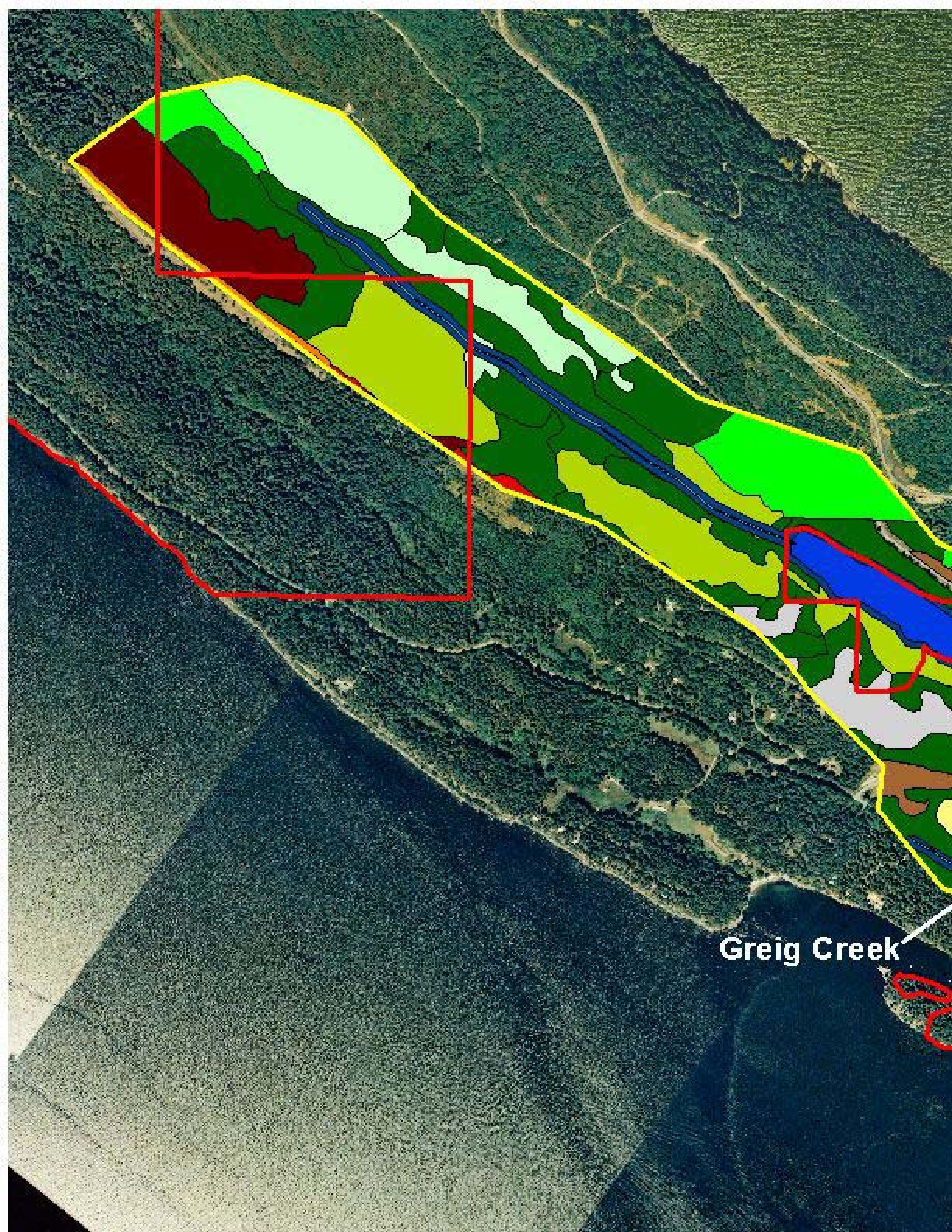
are also lost via evaporation and evapotranspiration (Harrison, 1994). Topography plays a directorial role in how surface and subsurface water concentrates and moves across the land. The Island's ridges and gullies delineate elongated catchment basins. Two of these watersheds factor into the study area, Beaver and Greig Creek (Map 5). Fine textured sands from upland sites and marine deposits characterize the substrate of low-lying areas on Galiano Island. These finer soils act as water retention areas forming a variety of wetland types, from shallow lakes, to bogs and swamps.

Well draining colluvial deposits dominate the low grade backslopes of Galiano Island's bedrock cuestas. Coarse sands and gravels appear at ancient beach and delta sites (Eis and Craigdallie, 1980). The coarse nature of the upland soils and their shallow profiles provide for relatively rapid subsurface percolation of water. The low porosity and massive nature of the bedrock lithology forms a plain for subsurface flow. Local undulations in the bedrock and shallow overburden create conditions by which ephemeral pools form.

The seasonal dichotomy in rainfall plays a significant role in defining temporal surface and groundwater availability. The annual trend is winter surpluses and summer droughts. Water levels rise with the onset of fall and winter rains, and groundwater recharges. Conversely, flows dry up, in some cases totally, during the late summer and early fall months, and groundwater tables drop. In general the longer



Average monthly precipitation for locations in the proximity of the survey area From Agriculture Canada, Soils of the Gulf Islands of BC, Vol. 3, 1989


Greig Creek

water is retained at or near the surface the greater the chance of it contributing to groundwater recharge. Beaver (*Castor canadensis*) play a significant role enhancing water catchment retention in drainage systems throughout the island. Groundwater recharge potential is increased significantly by damming activities. The levels of water retained in impounded areas lower seasonally through evaporation and subsurface percolation. Human manipulation of the landscape has changed hydrologic balances. Seasonal fluctuations have been accentuated to extremes. Wetlands and lakes have been drained for cultivation and development, transforming creek systems overnight. Roads and associated ditches effectively concentrate both surface and subsurface flows. Compact surfaces increase runoff and erosion and decrease ground water recharge. Roads ultimately reduce watershed buffer capacity, by reducing infiltration pathways and increasing conduits of flow. These alterations result in much flashier flow cycles in local streams.

Surface and groundwater stores have been directly exploited to quench a growing population's thirst. Forests have been cleared for rural development and extensively clearcut for forestry. Vegetation plays a vital role in regulating water concentration and loss. Trees filter water through their foliage slowing soil saturation rates. Soils are shaded by vegetation reducing solar radiation and hence evaporation. These benefits are completely lost in the short term through clearcutting and may take decades to recover (Harrison, 1994). Harrison (1994) quotes several studies referring to the significant contribution trees make to the water regime of a forest by capturing fog. This is of particular significance during the droughty summer months in the CDFmm.

Characteristic Vegetative Communities

The vegetative communities of the Coastal Douglas Fir zone are characterized by the unique Mediterranean like climate present in the rainshadow of the Vancouver Island and Olympic Mountains. This effect creates long dry summers, which is a major factor in the ecology and vegetation found within the varying ecosystems (Egan, unknown). The vegetative communities of the CDF zone have been well described by Nuszdorfer, Klinka, and Demarchi (1991). The area is limited to a small part of southwestern Vancouver Island, several islands in the Gulf of Georgia, and a narrow strip of the adjacent mainland. The majority of the forests that are found today in the CDF zone have regenerated after late 19th and 20th century logging. Old growth remains in only a few areas such as parks and comprises less than 1% of the CDF. The vegetative communities vary by the amount of nutrients and moisture present on a site. Soil texture and depth as well as the slope position are controlling factors. Galiano Island has virtually no land on which the vegetation has not been heavily impacted by human activities. Conversion of many areas to plantations after clearcutting has occurred. DL63 falls into this category having been clearcut in two passes and planted to monoculture Douglas-fir forests.

Exotic plant species comprise an increasingly higher percentage of the vegetative communities on Galiano Island. These are plants that exist in non-native locations and are generally considered to have a negative impact on the local environment. Exotic species have developed in a non-native environment and are able to thrive without the natural predators and diseases associated with there traditional habitat. The two major exotic species in DL63 are Scotch broom (*Cytisus scoparius*) and Himalayan blackberry (*Rubus discolor*).

Scotch broom is an invasive shrub found extensively on Galiano Island. It is considered to be detrimental to the maintenance of native biological diversity by precluding many rare endemic plant species from becoming established and spreading (Zeilke, 1992). Broom readily colonizes disturbed sites, open forests, and even natural meadows (Pojar, 1994). Broom is able to reproduce from both seed and will sprout from a stump if damaged or cut. It is known to produce large amounts of seeds with one bush able to produce 2000-3500 seed pods with up to nine seeds per pod. These seeds can remain viable in the soil for up to 30 years, waiting for a disturbance that will create an open, warm, exposed mineral soil for germination (Zeilke, 1992).

Himalayan blackberry forms large, impenetrable thickets of armed vines that displace any native vegetation present. As long as light is available to the plant, it remains on site, dominating the vegetative structure. As light is lost due to canopy closure shoots are sent out to seek out available light by running along the ground or climbing other vegetation. Once a canopy is closed the plant is slowly shaded out and dead remnant vines are often present in the understory.

An example of some typical mature forest vegetative communities associated with the Coastal Douglas Fir zone and a diagram showing their location along a slope profile is attached in Appendix (I)

Fauna

As previously mentioned, geo-climatic factors define the ecological conditions characteristic of the CDFmm. These conditions characterize, and are further characterized by, local vegetative communities. The interaction between ecological conditions and vegetative communities creates unique habitat niches exploitable by appropriate faunal communities. Fauna develop relationships, or webs, between kingdoms which define their habitats. For example, herbivores are intricately connected to vegetative community patterns.

Human cultural pursuits, in the historical and modern sense, have had a direct influence on animal populations and their habitats, and therefore ecosystem webs. These influences are accentuated when they are concentrated and confined by geographical or aquatic barriers, such as in an island context.

While conducting the field work component of this study, animal sightings or signs were recorded in the field notes. Species directly observed in the field included; Red legged frog (*Rana aurora*), Pacific tree frog (*Hyla regilla*), long-toed salamander (*Ambystoma macrodactylum*), Roughskin newt (*Taricha granulosa*), Raccoon (*Procyon lotor*), Mink (*Mustela vison*), Douglas squirrel (*Tamiasciurus douglasii*), River otter (*Lutra canadensis*), Beaver (*Castor canadensis*) and Black tailed deer (*Odocoileous hemionus*).

Many species of birds reside or migrate through Galiano Island. An extensive list appears in Appendix (II). Birds observed during our field studies included; Bald eagle

(*Haliaeetus leucocephalus*), Turkey Vulture (*Catharted aura*), Pileated Woodpecker (*Dryocopus pileatus*), Downy Woodpecker (*Dendrocopos pubescens*), Red-Breasted Sapsucker (*Sphyrapicus varius*), Dark-eyed Junco (*Junco caniceps*), American Robin (*Turdus migratorius*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), Common Raven (*Corvus corax*), Northwestern Crow (*Corvus caurinus*), Northern Flicker (*Colaptes auratus*), Chestnut-backed Chickadee (*Parus rufescens*), Brown Creeper (*Certhia americana*), and Winter Wren (*Troglodytes troglodytes*).

Out of necessity, intention or chance, animals, particularly large mammals, would have traveled between islands in the Georgia Basin (Hammond, personal communication). Some of the larger Islands, including Galiano, may have had small resident populations of larger mammals (Green et al, 1989). Cougar *(Felis concolor*) and Black Bear (*Ursus americanus)* sightings are occasionally reported on the islands. Gray wolf (*Canis lupus*), and Wapiti (*Cervus elaphus*) appear in the archaeological record of Galiano Island, likely indicating local presence (Wilson, 1992). Large mammals were highly susceptible to intentional extirpation at the guns of colonial humans. None of these mentioned large mammals reside on the island today.

As has been mentioned almost all of the ecology of Galiano Island has been altered by human development. Old-growth stands have been reduced to small patches, and none of these remnants are pristine. At the same time the amount of land converted to monoculture plantation is extensive. Such alterations in ecosystem representation also dictate changes in the associated animal species that depend on these habitat types. The success of long-term restoration goals aimed at restoring ecological complexity in forests, may be measured by the associated shifts in faunal assemblages.

Key Species

The largest wild animal currently found on Galiano Island is the Black tailed deer (*Odocoileous hemionus*). The local population is thought to be substantial and lacks natural predators. With the elimination of large predators from the ecosystem, deer population control has shifted to food resource availability. An uncontrolled deer population can have a tremendous impact on food web relationships. Extreme grazing pressure can stress and alter forest successional patterns making deer an important factor to consider when planning restoration prescriptions.

Evidence of the presence of beaver on Galiano island dates back thousands of years (Wilson, 1992). Beaver are very important when studying ecological restoration because of the dynamic way they intentionally alter their local environment. The ecosystem altering behavior of beaver identifies them as a keystone species. Beaver damming activities provide habitat for many other animals, from fish and amphibians, to birds and large mammals. Beaver are probably second only to humans in their ability to alter the local environment to suit their needs.

Riparian zones are heavily impacted by beaver activities. Trees are chewed down for food and building material, changing the riparian forest structure and species composition. Dam construction raises water levels flooding forested areas resulting in tree deaths and snag creation. As will be covered later in the paper, snags add invaluable complexity to forests providing habitat for many species of insects and animals. The dynamic nature of beaver activities pose interesting challenges when trying to establish restoration goals in areas where beaver reside.

The Pileated Woodpecker is another keystone species found in the study area. The woodpecker itself was observed and heard, hunting on both live and dead trees in the study areas. Most snags, over 10cm in diameter, observed during field studies, had evidence of Pileated Woodpecker use. It is the cavities created by the woodpecker while hunting which makes it such an important species. Many species of mammals and birds rely on the cavities created by the Pileated Woodpecker, for their nest sites. Woodpeckers in general are also crucial in controlling insect populations in forest environments.

Traditional Occupation

Galiano Island falls within the Cowichan tribes traditional land base (Wilson, 1992). Galiano Island has been inhabited by indigenous peoples for millennia. The oldest sites date to the Lithic cultural sequence and have been dated between 4500 and 7000 years ago (Mitchell, 1971). Subsequent occupations are found up to June of 1792 when it is recorded that Spanish sailors met natives residing on the island (Wilson, 1991)

The archaeological record emphasizes the fact that these cultures relied heavily on the ocean for food. However, inland areas were also used extensively for food and technological resources. Land animals were hunted including, Beaver, Deer, Wapiti, as well as a variety of birds and small mammals. Many plants and trees were also utilized. Berry producing shrubs were of vital importance, Salal (*Galtheria shallon*), Salmonberry (*Rubus spectabilis*), Oregon grape (*Mahonia nervosa*), Service berry (*Amelanchier alnifolia*) and Huckleberry species(*Vaccinium sp*.) were some of the important seasonal crops. Berry producing plants were 'tended' by the harvester, who carried out pruning and fertilizing to promote the following years crop (Sewid-Smith, 1998).

The scale and breadth of habitat use is described by Turner's writing (1998):

> *From woods they have carved implements, containers and canoes, built houses and shelters, and fuelled fires for heating homes and for cooking and smoking foods. They have used sheets of bark to make containers and canoes, for lining underground food caches, and as roofing. With bark, stem, leaf and root fibers they have made twine, ropes, fishing lines and nets, baskets, bags, mats, and clothing. They have also used plants and plant products as bedding and floor coverings, as lining for berry baskets, drying racks and steaming pits, to make storage vessels, water conductors and Soapberry beaters, as herring-spawn collectors, infant diapers, abrasives and tinder to start fires, for dressing wounds, and to make paints, dyes, tanning agents, glues, animal poisons, insect repellents, scents, soaps and cleansing agents, decorations, and toys.*

It can be concluded that a natural area with a long history of occupation by a technologically complex human culture would reflect these cultural activities. Culturally modified trees, for example, Douglas Fir and Western Red Cedar, exist proximal to the study areas (Personal observation.). The depth of reliance that aboriginal cultures had on local resources, required a respectful observance of natural processes. Turner (1998) highlights this reverence by quoting "Words of Praise –Prayer to a Young Cedar" a ritual verse spoken before a woman would harvest bark from a young Cedar tree. In the majority of cases, resources were harvested using techniques which ensured the survival of the individual.

Forestry History

First settlement of Galiano Island by Europeans is recorded during the 1860's (Elliot, 1984). Early homesteads were concentrated in the south end of the island. By 1909 there were but 39 registered voters on Galiano Island (Wilson, 1992), representing the relatively small Island population of the time. Many of the lower lying areas were cleared, and swampy areas and lakes were drained for agricultural purposes. By the 1920's extensive areas of forested land on the island had under gone some degree of high-grade logging. This traditional approach to logging was carried out using ocean landings to access and remove selected timber from the forests. The earliest cuts were made by hand plied cross cut saws and axes; men would have worked for hours on elevated springboards to fell a tree. Areas with easy access and desirable tree species would have been cleared and possibly burned.

By the 1940's logging was moving into a higher gear on the island with roads, saws, yarding cats and large logging trucks dramatically increasing the efficiency of logging operations. Larger areas were clearcut, burned, and replanted with conifer seedlings. The seedling stocks were from off island seed stock raised in off island nurseries. As technology developed, the ability to transform landscapes increased. Large industrial logging companies, with huge capital at their disposal, carried out military scale machine operations in the exploitation of forested lands.

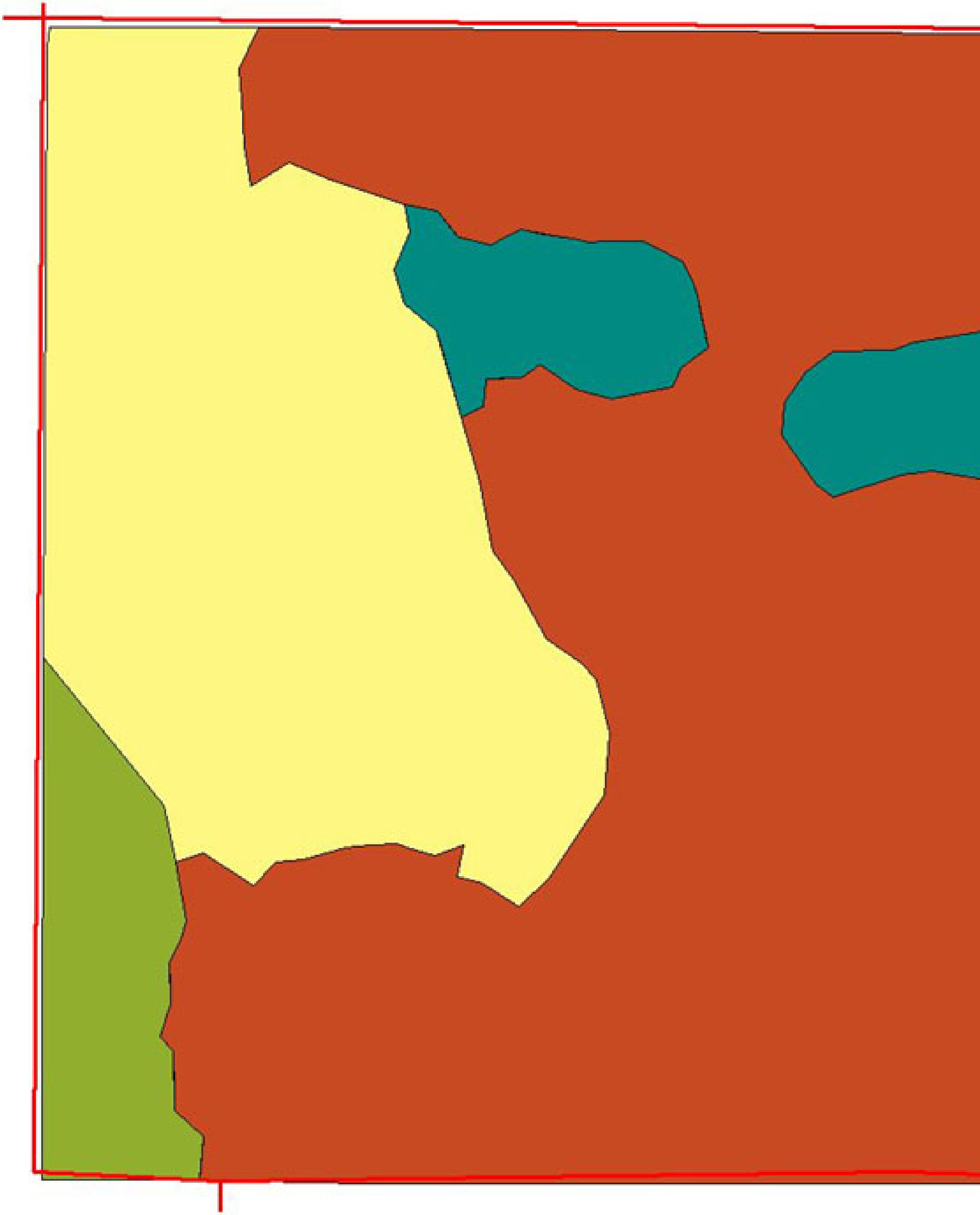
MacMillan Bloedel obtained over half of the land area of Galiano Island in the 1950’s. 1960’s logging involved clearcutting, broadcast burning, and replanting with Douglas-fir. Large scale clearcuts were the norm on the Island during the 1960’s and have continued as the dominant ‘forest management’ approach through 2000. By the 1980’s slash was piled and then burned, with the site subsequently replanted. Plantations were then managed by brushing, and thinning to promote faster volume growth on trees.

Needless to say the resulting forests hold little semblance to any natural forest, or even one found under any natural disturbance regime. Most of the structure has been eliminated in the name of efficiency, leaving forest function impaired.

District Lot 63 of the Pebble Beach Reserve was clear-cut over two separate entries, one in 1967 removing just under 20% of the forested area, and one in 1978 that left only one corner of the lot, or approximately 4% of the total land base intact (Map 6). The 1967 cut left as its legacy a severely burned (removing all slash and remaining vegetation), evenly spaced, closed canopy Douglas-fir plantation consisting of off-island genetic material. The 1978 cut was quite different. Slash and topsoil were bulldozed into long linear piles or windrows, followed by a broadcast burn that did not take. These windrows still remain on the site, housing coarse woody debris of all sizes (some well over 1m in diameter) at various stages of decay. After burning, the area was planted with Douglas-fir, again with off-island genetic material.

Fire History

Many ancient old-growth forests of coastal British Columbia contain giant Douglas-fir trees representing the legacy of fires that have swept the landscape for centuries (Pojar, Mackinnon, 1994). Douglas-fir trees have evolved deep furrowed bark enabling them to



survive moderate surface fires (Hosie, 1969). This allowed individuals to persist in many circumstances for more than 1000 years. Douglas-fir tree communities have evolved through an association with co-dominant shade tolerant species that have a high susceptibility to fire mortality resulting in its widespread appearance as a climax species (Fowells, 1965).

Agee (1991) describes the fire history of Douglas-fir forests as varied and complex because Douglas fir grows under a variety of conditions. Disturbance by fire was neither a unique event nor one easily characterized as it occurred at various frequencies, intensities, and extents. Many factors relating to climate, vegetation, topography, human disturbance, stand density and composition, wind direction, fuel loads, etc. all combine to characterize a fire. Fire severity regimes (severity referring to the impact on the trees or the forest stand) can be defined by the categories of high, moderate and low. Frequent, low intensity fires indicate a low severity fire regime. Infrequent stand replacing fires indicate a high severity fire regime. A moderate severity fire regime (also called mixed severity) is indicated by a complex combination of high, moderate, and low severity fires (Agee, 1996). It is anticipated that Galiano Island would have been characterized by a combination of all three fire severity regimes resulting in a mosaic of stand structure and successional stages across the landscape. The one common feature is the presence of large standing Douglas-fir trees that have survived past fires.

Under natural conditions fire is likely to disturb a stand of Douglas-fir long before the more shade tolerant species such as Western Red Cedar and Western Hemlock are able to establish themselves as the dominant canopy. In the Coastal Douglas-fir zone, one estimate of average fire return interval is about 230 years (Agee, 1991), about one-fifth the potential longevity of an individual Douglas-fir tree. When combined with the tendency of shade tolerant species to burn more readily than Douglas-fir, this fire interval becomes the primary factor leading to a Coastal Douglas-fir climax forest.

Human caused fires may have been locally important, but lightning appears to be the most significant in explaining fire history. Landscape level management activities such as fire suppression also can result in stand-level changes of a forest to the point where ecosystem composition and structure will differ significantly from that expected under traditional succession.

A visual inspection of adjacent DL60 revealed evidence of historical fires through the presence of burn marks on remnant old Douglas-fir trees and high springboard stumps left from early high-grade logging. This indicates the area was traditionally subject to fires, although the severity is not known. It is also possible that the fire evidence in DL60 indicates a First Nation's land management activity, rather than a natural fire. All evidence of fire within DL63 was eliminated as the forest stand has been removed by industrial clearcut logging and the remaining landscape burned.

SECTION III: Methods

The following list describes the methodology used to complete this restoration plan:

1. Identify land use history, the extent and timing of human induced impacts and any large scale natural disturbances that have affected the study area.
    - Reviewed available historical literature and reports including Macmillan Bloedel Forest Inventory Maps, Agriculture Canada soils maps and reports, any management plans completed for the area itself or for surrounding lands, any archeological reports or findings, original land survey maps etc.
    - Analysed historical aerial photography dating as far back as 1932. Stereo pairs of air photos were obtained from the Base Mapping and Geomatic Services Branch of the BC Ministry of Sustainable Resources Management. Photos were viewed at the Air Photo Library in Victoria before purchase to ensure the correct coverage and to assess photo quality.

2. Create a map of the various ecosystems found within the study area.
    - Individual polygon units were delineated based on the following criteria:
        - Forest age
        - Stand structure
        - Aspect
        - Vegetative composition of forest canopy (greater than 75% conifer, greater than 75% broadleaf or mixed)
        - Density of forest canopy
        - Type and severity of historical human impact
    - The map was derived through air photo interpretation and land use history review.

3. Devise field sampling strategy and collect field data to provide appropriate information on soils, vegetation, site characteristics, and all aspects of forest structure for the entire study area.
    - Data collection forms and techniques from the BC Ministry of Forests and BC Ministry of Environment, Lands and Parks "Land Management Handbook #25: A Field Manual for Describing Terrestrial Ecosystems" were used for this study.
    - Data collection was conducted in one 20m x 20m or $400m^2$ plot located within each of the delineated polygon units.
    - On ground visual inspections of each polygon were conducted to determine whether additional data collection plots were necessary to account for natural ecosystem variability. In polygons where visual inspections indicated a need, plots were added at an approximate intensity of one per hectare.
    - Data collection plots were located on sites representative of the overall composition and structure of the target polygon unit.
    - Two data collection intensities were used, Full Plots and Ground Inspection Plots. One full plot was completed for each polygon unit[1]. All additional data collection within each polygon unit was completed using ground inspection plots. In full plots, detailed data describing the site, soils, vegetation, and coarse woody debris was collected. Ground inspection plots included summary data describing the site, soils, and vegetation. Tree mensuration data was collected in the same manner for both plot types. The dimensions and ages of representative trees were taken and a diameter class, height class and species sweep of every tree within the plot boundaries was conducted. Examples of the data collection forms are included in Appendix (III) of this report

[1] Due to revision in step 4 (next page), many of the newly created polygon units were not characterized by full plots. After ground inspection, plots were added to the original polygon in order to account for natural ecosystem variation. As a result, there are some gaps in coarse woody debris data. These gaps could not be addressed due to time constraints.

4. Revise map of ecosystems based on collected data and visual inspections of polygon units.
    - Polygon boundaries were adjusted as necessary with some delineated into several new units and others combined into one.

5. Enter field data into digital databases.
    - Programs developed in conjunction with the "Describing Terrestrial Ecosystems" field manual (called Venus and Gravi) were used for digital data entry. The programs were available as downloads from the Ministry of Water, Land and Air Protection web site. These programs were used to generate summary reports and to export data into a spreadsheet form for further or more detailed analysis.
    - Information collected from the diameter class, height class and species sweep was entered directly into a spreadsheet for analysis and report generation.

6. Analyse collected data and address restoration needs of study area.
    - Analysed data was represented in tables and charts or was transferred from a spreadsheet into a Geographic Information System (GIS) database where it was spatially linked to each polygon unit. This allowed for map production and a visual representation of the study results. Maps were created depicting attributes of forest composition and structure.
    - Data was analysed to provide insight into the current conditions of the study area.
    - Research, data analysis and personal observation were used to identify attributes of forest composition, structure and function in the study area that are altered, missing, or impeded as a result of human land use.
    - Attributes of forest composition, structure and function that can be feasibly or realistically manipulated through restoration treatments were identified.

7. Consult with experts in the fields of restoration, forestry and ecology.
    - Maps, data analysis and ideas for recommendations were presented and discussed.
    - Focal areas for restoration treatments were visited in the field.
    - Consultations provided insight into data interpretations and possible restoration recommendations. Consultations introduced different perspectives and offered a pool of knowledge from which to draw on.

8. Identify appropriate restoration treatments and develop recommendations.
    - Identified restoration treatments were developed based on ecological condition, feasibility, and landscape level significance.
    - Recommendations were considered over short, mid and long-term temporal scale based on results of the assessment of restoration treatments.
    - A low impact approach was taken when designing restoration treatments.

9. Design appropriate monitoring techniques for all restoration treatments.
    - Criteria for design included effectiveness for tracking changes in ecosystem composition and structure, and effectiveness for reporting on relative success or failure of specific restoration measure.

SECTION IV: Results

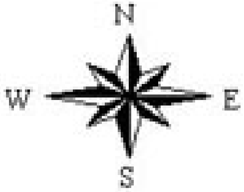
Polygon Delineation

Air photo interpretation followed by ground based inspections and inventory resulted in the creation of 50 individual polygon units. Polygons were reviewed and changed throughout the project progressing from 18 original units to the final count of 50 (Map 7). The polygon map can be viewed accurately to a scale of 1:2,500. Some ecosystem variation was found in all polygon units, although in most cases this is inconsequential when viewed from the perspective of the entire study area. All the data for each poygon is included on CD (Front Pocket). Polygon units are also grouped and described according to various compositional and structural attributes presented in the remainder of the Results section.

Composition

Ecosystem Types.

Air photo interpretation combined with ground inventory resulted in the identification of 13 basic ecosystem types. Ecosystem types were based on soil moisture regime, soil nutrient regime, vegetation and forest structure. Soil and vegetation data were combined to identify Site Series. The following ecosystem types were surveyed and identified:



Polygon Unit

Stage 1:

Broadscale polygon units were developed based on stand age, aspect, tree density, and canopy composition.

Stag

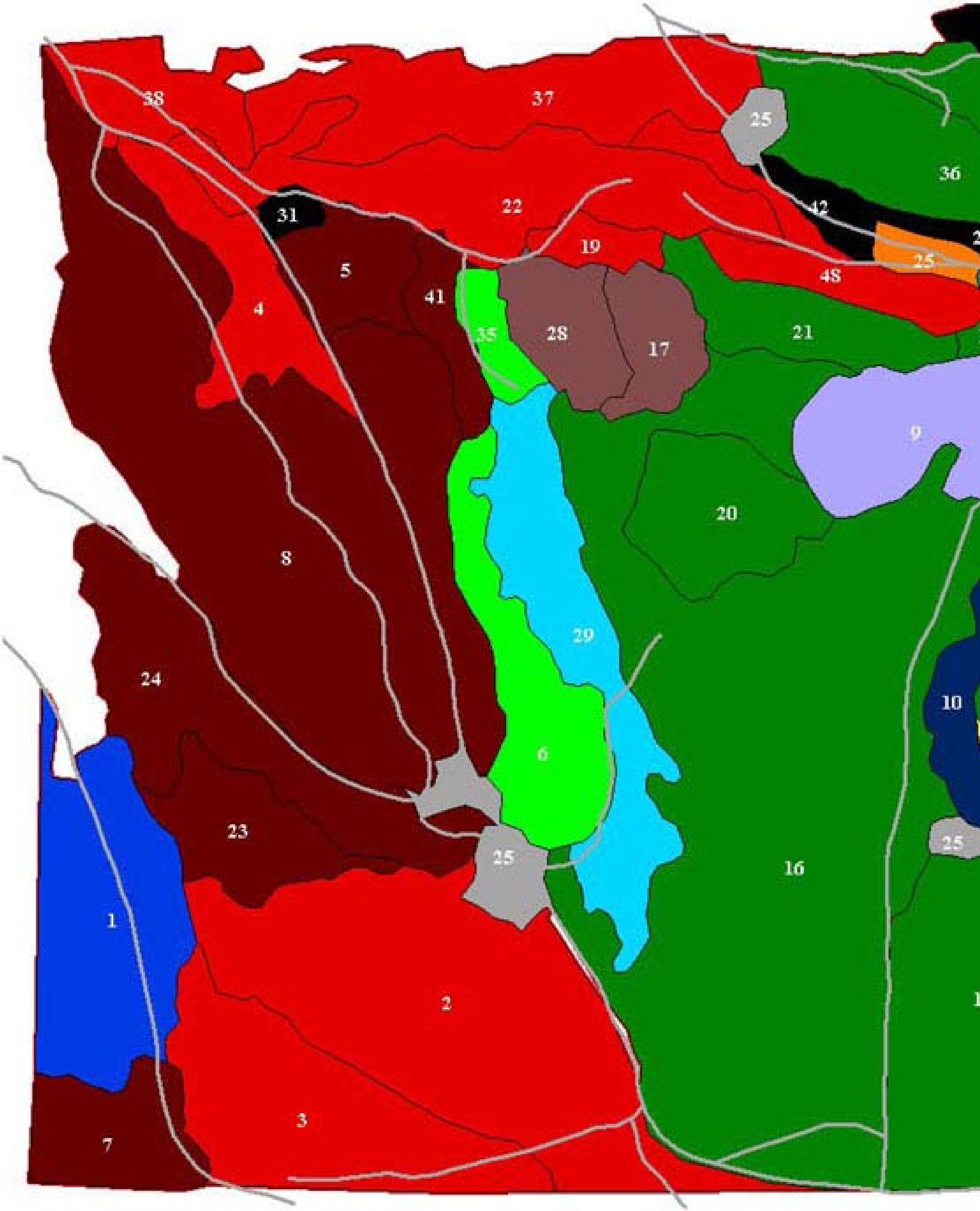
Polygon units were rev inspections and futher

ECOSYSTEM TYPE	Area (Ha.)	% Total Area
Douglas-fir – Salal: Pole / Sapling	19.1	32.4
Douglas-fir – Salal: Young Forest	1.5	2.5
Douglas-fir – Salal: Mature Forest	DL 60	n/a
Douglas-fir, Grand fir – Oregon grape: Shrub / Herb	0.4	0.7
Douglas-fir, Grand fir – Oregon grape: Tall Shrub	0.15	0.3
Douglas-fir, Grand fir – Oregon grape: Pole / Sapling	13.6	23
Douglas-fir, Grand fir – Oregon grape: Young Forest	11.3	19.2
Douglas-fir, Grand fir – Oregon grape: Mature Forest	1.1	1.9
Western Red Cedar, Grand fir – Foamflower: Shrub / Herb	0.6	1
Western Red Cedar, Grand fir – Foamflower: Pole / Sapling	2.35	4
Western Red Cedar, Grand fir – Foamflower: Young Forest	2.8	4.7
Western Red Cedar – Skunk cabbage: Tall Shrub	1.5	2.5
Western Red Cedar – Skunk cabbage: Young Forest	1.0	1.7
Other	3.6	6.1

"Other", includes a cliff ecosystem type, a steep banked riparian ecosystem type, landings and roads. A description of the dominant and associated vegetation exhibited in each ecosystem type is located in Appendix (V) of this report. The locations of ecosystem types are shown on Map 8.

Soils

A significant pattern emerged when data depicting mycelial abundance was examined. It was found that all plots where mycelial abundance was characterized as common or abundant were in close proximity to mature forest areas surrounding DL 63. Plots located in polygons 7, 12, 15, and 44 and one plot located in the centre of the mature forest on DL 60 exhibited this trend. All other plots in the study area had an abundance of none or few.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Root restricting layers were found scattered throughout the study area. Compacted morainal material was cited as the root restricting agent at 24cm in a landing site located in polygon 25 and at 35cm on a heavily impacted site within polygon 3. These were the only plots found to have restrictive layers within ecosystems classified in the 'Douglas-fir, grand fir – oregon grape' association. Polygons characterized by the 'western red cedar – skunk cabbage' association were both found to have restrictive layers of water at approximately 20cm. Only two out of five plots in the 'western red cedar, grand fir – foamflower' association exhibited restrictive layers of water at 43cm and 65cm in polygons 22 and 26 respectively. On zonal Douglas-fir – salal sites, restrictive layers of sandstone bedrock, clay pans and a strongly cemented horizon were identified. Lithic contact occurred in polygons 12, 21 and 36 at depths of 38cm, 30cm and 64cm respectively. Clay pans occurred in polygon 16 at depths of 26cm and 30cm in plots along its western boundary. This could provide an explanation for the occurrence of a moister 'western red cedar, grand fir – foamflower' ecosystem type (polygon 22) upslope and immediately to the west of polygon 16. The clay pan may act as a partial barrier to sub-surface water flow leading to upslope back-flooding into polygon 22.

Soils were generally well to rapidly drained except in polygons 3, 9, 11, 18, 22, 25 and 29 where drainage ranged from very poor to imperfect.

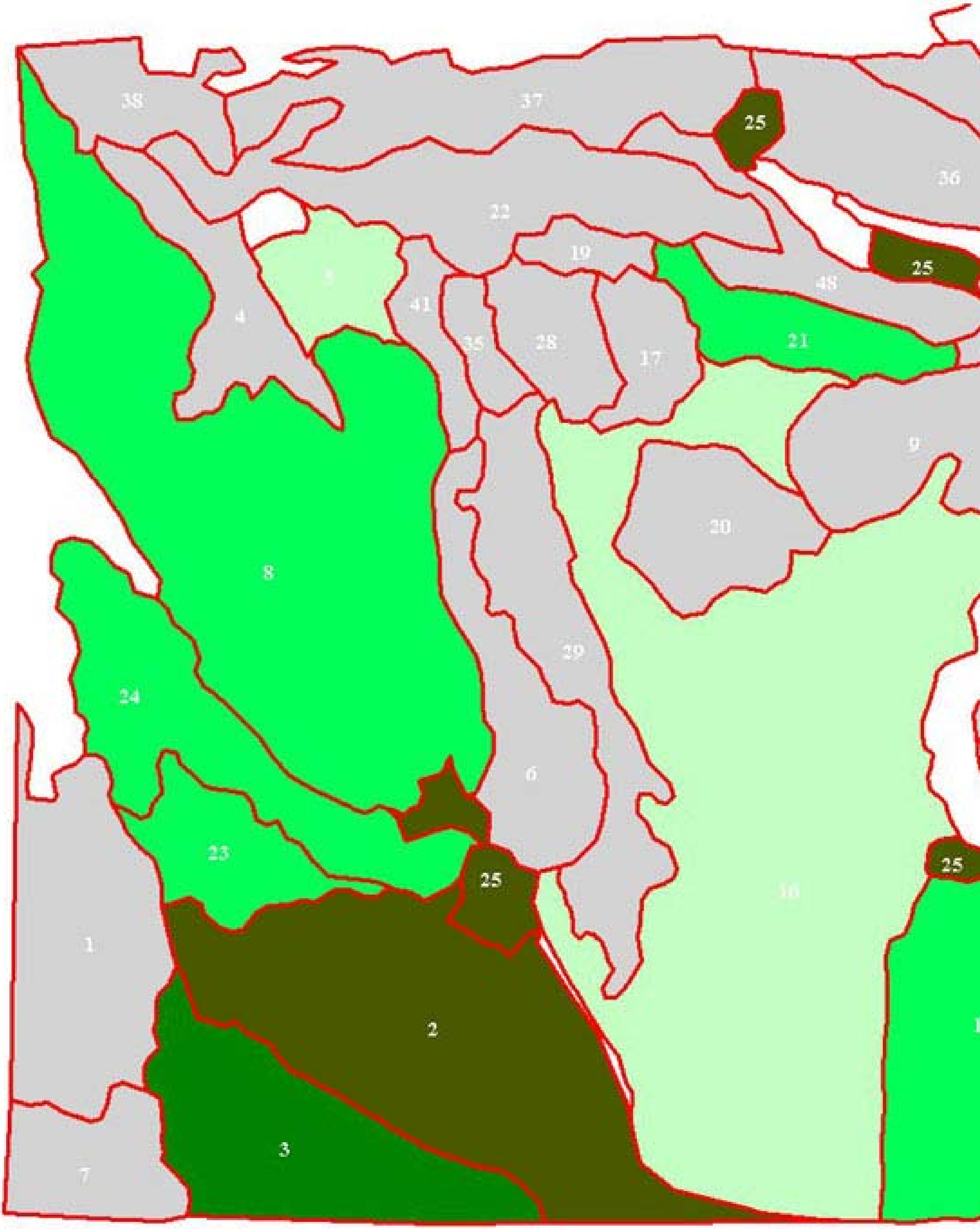
Moder humus forms were found in all polygons except in the grass and shrub dominated landing site of polygon 25 where a mull was found.

Vegetation

Vegetation surveys were completed between late September 2001 and late February 2002. Spring and summer annuals were not accounted for and cover estimates were based on presence of fall and winter vegetation. Cover and canopy closure for deciduous tree species were estimated during winter months.

One hundred different species of vegetation were identified within the study area. Of these 14 were found to be exotic accounting for just under 2% of the total vegetative cover. Plant species found in the area can be viewed in Appendix V along with their respective total cover and relative presence. Douglas-fir was by far the most abundant species in the area accounting for over 31% of the total vegetation and 58% of total tree density over the study area. Red alder, salal, Western red cedar and sword fern were also prolific representing 11.17%, 9.08%, 7.56% and 6.04% of the total cover respectively. Other well represented species include Big Leaf Maple, Salmonberry, Bitter Cherry, Oregon Beaked Moss, Dull Oregon Grape, Oceanspray, Slender Beaked Moss, and Arbutus, each accounting for over 1% of the total vegetative cover. Trailing Blackberry and Red Huckleberry, although not contributing significantly to the overall vegetative cover, were present in over 65% of all data collection plots. Out of all the identified species, 62% had a relative presence less than 0.1% and were considered to be rare occurrences within the study area (see Appendix VI for species list).

Invasive exotic vegetation was found throughout the area and was mainly confined to landings and roads. Two species, Scotch broom (*Cytisis scoparius*) and Himalayan blackberry (*Rubus discolor*) accounted for 90% of all exotic vegetation recorded in the area. Exotic vegetation was concentrated in three polygons, 2, 3 and 25 with an average percent cover per plot of 20, 10 and 60.75 respectively. Presence of exotic vegetation species within the study area can be seen on Map 9. Exotic vegetation in polygons 2 and 3 primarily consisted of Himalayan blackberry, dominating roads and areas where tree planting was not successful. Dead blackberry vines were found throughout these polygons where canopy cover from established trees resulted in significant shading. Scotch broom was the dominant exotic species in Polygon 25. This is largely due to soil compaction resulting from its use as a landing site. Polygon 25 is representative of most landing sites identified in the study area. Visual inspections of the Telus right-of-way concluded that it was also dominated by Scotch broom. In addition to the identified 'high concentration areas', Scotch broom and Himalayan blackberry were scattered sporadically throughout the district lot. Presence of these species was generally restricted to roads, trails, and canopy gaps maintained since stand establishment.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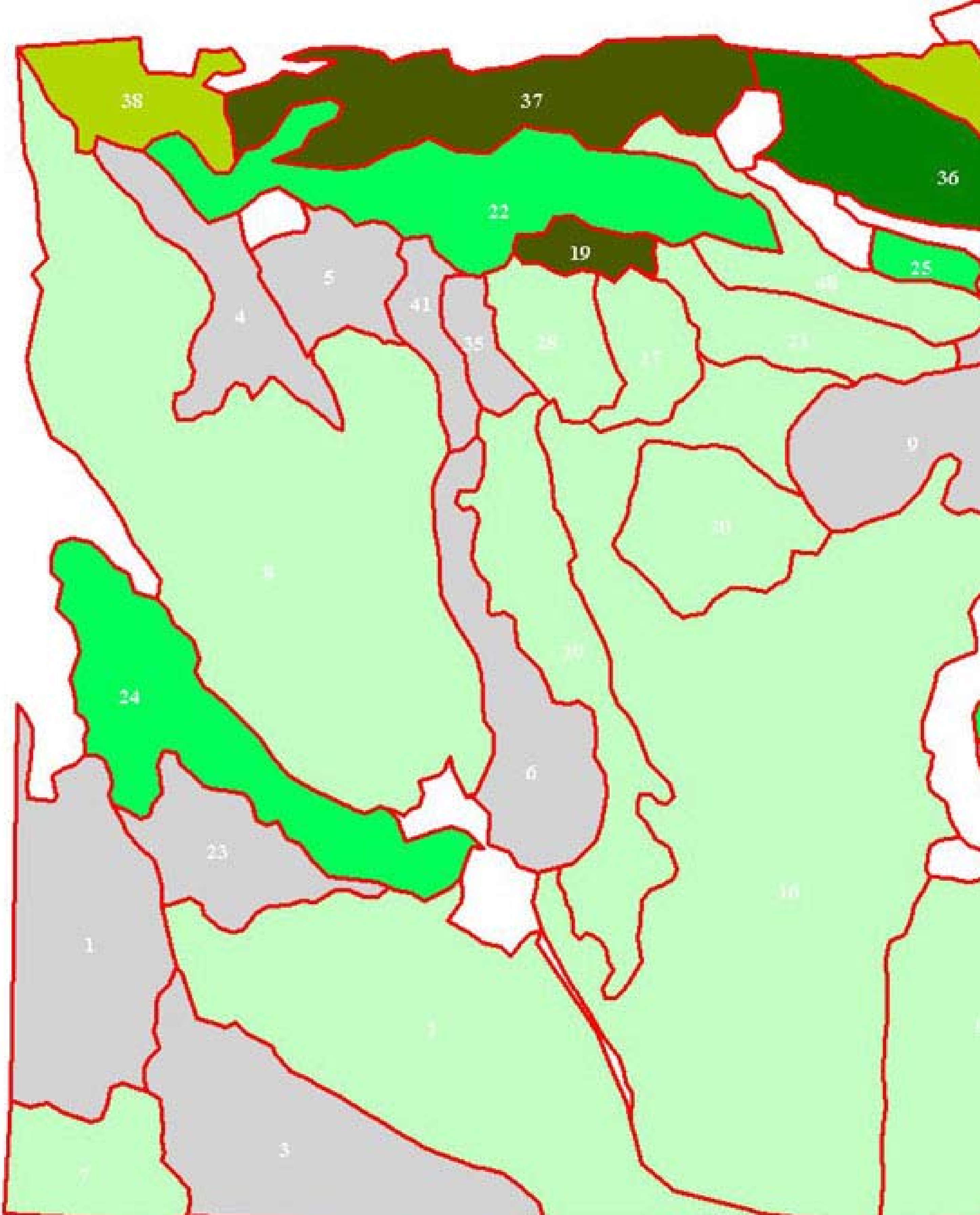
Removal of Scotch broom took place in 2000 and 2001along major roads, trails and in landing sites throughout the area. However, small broom seedlings have re-sprouted in most of the cleared areas.

Tree seedlings less than 2m in height were found scattered throughout the study area. As seen on Map 10, seedlings were concentrated in polygons occurring along the edges of the study area. This was due largely to the seed sources within the mature forest areas bordering DL63. Western redcedar accounted for the vast majority of seedlings. Douglas-fir and Western hemlock were sparse but present throughout the study area. Grand fir and Red alder were also present but rare. Western yew seedlings were recorded in polygon 18 and observed during visual inspections in polygon 20.

Genetic Diversity

Both the 1967 and 1978 logging entries in DL63 were planted with Douglas-fir. Tree aging using increment borer and standard tree age correction factors supported the fact that Douglas-fir trees were planted in the same year or the year after each of the cuts. Personal communication with an Island resident who was responsible for some of the planting in the study area revealed that the seedlings did not originate from Galiano Island, and were most likely imported from a major nursery on Vancouver Island. Employing the principles of island biogeography, there is a high probability that the planted seedlings are genetically dissimilar to native Galiano stock. Naturally regenerating Douglas-fir seedlings may or may not originate from native Galiano stock as plantation stock was observed to be producing viable seed. All other tree species (seedlings and large stems) are assumed to be of native to Galiano genetic stock.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Forest Structure

Canopy and Understory Vegetation

(Refer to Map 11 for understory to canopy cover ratios and spatial relationships)

(Refer to Figure 1 for detailed representation of vegetation layers)

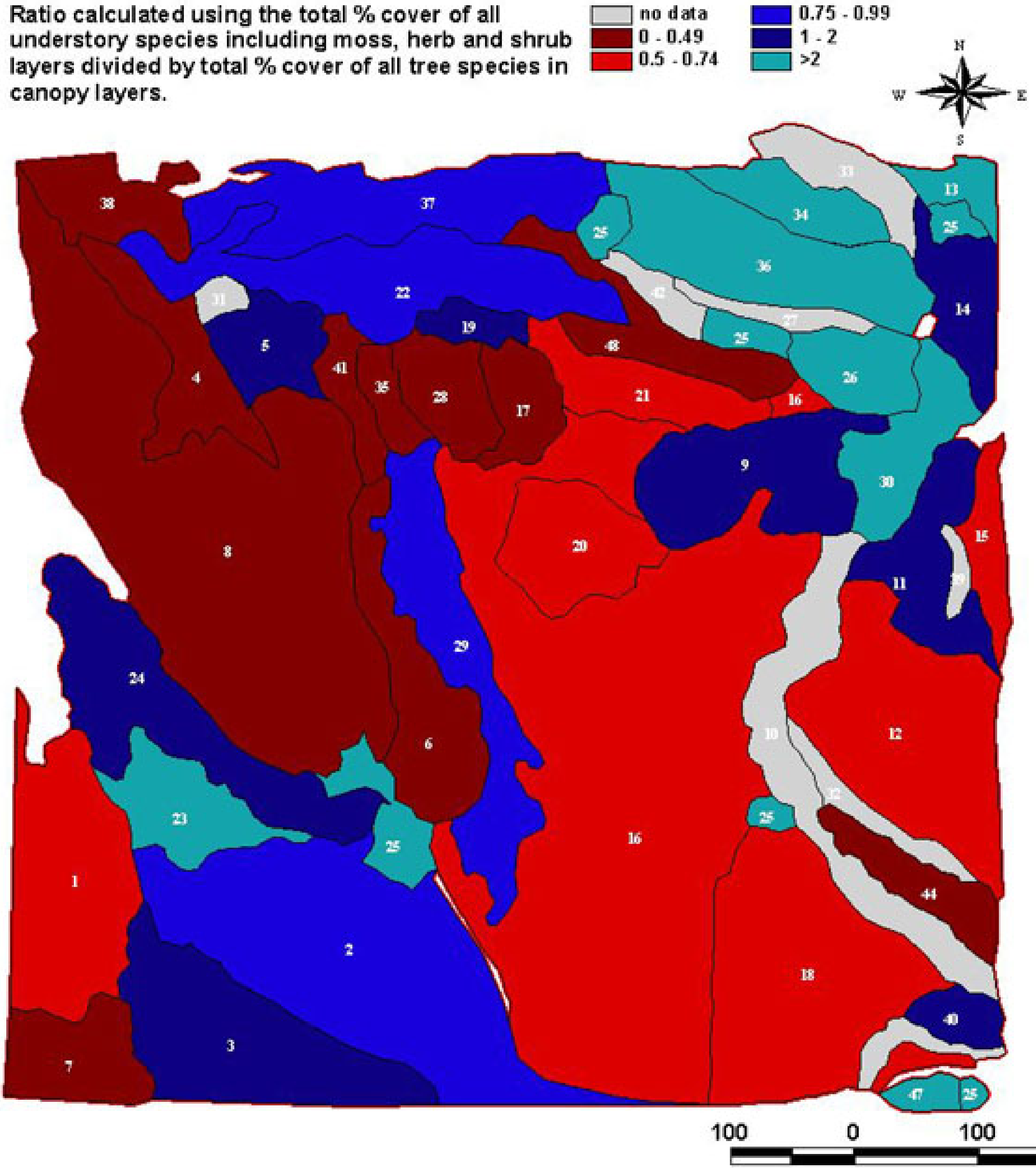
Low light conditions created by the thick, tightly spaced Douglas-fir canopy allowed for very little development of understory species over much of the study area. This was particularly evident in the 1967 clear-cut (polygons 4 and 8) where stem and understory exclusion were well established. This area, with the exception of a few small gaps created by laminated root rot, was characterized by even aged, single-storied Douglas-fir canopy, with stems uniformly spaced in rows along the south-west facing slope.

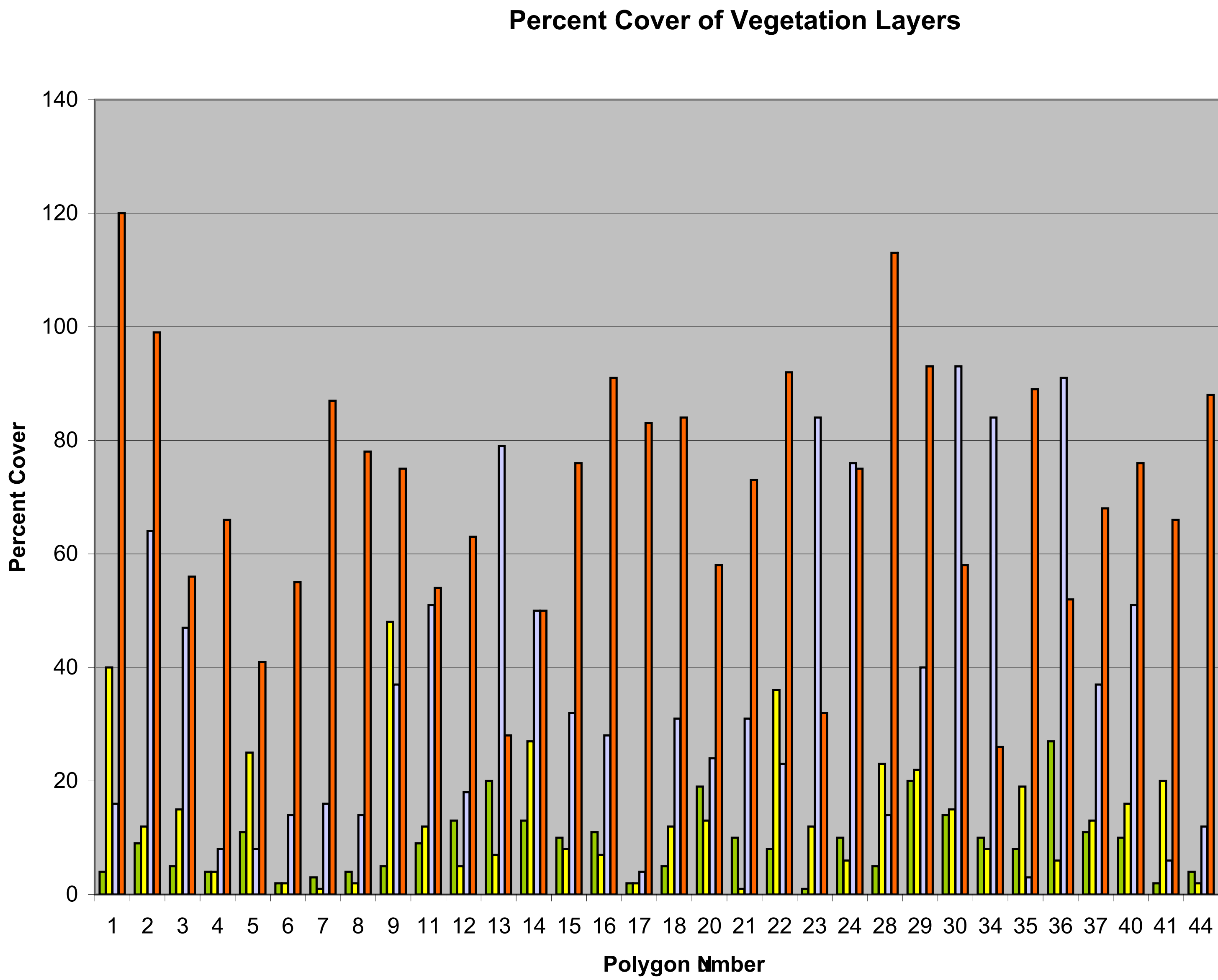
The level of understory exclusion in polygons 4 and 8 was also seen in the majority of polygons that contained larger and older residual trees (Western redcedar, Bigleaf maple, Douglas-fir). Canopy structure in these areas leaned more towards multi-storied, mixed species than single-storied, single species. However, in some cases young (30-80yrs old) Western redcedars or Bigleaf maples had established dominant canopies, resulting in exclusion of understory growth (polygons 1, 17 and 28). In successfully planted areas, Douglas-fir established a dense canopy amongst older cedars, again creating poor light conditions for understory growth. (polygons 6, 35 and 41). Only polygon 7 was dominated by older Douglas-fir, where a dense, probably naturally regenerated 75 to 85 year old canopy had been established. Polygon 7 was likely clear-cut or heavily highgraded in early times. Of these residual tree areas, only polygons 5 and 24 had high understory to canopy ratios. This was largely due to small interior areas combined with horizontal light penetration from trails and roads.

Canopy and understory structure in the younger plantation was characterized with more variation due to its age, size and stage of development. In general, the 1978 clear-cut area was found to be on the cusp of the stem exclusion stage, moving from a pole/sapling to a young forest. Variation in site and soil characteristics such as steep slopes, soil

Understory to Tree Canopy Ratio

Ratio calculated using the total % cover of all understory species including moss, herb and shrub layers divided by total % cover of all tree species in canopy layers.




Percent Cover of Vegetation Layers
Percent Cover
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40
60
80
100
120
140
Polygon Number
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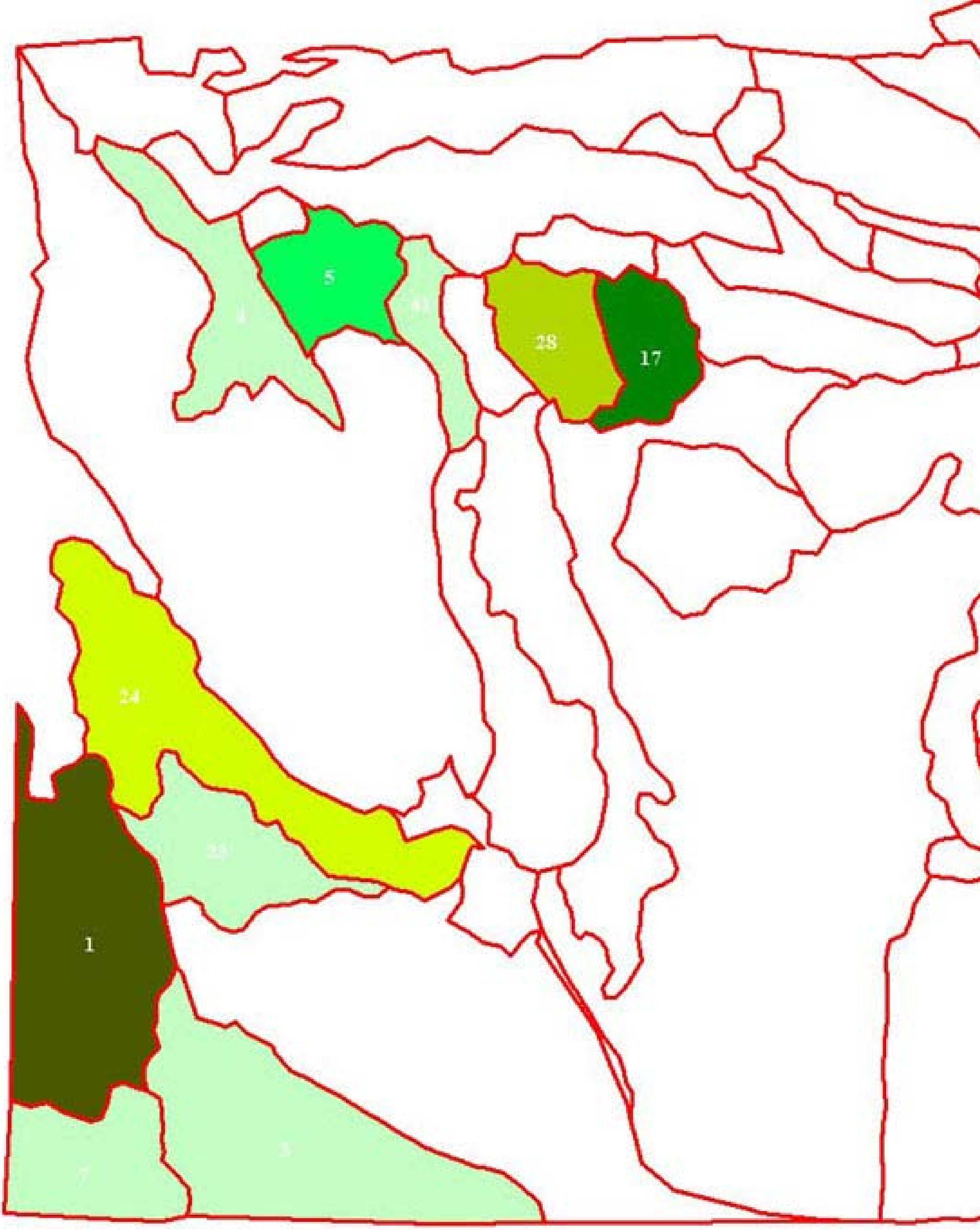
compaction, and soil depth resulted in slightly restrained tree canopy growth and favorable light conditions for understory development. Variations in soil moisture regime resulted in several polygons being dominated by Red alder, allowing better growth of understory species due to higher levels of light infiltration. Evidence of failed tree planting efforts was found in several other polygons, where a well developed shrub layer (including exotic species in some cases) and a sparse tree canopy were the dominant vegetative cover. The remaining polygons within the 1978 cut area were characterized by dense canopies and poor understory development. The overwhelming majority of this area was characterized by single-storied conifer canopy dominated by Douglas-fir, although considerable broadleaf content was found in moisture receiving polygons (18 and 20) where stand composition was defined as 'mixed'. Evidence of the onset of stem exclusion was seen through the abundance of small diameter, dead-standing Red alder and Bitter cherry stems. In addition, dead-standing Douglas-fir stems were consistently observed in the B1 and A3 vegetative layers. As in polygons 4 and 8, a few small gaps created for the most part by laminated root rot were scattered throughout the area, producing light conditions conducive to understory growth. In polygons, 16, 18 and 20, long, linear piles of slash (windrows) have maintained canopy gaps since stand initiation. These areas are currently centres of understory and broadleaf species diversity, but due to their linear nature or lack of width, are quickly being shaded out by surrounding conifers.

Large Trees

Trees with diameters greater than 50cm occurred at an intensity of 5.45 per hectare across the entire study area. All 50cm+ trees were residuals that pre-dated the clearcuts. Large trees were observed in only 11 of the 50 polygons within the study area (Map 12). Western Red Cedar was by far the dominant large tree species accounting for 68% of all records. Douglas-fir and Big Leaf Maple were also represented accounting for 20% and 12% respectively. Although not represented by collected data, polygon 6 was noted to contain a number of residual Western Red Cedars with diameters greater than 50cm during visual inspections.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Trees with diameters between 25cm and 50cm were more abundant occurring in 39 of 50 polygons. A large tree ranking based on the frequency and size of trees was applied to each polygon. The rank indicates the overall potential for polygons to fulfill present structural roles for wildlife, supply snags in the future, and contribute to large woody debris volume (Map 13). Large trees (>25cm) occurring within the 23 year old plantation, that were not residuals, tended to occur on the edges of canopy gaps, where light was available, and the tree canopy could expand almost to the base of the stem.

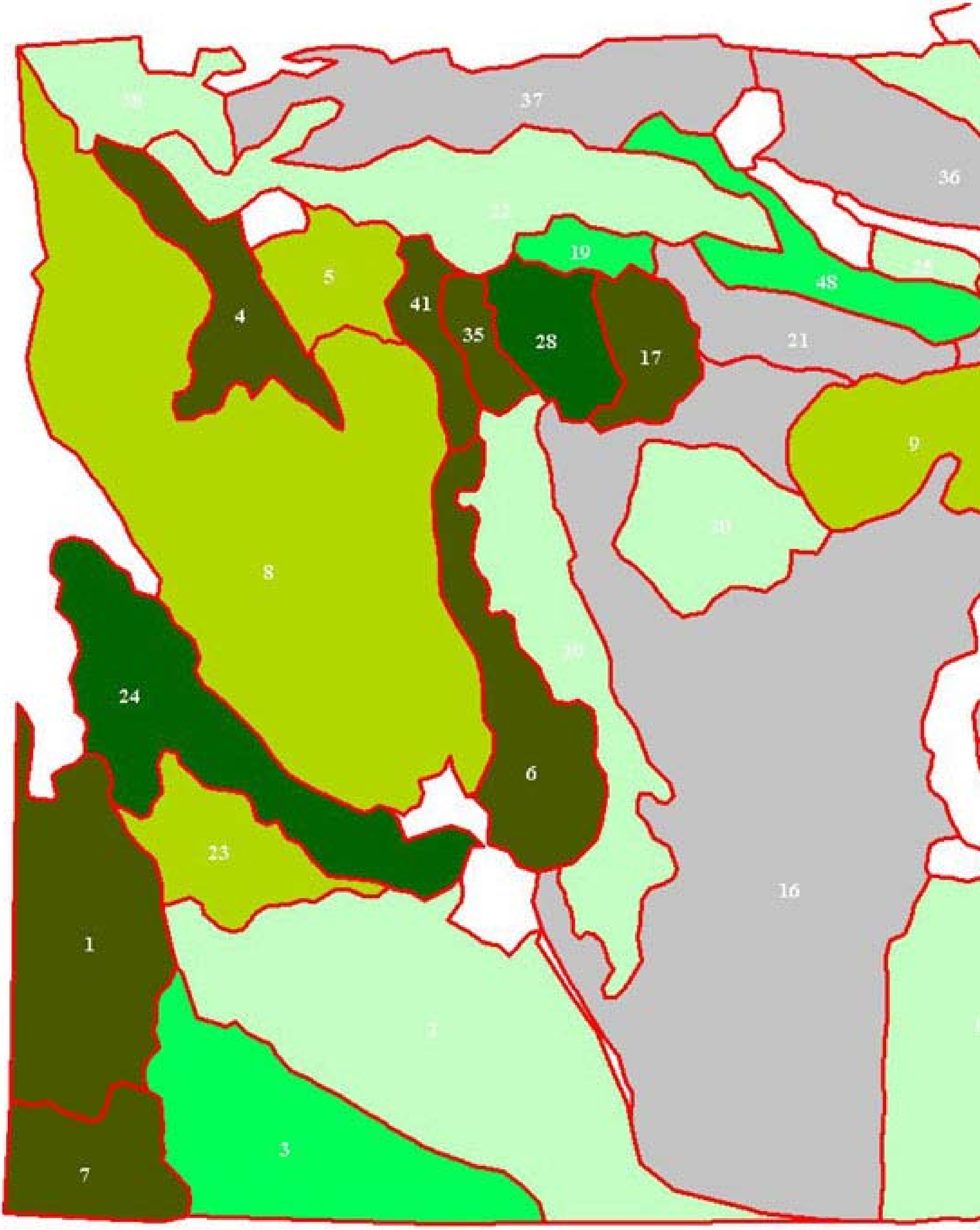
Snags

Only two large snags greater than 25cm in diameter were recorded. Both were western red cedars greater than 50cm in diameter. One was found in polygon 30 and the other in polygon 35. Though not observed within any of the data collection plots, the occurrence of large snags was noted during visual inspections in several other polygons including 1, 17, and 28. Using recorded data, large snag (>25cm diameter) occurrence was observed at 0.8 stems per hectare over the entire study area.

Coarse Woody Debris

The size of coarse woody debris (cwd) across the entire study area could be characterized as small, with 93 percent of all surveyed pieces having diameters less than 50cm. Furthermore, 76 percent of these were found to have diameters less than 25cm (Figure 2). Coarse woody debris was primarily comprised of Western redcedar and Douglas-fir accounting for 36.3% and 35.2% respectively. Red alder and Western hemlock comprised just under 3% of all surveyed pieces while the remaining 26% could not be identified due to extensive decay.

All five cwd decay classes (DC) were represented within the study area. Decay classes 1 and 2 were poorly represented accounting for 0.34% and 5.87% of the total surveyed volume respectively. In contrast, just over 39% of the coarse woody debris volume was found to belong to DC 3, 33% in DC 4, and just over 21% in DC 5 (Figure 3). This indicates that the input of fresh cwd is limited due to the removal of all large live and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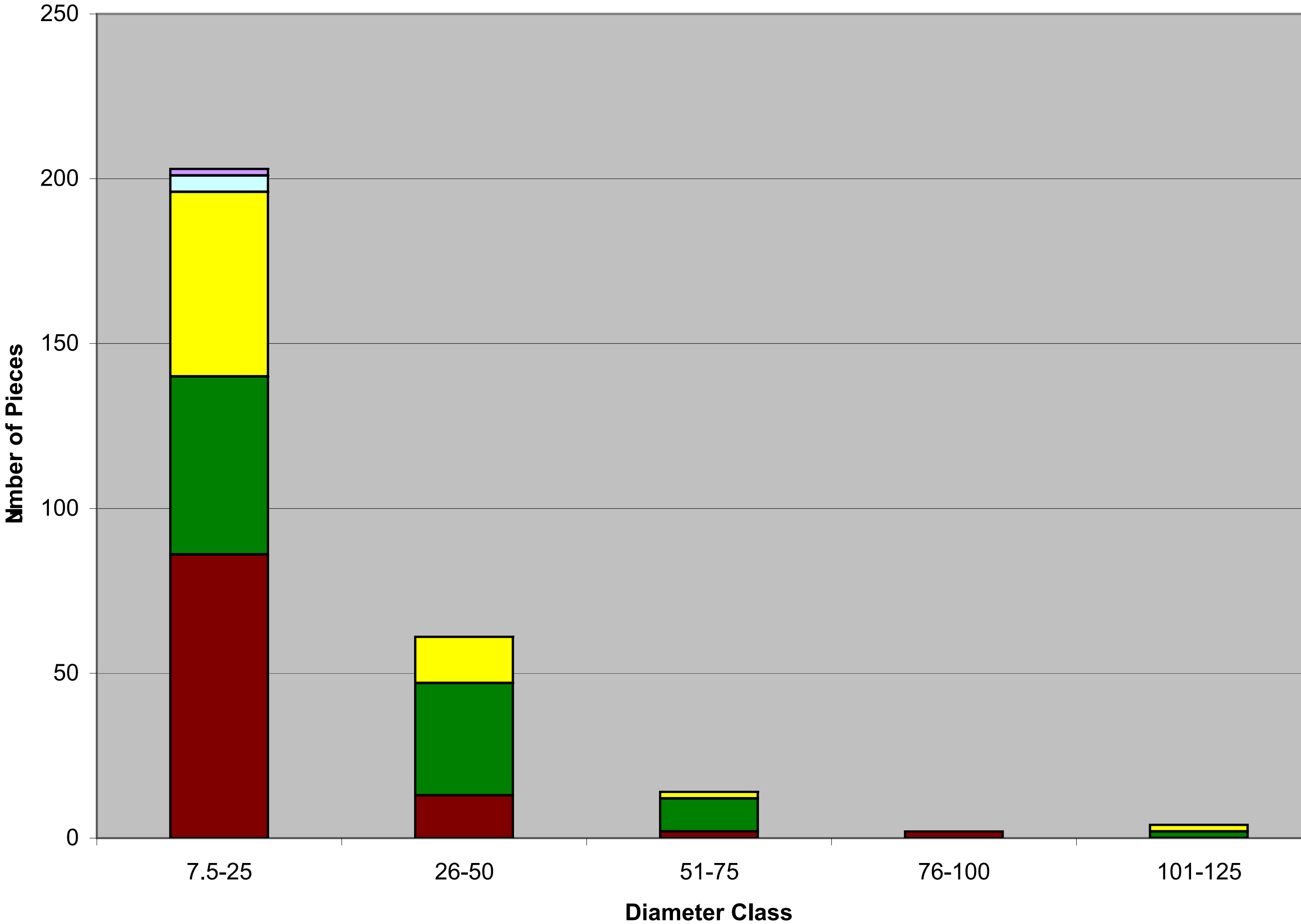
Coarse Woody Debris Occurrence by Species and Diamete



Volume (m3): calculated using diameter and length measurements of all cwd pieces intersected by two 24m Transects

Polygon #	DC1	DC2	DC3	DC4	DC5	TOTAL VOL	m3/ha	m3/ha MOF	# of Pieces	# of w/dia
1	0	0	0.08	4.29	0.65	5.02	103	141	10	
2	0	0.73	1.35	0.03	0.88	2.98	69	94	10	
4	0	1.75	0.07	2.95	3.13	7.90	159	217	12	
5	0	0.04	0.54	0	9.25	9.83	239	327	6	
6	0	0.13	0.73	1.15	0.82	2.83	89	122	14	
7	0	1.1	7.93	6.03	14.23	29.29	358	490	14	
8	0.085	0.179	0.356	1.065	0.694	2.38	107	147	8	
11	0	0.67	1.52	0.17	0.44	2.80	105	143	12	
12	0	0.25	2.24	0.62	0	3.11	87	119	14	
13	0	0	4.38	0.40	0.18	4.96	96	131	8	
14	0.17	0	0.6	2.23	1.29	4.29	131	179	8	
15	0	0.58	2.96	1.10	0.13	4.78	133	182	20	
16	0	0.46	7.08	0	0	7.54	218	299	4	
17	0	0.17	5.80	1.15	0.71	7.83	116	159	12	
18	0	0	2.52	0.18	0.61	3.32	87	119	10	
22	0	0.08	1.81	0.61	0.1	2.60	134	184	12	
24	0.43	0	0.04	0.00	0.63	1.10	22	30	10	
26	0	2.23	2.27	0.16	0.22	4.88	220	302	17	
28	0	0	0	0	0.53	0.53	30	41	1	
30	0	0.39	1.69	29.67	1.11	32.87	395	542	10	
36	0	0	0.79	0.29	4.75	5.83	295	404	11	
37	0	0.59	9.68	0.36	1.60	12.22	189	298	23	
38	0	0.07	5.82	0.69	0.29	6.86	128	201	11	
40	0	2.30	15.99	0.34	0.02	18.64	313	493	8	
44	0	0	2.66	12.05	0.21	14.92	197	309	11	
Average (DL63)	0.03	0.47	3.16	2.62	1.70	7.97	160.8	226.92	11.04	
% of Total	0.34	5.87	39.59	32.88	21.31					

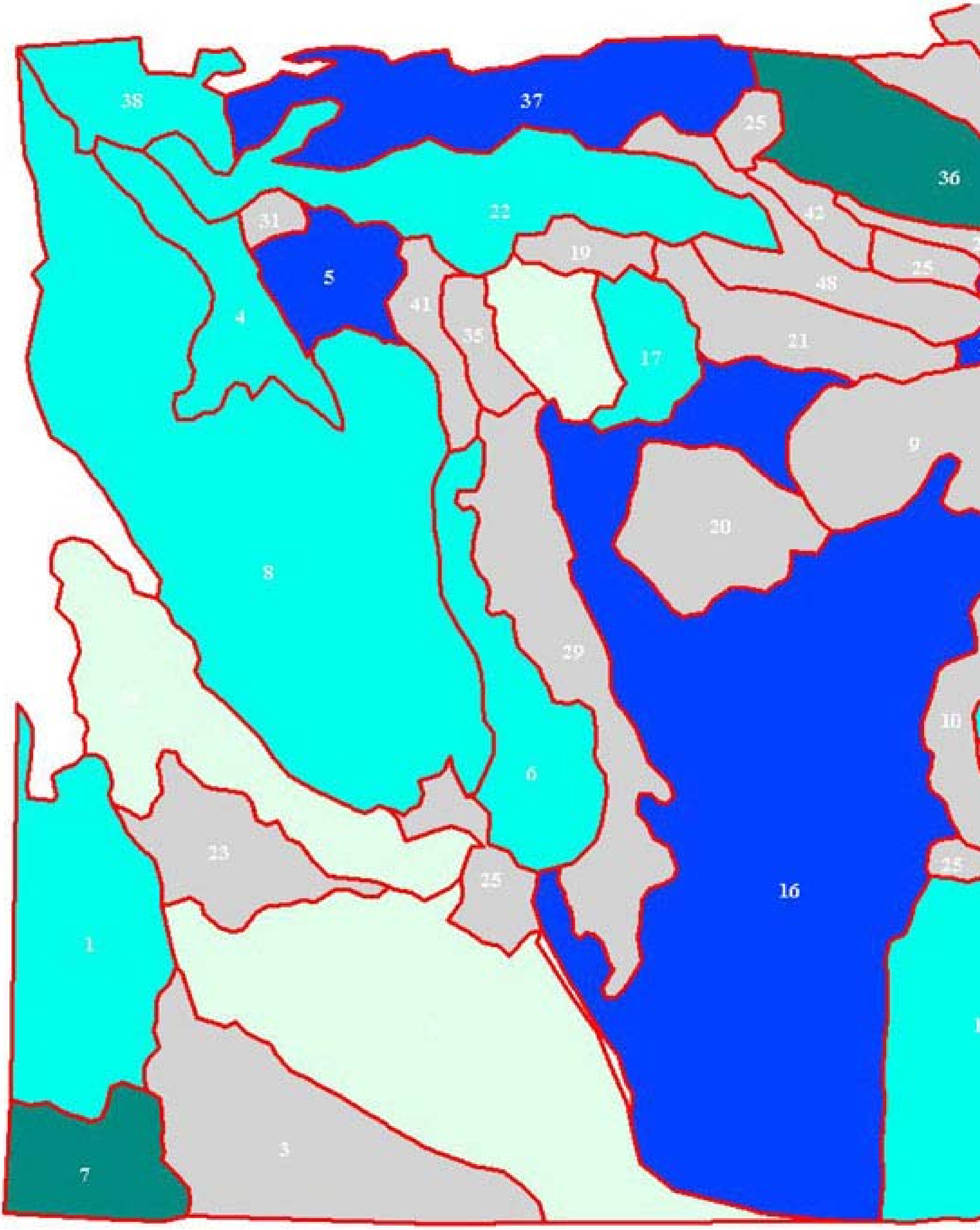
dead trees during logging. Most wood found in DC 1 and 2 was contributed by root rot and stem exclusion processes in the plantation stand. Most wood found in decay classes 3 and 4 was either leftover slash from logging (including snags), as evidenced by saw cuts at both ends or as small plantation trees in moist microsites where decay rates are high. Wood found in DC 5 was most likely on the ground before logging and was spared from land clearing and burning.

Polygons exhibiting atypically large volumes of cwd included 7, 30 and 40 (Map 14). Polygon 7 represents a young to mature forest that has been subject to severe blowdown. The polygon is located on a ridge overlooking land that has been partially cleared for residential development. The combination of canopy loss below the ridge, high wind exposure, and heavy highgrade logging (within the polygon) early in the century has resulted in the observed levels of blowdown. The major contributor to coarse woody debris volume in polygon 30 was beaver activity. This polygon encompasses the riparian area of a relatively level section of Beaver Creek that has been the focus of extensive damming and feeding activity. Polygon 40 also encompasses a riparian area, though no evidence of beaver activity was found. Several large pieces of cut timber were left behind in this polygon, possibly due to extensive heart rot at the time of logging.

Polygon 36, which was found to have just over 400 m^3/ha of cwd owed its results to leftover logging slash. One large piece of Douglas-fir timber 5m in length accounted for over 80% of the total cwd volume.

The rest of the study area showed a distinct lack of cwd content. This was partially due to intense broadcast burns especially on south-west facing slopes, such as those seen in polygons 2, 3, 4, 8 and 24.

Polygons 16, 18 and 20 exhibited minimal amounts of debris and organic material on their respective forest floors. After logging had occurred, organic material was piled in windrows and left as fuel for a subsequent broadcast burn. However, the burn appeared to fail, leaving most of the piled debris intact. This resulted in forested strips, depleted in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cwd and approximately 20 meters in width, spaced between very rich cwd rows, approximately 5m in width generally running from east to west throughout the polygons. The windrows are shown on Map 15. The reported 299 m^3/ha of woody debris found in polygon 16 is misleading. Polygon 16's high cwd content is due to one of the 24m sampling transects crossing the corner of a windrow. Otherwise, it would show a very low cwd content estimated at 26 m^3/ha. Coarse woody debris in the windrows is variable in size and decay class. Solid (decay class 2-3) pieces with diameters up to 1.5 meters, and lengths in excess of 20 meters were observed.

Landscape Connections

Drawing on existing compositional, structural and functional attributes of the Study Area, opportunities for connectivity have been identified. Analysis of the results of this report have shown a spatial pattern of ecosystems exhibiting relatively high compositional, structural or functional attributes. These ecosystems include:

1. Polygons 10, 30, 14 and 33: Stream and riparian corridor with high functional value for wildlife.
2. Polygon 9: Wetland area, with high compositional and functional value for wildlife and moderate structural value.
3. Polygons 17, 28, 35, 41, 6, 5, 4, 23, 24, 1 and 7: Forested areas with residual large trees and snags providing high structural value for wildlife.

When seen on Map 16, these polygons form an almost continuous connection between the mature forests of DL 60 and DL 66, ultimately providing a vital link within the 'Mid Island Protected Areas Network'.


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DL 66
Greig Creek
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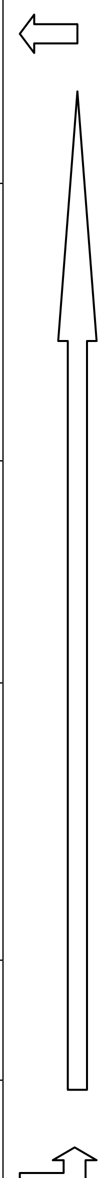
SECTION V: Discussion

The objectives of this study were to assess plantation forests for their ecological integrity as forest ecosystems. Intense scrutiny of these stands and comparative study of other site and stand types, has highlighted a number of aspects of forest ecology, structure and function that are in a depressed state. Forests are dynamic and infinitely complex ecological systems. Restoration strategies should be developed and applied to address problems rooted in ecosystem simplification.

Disturbance in the guise of 'Forestry', can disrupt all aspects of an ecosystem from microscopic bacteria to local topography and climate. Industrial forestry approaches a forest with an eye to convert a functioning ecosystem into a marketable product, timber. Efficient timber production then becomes the prime directive governing forest management. Silviculture systems are employed to replace natural process in the name of timber production efficiency.   Tree farm lands replace forests. The nature of industrial forestry with its roads, landings, clearcutting, site preparation, planting, tending, thinning, pruning, and harvesting regimes results in an effective debasement of natural forest ecology, structure and function.

TREATMENT	RESULTS
Roads and landings	-eliminate natural processes from land, especially forest function -severe soil compaction -introduction of exotic species -change local hydrology -fragments landscape

Clearcut / Harvesting	-Elimination of all vertical structure in a forest. Including large trees & large dead trees (snags), -removal of nutrient sinks (tree trunks) ultimately impoverishes soil -soil compaction &disturbance
Site preparation	-soil compaction and disturbance -removal of horizontal structure with CWD removal, impoverishes soil -burning eliminates other vegetation moss, shrubs, herbs
Planting	-bypasses natural succession -introduces even-aged mono-culture -reduced genetic diversity with nursary stock -artificially selected microsites
Brushing- mechanical / chemical	-suppresses natural succession -reduces species diversity -uses artificial selection rooted in timber values -introduces chemicals to ecology
Spacing	-bypasses early successional species -further reduces species diversity -reduces vertical complexity with single species selection -artificially selects trees (timber criteria)
Pruning	-promotes development of clear wood -reduces vertical structure
Harvesting / Clearcut	-eliminates mature and old-growth stages and all associated dependent species, structures and functions



<u>The Island on the Landscape Level</u>

Fifty percent of Galiano Island is covered in young forest, or recently harvested forest. Much of this 'forestry' has been in the form of clearcutting followed by plantation establishment. The extent of clearcutting has largely fragmented the mature stands remaining on the island (Map3). These mature forest stands were high graded in the early part of the last century, but retain enough structure to function as mature stands, however each likely suffers from the edge effects from surrounding land use. The value of these mature stands could be enhanced on the landscape level by managing, where feasible, for connectivity between protected mature stands.

Protection of land is a crucial starting point for any restoration initiative. If the land is not protected, any restoration projects may be jeopardized by future land use decisions. DL63 falls between three protected areas on Galiano Island, spanning Coast to Coast (Map2). The watersheds of two perennial creek systems dominate the landscape of the protected areas. The Greig creek watershed includes Laughlin Lake a relatively rare landscape feature (Map5). The lake has exceptionally high ecological value.

Patches of mature forest characterize much of Greig creek's riparian zone, as well as the dominant forest type in DL60 (Maps 5). From a landscape perspective DL63 lies in a significant location between two watersheds and associated mature forest stands. Promoting the restoration of forest structure and complexity within DL63 plantations would effectively enhance the value of the mature stands by encouraging landscape connectivity between identified areas of greater ecological diversity and habitat value. Restoration efforts in the plantation would promote habitat complexity expanding useable habitat for fauna currently confined to mature patches. The inherent complexity of a forest stand is a measure of its genetic, species and structural diversity. These values vary throughout the life of a forest, culminating during the successional climax, or old-growth phase.

Structural Diversity

Forest structural diversity is a stand level measurement, which considers diversity in horizontal and vertical dimensions. Factors such as species diversity canopy layering, vegetative community patterns, gap occurrence, large tree presence, snag densities, CWD distribution and soil types all compose a portrait of forest structure.

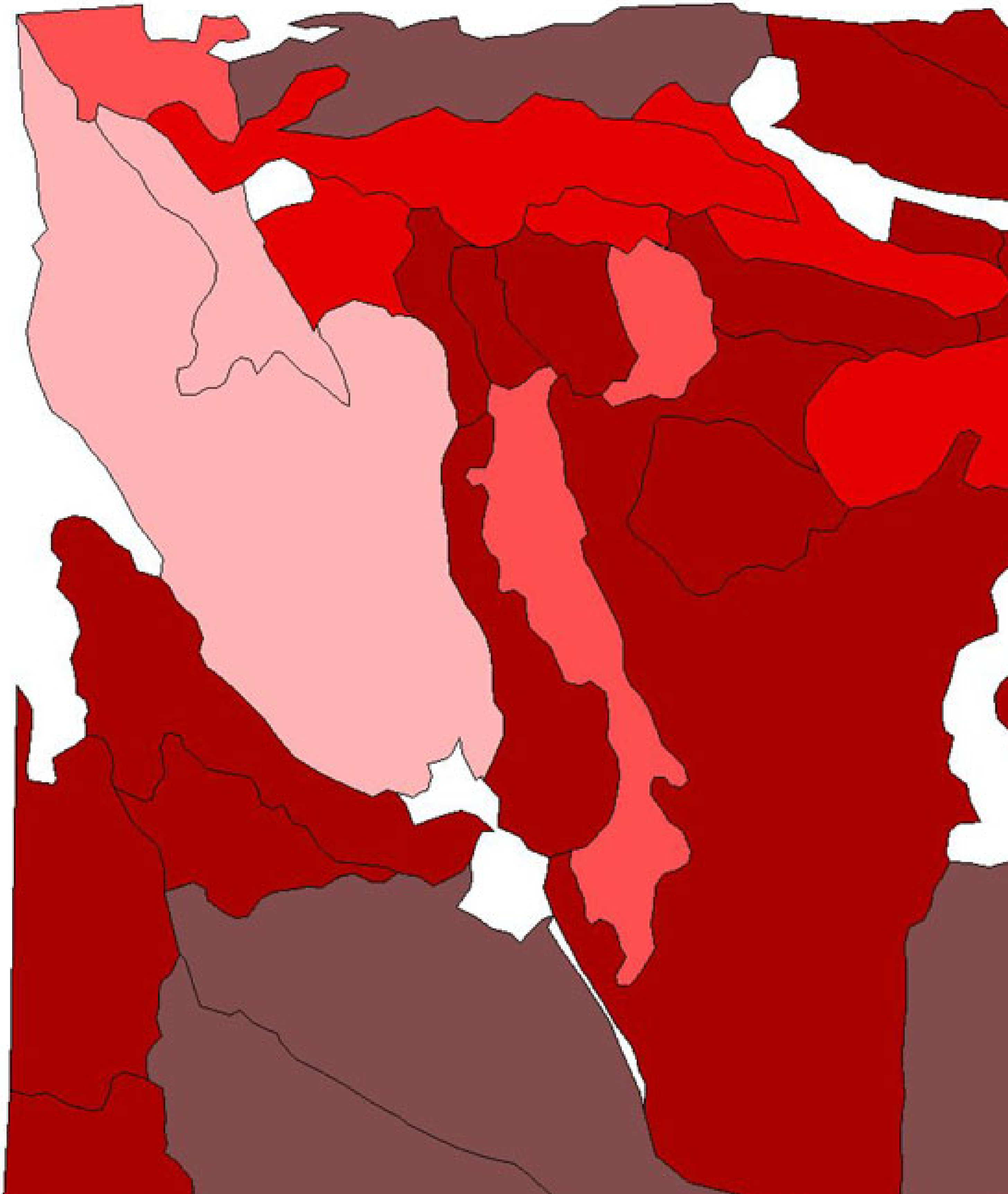
Spatial Scales

Large-scale disturbances such as a high severity fire might revert succession to a pioneer seral stage, however, as mentioned in the 'Fire History' section, a stand is never completely flattened. Fires of all intensities tend to be patchy, thoroughly burning some areas and leaving others intact producing a mosaic texture (Perry, 94). Trees will survive natural disturbances, Douglas-fir tree fire resistance almost ensures survival after even high intensity fires. Many trees that are killed remain standing, and as will be discussed, provide valuable habitat, as well as future coarse woody debris. Spatial structural diversity influences regenerating stand composition. The spatial patterns in forest succession in the CDFmm, would tend toward a mosaic appearance with huge veteran Douglas-fir trees dominating the canopy. When a large veteran tree falls, the gap that is created further promotes the quilted mosaic. Early seral stages may have a dominant Douglas-fir composition, however other species are likely well represented. Gaps in the regenerating trees would promote the maintenance and recruitment of a diversity of species.

Species Diversity

Planted Douglas-fir trees are the dominant species in DL63 (Appendix 5). The fir trees occur with and average density of 1158 stems per hectare, or 51.5% of tree cover across the district lot. This artificially introduced horde takes on a more threatening appearance when looking at it in the context of the 'Tree Diversity (Simpson's) index' (Map 17). Polygon 8 has the lowest index rating representing a low degree of diversity, this is attributable to a high degree of canopy closure. Polygon 8 is 13 years older than the rest of the plantation. Polygon 8's structural development is a window into the future for the younger Douglas-fir dominated polygons whose higher diversity indices are rooted in its early stem exclusion stage. Much of the existing species diversity (polygons with indicies >0.55), could be lost to stem exclusion over the next 10 years.

Structural complexity is increased by the presence of different tree species due to the various ranges of requirements, limitations and preferences characteristic of each species. Each species is a unique member of the ecological community. Each occupies space and affects its ecosystem in unique ways. Deciduous trees build soil by adding their leaves to the forest floor each fall. Red alder helps restore soils by fixing nitrogen, of particular importance when dealing with heavily disturbed sites. Bigleaf maples are excellent hosts for epiphytic plants and provide complex habitat with their huge lateral branching patterns. Different trees have evolved different plant and animal associations ie. Squirrels and Douglas-fir cones, maple trees and Licorice fern (*Polypodium glycyrrhiza*).



It follows that the greater the tree species diversity the greater species diversity in general.

Trees planted in DL63 did not originate from a local source. This raises the problem of a tree species dominating an ecosystem in which it did not evolve. The planted trees have been selected for their efficiency at producing a marketable saw log, over the first 80-100 years of their lives. Indigenous trees have a genetic heritage, which has been shaped and refined by natural conditions and processes, over the past 10000 years. Douglas-fir has become the dominant climax species over this period, with the potential to live and reproduce for well over 1000 years. The vast coverage of plantations on Galiano Island, all of which consist of off-island stock[2], only highlights the importance of maintaining the remnants of locally adapted genetic lineage. In order to promote local genetic integrity and to encourage species diversity within DL63, where possible, native tree species should be given survival precedence over plantation stock.

Referring to the 'Seedling Occurrence' Map (10), it is clear that higher concentrations of seedlings fall around the edges of the district lot. This trend is related directly to the presence of seed sources in the adjacent district lots. The presence of these seedlings provides an excellent restoration opportunity to enhance species diversity. Point treatments should be initiated in these polygon's (34, 36,37,38, 15, 11, 12, 19), thinning plantation stock to encourage seedling development. As will be discussed in this section, these point treatments will fulfill multiple objectives in addition to those outlined for species diversity.

As mentioned above, gaps play a role in natural forest stands. Gaps, or gap like effects are present throughout DL63. Apart from landings, roads and the Telus right-of-way, gaps are found around the windrows and cwd piles remaining from the 1978 logging (Map15). These areas occupied by the piles of wood were not planted and support a wide variety of native species. Some of these gaps have been excluded by canopy closure. It

[2] Trees for many recent plantations (not DL63) were provided by a local (on Galiano) nursery. However, seed crops were collected from previously planted trees that originated from off-island. (personal communication)

may be prudent to maintain some of these artificial gaps by thinning plantation stock and preventing or delaying closure. This would add to the textural complexity of the stand and should simulate natural gaps. Treatment would vary on a site by site basis.

Gaps occasionally occur due to the presence of laminated root rot in the stand (*Phellinus wierii*). *P. wierii* induced gaps are most prevalent in Polygon 8, likely related to the age of the plantation. Most of these gaps have *P.weirii* resistant deciduous and tolerant cedar trees taking advantage of the light, as well as herb and shrub layer development. This natural diversification of the stand should be regarded as being a positive impact on the structural diversity of the stand. The dying fir trees provide temporary snags and add much needed coarse woody debris to the forest floor. Without host fir trees the *P. weirii* fungus will eventually die out.

The *P.weirii* fungus is viewed as a scourge by foresters as it can affect extensive areas of young mono-culture Douglas fir plantations (Norse, 1990). Trees killed by the fungus tend to break off on the stem leaving infected root systems in the soil. The root systems

readily spread to closely spaced vulnerable hosts. When stand management objectives lie in forest complexing and diversity, rather than timber production, the *P. weirii* fungus is easily viewed as an ally waging the crusade against the mono-culture. Monitoring the development of theses gaps could serve as a comparative study for other gaps, artificial and natural, located throughout the study areas.

Snags

Standing dead trees, or snags, are important attributes within any forest stand. Snags are used by many species from fungi and insects to birds and mammals. Snag use includes perching, roosting, nesting, foraging, courtship, drumming and hunting (Neitro et. Al. 1985). The value of a snag varies with its species, size, and extent of decay. Large trees (>50cm dbh) offer greater value as habitat structural features. Larger trees tend to remain standing longer and provide a greater variety of habitat conditions, like sloughing bark, perching limbs and broken tops (Norse, 1990). Cavity nesting birds and mammals require large snags of various decay classes. Cedar and Douglas-fir remain as snags much longer than deciduous species and other softwoods, relating value to temporal extant. Snags also ensure a supply of cwd to the forest floor.

As mentioned in the results section, DL63 exhibited an extremely low frequency of large snags. The fact that large snags are almost non-existent is a testament to the efficiency of industrial clearcutting. Small snags (25-50cm dbh) are found with more frequency, but are still relatively low in number. The current progression of canopy closure across the district lot may increase snag recruitment in the smaller size class. However, these trees have relatively low values when considering their habitat attribute potential.

Structural complexity could be enhanced throughout the district lot by snagging or killing, rather than falling selected plantation trees during proposed thinning treatments. This will produce short-lived habitat structure suitable for wildlife foraging. However, snags created in this manner are unlikely to serve habitat nesting purposes. Existing plantation trees for the most part, lack the required girth. The initiation of well planned, thinning treatments designed to encourage rapid growth of tree diameters could hasten the supply of larger snags in the future. While some of the 'enhanced' trees may be left to complete their natural life-cycle, a portion could be snagged once diameters appropriate for wildlife utilization are achieved.

Provision of immediate large snag complexity would involve standing or erecting appropriate pieces of cwd found in the windrows of polygon 16, 18 and 20. Intial surveys revealed a supply of wood, mostly cedar, which would be ideal for erecting. This could be carried out by hand (low impact), offering immediate increase in habitat and structure values within these polygons.

Coarse Woody Debris

The presence of fallen dead trees, or coarse woody debris, is an essential structural component of a healthy forest ecosystem. A tree's ecological role does not end with its death, whether it remains standing or falls, function changes but remains a vital contribution to the forest. Fallen trees slowly breakdown providing a variety of ecological functions as they return to soil organic components. Coarse woody debris plays a significant role in providing habitat for many forest creatures, ranging from bacteria and invertebrate species to amphibians to large mammals. The sponge-like qualities of decaying wood enable cwd to soak up and retain large quantities of water. Organisms such as mychorrhizal fungi depend on these moisture sinks for survival during dry summers in the CDFmm (Stevens, 1997). Coarse woody debris also provides initial soil stability on slopes, and is ultimately incorporated into the soil, enhancing nutrient content and structure (Bartels et. al. 1985).

Important functional attributes of coarse woody debris are sorely missing within the majority of the DL63 plantation. The overall lack of woody debris volume is compounded by the size of the material that is present. Small diameter downed wood decays rapidly, providing forest floor structure for only a short time. Many of the functions inherent in large diameter debris do not translate to smaller pieces. Habitat value for both vegetation and wildlife as well as moisture storage capacity are two of the primary deficiencies.

The vast majority of existing downed wood showed characteristics of advanced decay. Very few large structurally sound pieces of cwd were identified, there are not many expected in the near future either, based on the small average tree size. Short-term inputs of coarse woody debris within the plantation will be characterized by large quantities of small diameter pieces as stem exclusion continues. This will not greatly improve upon the current size distribution of debris, contributing further to future deficits in habitat complexity, water storage capacity and soil nutrient inputs.

Fortunately, large quantities of coarse woody debris have been piled in windrows throughout polygons 16, 18 and 20, accounting for lost structure over a major portion of the plantation area (approximately 14 ha). This local source of downed wood presents an outstanding opportunity for restoration. Distribution of this coarse woody debris will play a significant role in replenishing organic material on forest floors that were scraped clean after logging. Biological health in the well drained, coarse sandy soils will also benefit greatly from the moisture retaining and nutrient enriching properties of the rotting logs. Distribution of cwd will promote function within surrounding areas, which would otherwise take 100's of years to develop naturally.

Various techniques for distribution have been considered. Movement by hand aided by the mechanical advantage afforded by pulleys, hoists and cables was determined to be of lowest impact and therefor the most appropriate method. Heavy machinery was ruled out due to the need for trail creation and further compaction of already degraded soils. Pulling or skidding logs was deemed undesirable due the high potential for structural losses.

In areas not endowed with the legacy of windrows, forest floors will benefit from the immediate but short-lived addition of freshly cut small diameter trees. Contributions of small downed wood should coincide with thinning treatments designed to enhance species and genetic diversity. Given the current size of trees within the plantation area, thinning specifically for cwd is not a priority. The functional properties of downed wood will be greatly enhanced and rates of decay reduced, if trees are left to reach diameters upwards of 50cm before falling. As suggested in the discussion of snags, growth of existing large diameter trees could be promoted to achieve the desired diameter in a shorter time. Again, the required thinning treatments would have to be well planned to meet multiple objectives on a site by site basis. It is crucial that restoration prescriptions plan for future recruitment of cwd.

Large Trees

It has already come to light twice that existing large diameter Douglas-fir trees should be chosen for release to provide future snags and coarse woody debris. Releasing some firs to promote rapid growth, adding tree size and canopy differentiation throughout the stand should also be tried. The more diverse the structure the greater the possible functions. In their own time trees selected simply for growth will also become snags and cwd.

Roads and Landings

Roads and landings that are no longer in use should be restored. Most of the landings within the study area have failed to regenerate, likely due to severe soil compaction and disturbance. Piles of organic and mineral soil remaining from the landing construction can often be found on site. These soils could be used to construct raised micro-sites where native species could be planted. Red alder would be an ideal species as it functions as an excellent soil builder. Micro-sites could be constructed by hand to minimize further impacts, although it may be necessary involve some machine work on the larger landings and one identified road site. Some degree of surface decompaction (30-50 cm) is necessary and should be carried out on landing surface prior to building raised micro-sites. Cwd would add needed structure and function to the highly disturbed landings and road surfaces. Each landing would have to be studied and restored accordingly. Most landings have high densities of the exotic plant species Scotch broom (*Cytosis scoparius*) and Himalayan blackberry (*Rubus discolor*), which stresses the importance of encouraging shading through canopy closure within these sites. Hydrological issues such as pooling and diversion of run-off related to landings and roads need to be assessed on an individual basis and addressed accordingly.

Exotic Species

Broom readily occupies well drained, excessively disturbed or naturally poor sites. Eliminating broom from a site is not just a matter of cutting down existing plants. Young plants re-sprout vigorously after cutting and seeds can remain in the soil for up to 30 years. Establishment of native plant species and protection from any future site disturbance is essential. Broom removal from DL63 has been ongoing since 2000, although seedling growth was observed in several of the treated areas. These areas will require planting of native vegetation and repeated broom removal until adequate shading is achieved.

Plantation trees were least successful in polygons 2 and 3 (this can be seen with aerial photography shown on MAP 15). These polygons have a high percentage of *R. discolor* cover (MAP 9) . High levels of disturbance in the form of compact soils and hot burns were also observed within these polygons. It is likely that this dry south facing slope burned much more successfully than the north facing polygon 16. It is likely that the *R. discolor* colonized soon after the burn and presented a vigorous competitor to many of the plantation seedlings. Dead stems of *R discolor* drape among areas of dense fir occupation indicating where the plant has been shaded out. Encouraging tree canopy development is the best way to ensure eradication of this exotic. Micro-sites, similar to those constructed on landing sites, could be designed and planted to promote tree and shrub growth among dense patches of *R. discolor*. A variety of designs could be tried and assessed for success. Vigilant brushing regimes may be necessary in the initial stages of growth, as well as watering due to south facing aspect. Mulch may be beneficial in surpressing *R. discolor* growth, retaining moisture and building soil structure. A variety of native shrubs and trees should be planted and monitored. Those showing positive results could be applied elsewhere, as this exotic occurs in disturbed areas across the island.

Building Bridges

As with all ecological restoration projects, there is a strong component of experimentation and adaptation that is necessary to ensure success. Each site brings a new combination of variables, which must be addressed to ensure treatment energies are well spent. Each targeted treatment area will require a fairly elaborate layout plan prior to carrying out the work. Layout should be focused on eliciting the most structure, function and diversity possible on a site by site basis. Decisions must factor in spatial and temporal needs on the local site, but doing so in relation to stand, watershed and landscape characteristics. It may be prudent to carry out initial point treatments on smaller scales, assessing them for success before expanding their application. This strategy is far more desirable than applying blanket prescriptions, which treat the entire district lot in a uniform manner. Starting small will allow for easier recognition of what works and allow for the adaptation of methodologies and approaches based on local conditions. As mentioned earlier, forests are complex systems, forest restoration is therefor not a simple process.

Initial treatment areas should be determined with attributes of the landscape in mind. Provision of connectivity between the two adjacent protected mature forests and ultimately across the Island into the Trincomali channel (MAP 2) is of the highest priority. The beginnings of this connection are already present in DL63 with polygons identified on MAP 16 contributing a variety of highly valued structural and functional components. The riparian zones, wetlands, large trees and snags found in this corridor could be considered as centres of complexity and forest function in relevance to the surrounding, seemingly uniform plantation environment. The importance of this corridor is heightened when considering its habitat value in terms of the connection it provides between the Greig Creek and Beaver Creek watersheds.

The existence of this corridor provides a hub or center for restoration at the stand level. Priority will be given to restoration treatments that enhance the value of polygons adjacent to or in close proximity of this corridor. Over time treatments will fan out from the center, increasing the breadth of habitat value until the corridor effectively becomes the entire district lot.

SECTION VI: Restoration Recommendations

Map 18 shows recommended priority areas for outlined restoration treatments.

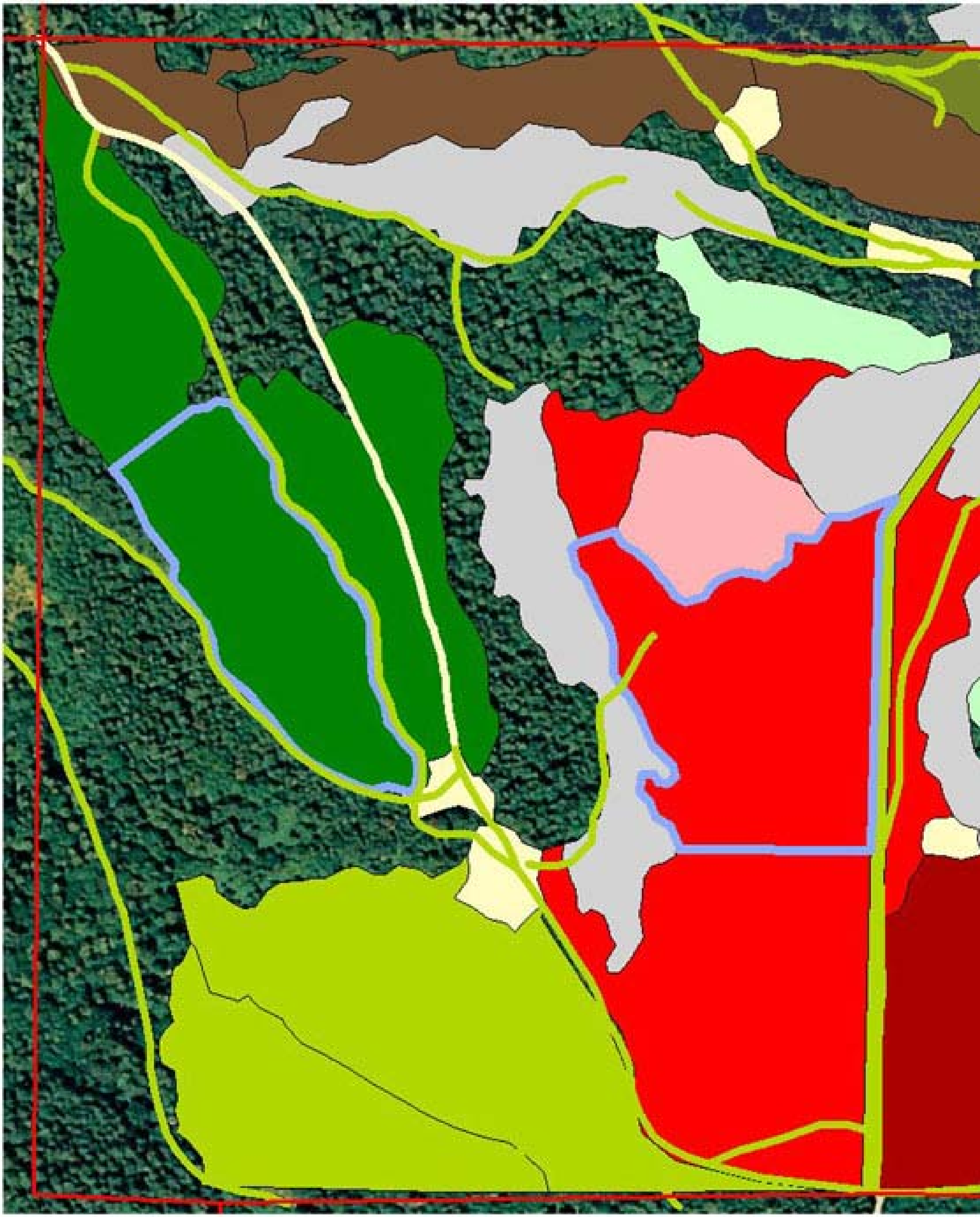
Map 19 shows spatial application of restoration treatments over time.

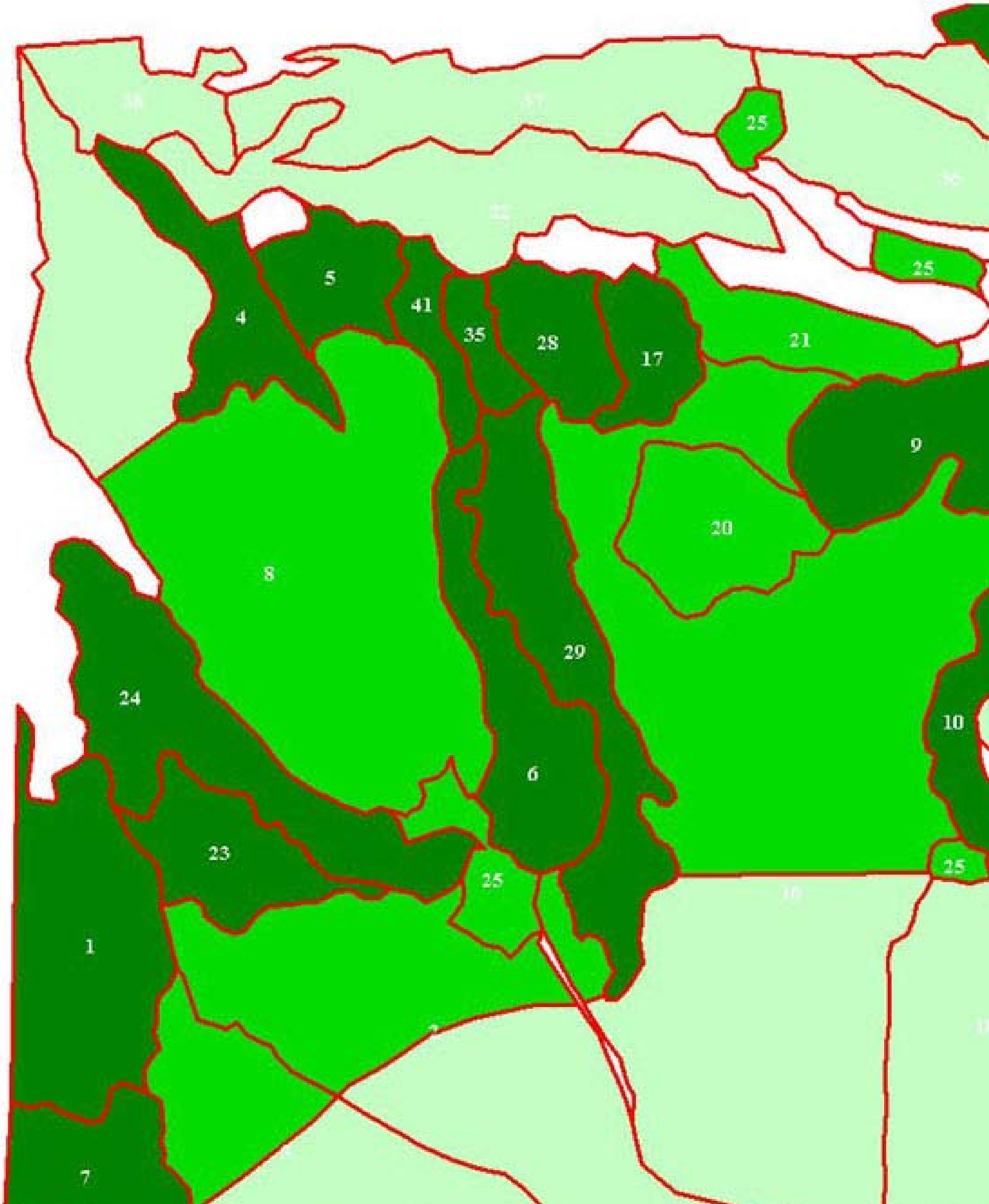
Dispersal of Coarse Woody Debris (Windrows)

Goal: Maximize area receiving benefits of coarse woody debris function.

- Intact windrows scattered throughout polygons 16, 18 and 20 can be used as the source for coarse woody debris dispersal.
- The piled wood can be moved using two techniques depending on the size and weight of the piece. Smaller debris (up to 1500 pounds) can be moved by hand, using up to 10 people to carry the logs with straps and poles. Larger debris (up to 4000 pounds) can be moved using an aerial cable yarding system that employs chain and lever hoists for mechanical advantage and utilizes plantation trees as spars.
- Determine structural integrity of all cwd pieces in target windrow and mark those appropriate for transport.
- Keep in mind that structure equals function. Excessive loss of woody mass (>25%) should be avoided.
- Leave pieces with advanced decay in place and minimize any incidental disturbance.
- Plan debris placement in surrounding forest keeping in mind the limitations of aerial cable yarding.
- Disburse individual pieces to pre-selected destinations by hand first, and then by aerial cable yarding.
- It is recommended that the dispersal of woody debris occur as soon as possible so as to minimize the loss of available material to decay.

Four people spending one day to move a single large piece of wood might save 300 years of impoverishment in the surrounding forest floor.

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Erection of Snags

Goal: Increase number of large snags within study area by erecting an average of one snag per hectare in polygons 16, 18 and 20.

- Intact windrows scattered throughout polygons 16, 18 and 20 can be used as a source of wood for snag erection.
- Selection of appropriate logs can occur during the structural integrity survey of coarse woody debris in windrows.
- Selected logs should have diameters greater than 30cm at breast height (keeping in mind that a portion of the log will be buried) and should be structurally sound. Select for western red cedar whenever possible. This will maximize standing life and utility to wildlife.
- Minimize manipulation or transportation of logs by selecting pieces that can be erected from the position they are found in. Selection for snags should take priority over selection for cwd dispersal.
- Holes can be dug by hand and logs erected using a cable and pulley system.
- Snags should be evenly dispersed over targeted polygons so benefits are as far reaching as possible.

Control of Invasive Exotic Vegetation

Goal: Control the spread of *Rubus discolor* and *Cytisus scoparius*, and wherever possible, eliminate completely.

Himalayan Blackberry (*Rubus discolor*)

- Current and potential growth of blackberry diminish naturally in the short-term through shading from adjacent native tree canopies.

- Conduct a visual assessment, specifically in the south-western portions of polygons 2 and 3, to determine the occurrence of highly impacted areas where shading from surrounding tree canopies is inadequate for short-term control.
- In high impact areas, encourage future canopy shading through the creation of micro-sites for native tree planting.
- Micro-site creation and planting should occur in early spring. Site checks should occur in mid summer and early fall to ensure that planted stock is not overgrown by competing blackberry.
- Any encroaching blackberry should be removed from around the micro-site.

Scotch broom (*Cytisus scoparius*)

- Roads, landings and other highly disturbed, unvegetated areas (including Telus right-of-way) should be targeted for broom removal.
- Established woody plants can be removed by cutting at the base, juvenile seedlings can be pulled. Young broom plants that have not developed woody stems, and are too large to pull without significant soil displacement should be left and reassessed in the following season.
- Areas previously treated (2000, 2001) should be revisited and juvenile plants should be removed
- Where regenerating native trees and shrubs are not present in the treatment area, micro-site creation and native species planting can occur.

Road and Landing Rehabilitation

Goal: Rehabilitate ten identified landing sites and one kilometer of road[3].

[3] The section of road identified as a priority for restoration is currently being considered as an emergency access route by the Galiano Island Transportation Committee. Consultation with the committee should occur before restoration is initiated.

- Establish successionally appropriate native plants in unvegetated, grass dominated, or exotic species dominated areas. Planting on prepared micro-sites can help to encourage native plant growth.
- Invasive exotic vegetation should be removed (as described above).
- Micro-site creation can involve: loosening of existing soil base; addition of nutrient rich soil with high organic content; addition of coarse woody debris for shading, water retention and long-term nutrient input; and manipulation of drainage patterns so as to avoid pooling water.
- Each landing and section of road should be addressed on an individual basis. The targeted area should be surveyed for:
    - Existence and accessibility of surrounding berms composed of top soil (rich in organic material) and piles of coarse woody debris. These attributes can provide material for micro-site creation.
    - Severity of compaction. This will help determine the necessary depth of soil loosening needed for micro-site creation.
    - Existing native vegetation and relative health. This will help to determine the distribution of micro-sites and effectiveness of planting in the existing substrate.
    - Evidence of pooling water and altered hydrology. This will help to determine the placement of micro-sites. Simple hand-dug trenches can be created in order to mitigate pooling or surface water diversion.

Diversification of Douglas-fir Plantation

Goal: Encourage species, genetic and structural diversity within single-species, single-storied forest canopies across the study area.

- Thinning techniques, including tree topping, girdling and traditional cutting can be employed to reduce uniformity within the study area. Thinning can be utilized to meet the following objectives:

    - Increase structural diversity through: snag creation by topping and girdling; short-term coarse woody debris creation by direct cutting of existing trees; growth promotion in existing large trees, which will in turn provide large snags and large pieces of cwd in the future; and gap creation to encourage understory growth and to provide multi-storied canopy in the future.
    - Increase genetic diversity through the release of native to Galiano seedlings.
    - Increase species diversity through: release of under-represented species such as Grand fir and arbutus; release of rarely occurring species such as Western yew; and release of conifer species such as Western Red cedar and Western hemlock in Red alder dominated stands.
- When creating snags, tree topping and the removal of green limbs is preferred in order to mimic better natural decay processes. Girdling should occur only when climbing a tree is not feasible. Girdled trees tend to rot from the outside in (rather than the inside out) and snap easily, limiting their value as snags.
- Designate control areas within each treated polygon so that comparisons can be made for monitoring purposes.
- It is recommended that thinning occur using two approaches: Point treatments and overall density management.

Point treatments

- Point treatments can be applied to the entire clear-cut area.
- Each individual point treatment should meet all three stated thinning objectives.
- Treatments should mimic natural patterns of small scale disturbance (such as those created by root disease and windthrow) at both the local and landscape scale.
- Approach point treatments in three steps:

  - Identify polygon or portion of polygon to be treated (no larger than 3 hectares at a time)
  - Identify sites where objectives can be met and complete layouts for each treatment. Layout should identify target trees, methods of thinning, and the anticipated direct impact on surrounding areas. Layout should also identify control sites having attributes similar to those found at the treatment sites.
  - Identified sites should be mapped and analyzed in the context of the entire study area, looking at pattern and intensity of treatments.
- Gaps created by point treatments may vary in size depending on the objectives being met and the specific characteristics of the target site.
- Current tree diameters in both the 1967 and 1978 cut areas lend themselves poorly to the creation of effective wildlife snags and fully functioning coarse woody debris. Both snags and cwd representative of the existing dominant tree diameters will be created naturally through current stem exclusion processes. In the short-term thinning for direct snag or cwd creation should not be a priority, but rather a byproduct of meeting other stated objectives.
- In the long-term, when dominant plantation trees have reached diameters of 50cm or more, snag and cwd creation may become a priority.
- Where appropriate, canopy gaps created by windrows in polygons 16, 18 and 20 should be enlarged through point thinning treatments (after cwd has been dispersed).

Overall Density Management

- Density management can be applied to those polygons exhibiting uniform, single storied plantation Douglas-fir canopies.

- Density management should employ the principles outlined in 'Point treatments' to achieve target densities. Layout will differ from point treatments through one additional step:
    - Gap size will reflect overall target density. (conduct point treatment layout first, then adjust gap size according to required overall density)
- Density management trials should be implemented in selected areas prior to stand level treatment (MAP 18). A total of 8, 2000 square meter plots should be established in each of the designated areas, representing two 20% mortality treatments, two 40% mortality treatments, two 60% mortality treatments and two controls. When laying out trial plots, ensure that variation in slope, slope position and aspect is kept to a minimum.
- Monitoring of ecological response to density management trials will lead to appropriate restoration prescriptions for all remaining areas. Management for a single density should not be applied uniformly across the identified polygons.

Monitoring

GOAL: To provide feedback on ecological responses to restoration treatments.

- All restoration treatments should be monitored.
- Monitoring techniques include permanent photo points, permanent data collection plots, repeated visual inspections and air photo interpretation.
- It is recommended that a combination of these techniques be used for each of the various restoration treatments.
- Monitoring should occur in treatment areas and in control areas. This will provide valuable data for determining changes in ecology over time and will

in turn provide a foundation for measuring the relative success of restoration treatments.

- Permanent photo points and plot corners can be marked with iron pins and mapped with a Global Positioning System.

Coarse Woody Debris

- Collect vegetation, soil, and wildlife use assessment data in 20x20 meter plots.

Snag Erection

- Conduct visual wildlife use assessment on individual erected snags.
- Record standing life-span of snag.

Exotic Species Control

- Collect vegetation data in 5x5 meter plots.
- Establish photo points.

Landing and Road Rehabilitation

- Collect vegetation, soil and mensuration data in 5x5 meter plots.
- Establish photo points.

Thinning – Point Treatments

- Collect vegetation and mensuration (including tree species density, height class, and diameter class sweeps) data in 20x20 meter plots that encompass created gaps.
- Collect information on gap size. Collect information on size of naturally occurring gaps (most likely caused by root rot) for comparison.
- Establish photo points.
- Analyse aerial photography for emergent landscape scale patterns.

Thinning – Density Management

- Collect vegetation and mensuration data in 10x10 meter plots for all trials and control. Plots should represent the variation of gap sizes.
- Conduct tree density, height class and diameter class sweeps in 20x20 meter plots.
- Establish photo points.
- Analyse aerial photography for emergent landscape scale patterns.

Timeline

Short-term (MAP 19)

- Woody debris dispersal
- Snag erection
- Control and elimination of exotic species
- Rehabilitation of landing and road sites
- Point thinning across study area
- Density management trials

Mid-term

- Monitor wildlife use of erected snags and dispersed coarse woody debris.
- Monitor response of exotic vegetation
- Re-apply exotic vegetation control treatments where monitoring results deem necessary.
- Monitor response of native vegetation growing on micro-sites. Assess for effectiveness and revise restoration treatment as necessary.
- Monitor growth response of targeted release species after point thinning treatments. Assess for effectiveness and revise restoration treatment as necessary.
- Monitor ecological response to gap creation from point thinning treatments.
- Monitor tree diameter of plantation Douglas-fir throughout study area and assess for snag or coarse woody debris utility. If diameters are greater than 50cm, initiate point thinning treatments to satisfy dead standing and dead fallen tree objectives.

- Monitor ecological response to variations in gap size and variations in tree mortality from density management trial plots. Assess for effectiveness and achievement of desired forest composition and structure. Initiate density management sporadically throughout the remainder of the identified polygons in accordance with trial findings.

Long-term

- Conduct assessment of study area for compositional and structural deficiencies. Collect information in a similar manner to this study to facilitate direct comparisons. Compare and contrast results of assessment focussing on treatment versus control areas. Report on findings.
- Continue to monitor all restoration treatments. Assess for effectiveness at individual treatment level.
- Continue thinning using point treatments if deemed necessary.
- Continue control of exotic vegetation species.

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