ENVIRONMENTAL CONDITIONS REPORT

FOR THE HAIDA GWAII / QUEEN CHARLOTTE ISLANDS LAND USE PLAN

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Executive Summary

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Leah Malkinson (MSRM) had the vision to initiate this work, and has had critical input into every aspect of the report. In addition, she has had the strength to hold it all together throughout the extremely short, yet extremely long process.

This document is available at: http://srmwww.gov.bc.ca/cr/qci/hgqci_env.htm
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OVERVIEW OF REPORT STRUCTURE

Haida Gwaii / Queen Charlotte Islands (HG / QCI) is currently in the process of developing a Land Use Plan (LUP). In order to provide background information to the Community Planning Forum (CPF) this Environmental Conditions Report provides an overview of the HG/ QCI environment - historically, currently, and into the future as defined by current management practices.

The report is written in four parts:

Chapter I: provides an overview of the rationale and context for the report, natural disturbance information for the islands, and a summary of the ecosystem mapping used in the analysis.

Chapter II: provides the condition and trends analysis results for the selected indicators: old growth forests, plant species and communities, watershed condition, cedar, northern Goshawk, Marbled Murrelet, black bear, salmonids, and key introduced species.

Chapter III: summarises additional species and elements of management concern, which may be relevant to land use decisions. Most of the elements in this chapter are not sufficiently well known to undertake the more detailed overview or modeling performed for indicators in Chapter II. Each indicator is presented in a separate subsection.

Chapter IV: provides detailed technical information about the indicator modeling reported in Chapter II.

Each Chapter has separate page numbers (identified as a section number with associated page numbers) to facilitate delivering the contents of this document to the CPF in sections.

The report attempts to summarise technical information in a manner that makes it accessible to the general public, while still providing sufficient detail and technical information that the product can be reviewed.

Conceptual background information is provided in brief, typically in greyed boxes for quick reference. In general, academic references are only supplied where they are considered key, to aid reading of the report.

This report is a compilation of work undertaken by the Process Technical Team (PTT) and individual experts on each species or element. Key source documents and primary analysts are identified at the beginning of each section.

Chapter 1. Introduction to Environmental Conditions & Trends

Ecosystems and species of the Haida Gwaii/ Queen Charlotte Islands (HG/ QCI) are recognised as globally significant. Temperate rainforests, endemic species and globally significant seabird populations are some of the elements that make the Islands ecologically unique. Yet many changes have occurred since the 1800's, including the impacts of harvesting of forests, fish and introductions of many non-native species. The intention of this report is to characterise some of the key ecological changes that have occurred over this time period (1800 – 2000), and to predict the additional changes that will likely occur in the future (2000 – 2250) if the current management practices and policies are continued.

Historic conditions and predicted future conditions provide a context within which to understand the current state of the environment, and so provides a broad context within which to understand the implications of land use choices and management decisions. In other words, since conditions change through time, it is useful to know where we are on the "supply curve" for individual ecological values. For example, in Fig. 1, different decisions about land use may be made by the CPF depending at which place on the "supply curve" we are currently situated.

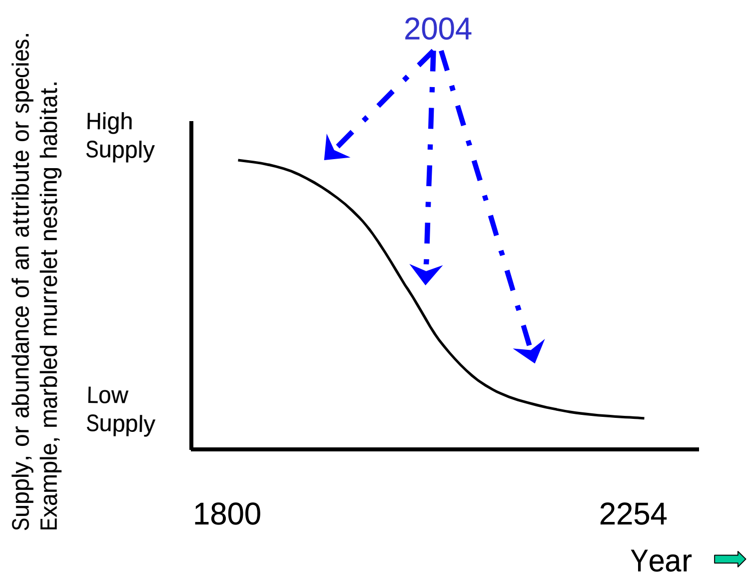

Figure 1. Example of a supply curve. Different land use plan decisions may be made depending on whether we are at the high, middle, or low abundance on a supply curve for attributes such as salmon or suitable bear denning habitat.

In order to produce such a 'curve' for each indicator a 'benchmark / baseline'[1], or comparison point is needed. For this work, benchmarks are defined by the abundance of an indicator under natural conditions – which for this report is defined as 1800. The influence of people is usually included in the benchmark (in this case the influence of the Haida people), but industrial activities are generally not included. The intention of the benchmark is not to suggest that all indicators should be 'restored' to a natural condition, rather that this provides an overview as to the full extent of current and future predicted change and to provide a context for understanding these conditions.

In addition to considering an indicator's historic and current state of supply, the predicted future state resulting from current management regimes will also be modeled for a number of the indicators. The

[1] Benchmark and baseline are used interchangeably in this report to signify the 'natural conditions' against which current and future conditions are compared.

intention is to provide the CPF with a view of what the future might hold if current management[2] continues.

This document is written specifically for the HG/QCI land use planning process currently underway. It is intended to provide background information on selected environmental values relevant to planning decisions under consideration by the planning forum. It is not intended to be an exhaustive summary of environmental conditions relevant to the Islands, but to be a pertinent summary of key details likely to be useful to Forum members in future decision-making. As such, the development of the document has been guided by members of the Process Technical Team (PTT) and input from forum members about issues of known interest locally.

Objectives are to:

- Summarise key information about environmental values of interest and to identify appropriate indicators for the environment of HG/QCI.
- Describe the identified indicators for the islands as they were in 1800, prior to most European contact and influence, as a baseline for understanding current ecosystem conditions.
- Describe the supply or abundance of the indicators as they are now, and the rate of change from the baseline.
- To forecast the future supply of key indicators, based on current management policies and practices.
- To summarise information on other species or elements of interest that are insufficiently understood to provide detailed trend analysis, but which may be relevant to the LUP decisions.

BOX 1: HOW TO ASSESS ENVIRONMENTAL CONDITIONS.

Understanding the state of the environment is a difficult task. Genes, species, populations, sub-populations, habitat elements, ecosystems and the processes that bind them together all need to be considered. We understand little about how ecosystems really work, what is needed to maintain their functioning, or even what the names of all the species are. Experts continue to discover new species previously unknown to science on HG/QCI.

A variety of approaches have been widely advocated to maintain ecological integrity, and similar approaches are useful for assessing the state of the environment. A well accepted approach is:

The **coarse filter / fine filter** approach

- The coarse filter focuses on maintaining ecosystem elements that provide for the vast majority of species. This can include a) representing ecosystems across the landscape, b) using umbrella or wide-ranging species which potentially provide habitat for wide array of other species, c) using keystone species (those that have a disproportionately higher ecological role than is suggested by their biomass), d) using indicator species which are sensitive and require a broad set of ecosystem elements.
- The fine filter approach identifies special elements that are likely to not be maintained by the coarse filter. Rare species, key ecosystem processes and specialised species are good examples of candidates likely to require a fine filter approach.

[2] Current Management is defined very specifically for timber supply analyses, as the current legislative and policy direction for management practices that is made known to licensees.

- Within this system a variety of spatial scales must be considered (e.g. using the coarse filter of maintaining old forests would require consideration of both the abundance and distribution of old forest landscapes, and of old forest stand structural elements within stands).

Understanding the extent to which biological diversity or ecological integrity is likely to be maintained requires an assessment of the adequacy of the coarse and fine filters.

1.1. INDICATORS AND SPECIES OF MANAGEMENT CONCERN

Indicators are chosen because they are thought to 'indicate' the 'health' or condition of the broad environment. Characteristics of good indicators include being:

- Representative of some key part of the broader ecosystem, and when packaged with other indicators are representative of broad facets of the environment
- Responsive to changes
- Relevant to the needs of potential users
- Based on accurate, available, accessible data that are comparable over time
- Understandable by potential users
- Comparable to thresholds or targets
- Cost effective to collect and use
- Unambiguous in interpretation.

Most indicators won't meet all these criteria, but good indicators will meet most of them.

BOX 2: DIFFERENT TYPES OF SPECIES OR ELEMENTS

Species can be categorised in many ways, and often are of conservation concern for different reasons. Here are some possibilities that are used in this report:

Indicator Species / Ecosystems: these are usually identified because they are thought to 'indicate' some ecological values larger than their own populations. Example indicators used in this report include old forest ecosystems, Marbled Murrelets, and salmon. These are of conservation concern because if they are not being maintained, likely other parts of the ecosystem will also not be maintained.

Endemic species: are native to, and restricted to, a particular place or geographic region. Endemics are often found on Islands, and in coastal BC are thought to have survived in refugia from the last ice age. These species are of conservation concern because they are vulnerable to loss simply because they are isolated, and loss from an area may result in total extinction because of their limited distribution.

Focal Species: are other species of concern to local people. On Haida Gwaii these may range from understory plants that were historically important, but now are rare due to deer browsing, to deer themselves, currently an important food source for people on the Islands. In this report, some focal species have been included as indicators.

Rare Species / Ecosystems: are those that are found uncommonly across a region, though they may be common in a local area. Rare elements may be naturally rare, for example a plant species that has very narrow habitat requirements. Or, they may be rare because human activities have made them rare. Both of these are of conservation concern because their rarity makes them vulnerable to being completely lost, - extirpated or made extinct. Some rare species are naturally rare and have stable populations, and not considered under threat. Other rare species and ecosystems are 'listed' by a variety of agencies. In BC the Conservation Data Centre 'identifies red (extirpated, endangered or threatened in BC) and blue-listed (of concern / vulnerable) species. Similarly, COSEWIC (Committee on the Status of Endangered Wildlife in Canada) identifies extirpated, threatened, endangered and special concern species at a national level. Many 'rare' or endemic species and ecosystems of concern in BC are not 'listed' by agencies due to data inadequacies and methods used for listing (J. Pojar pers. comm.).

"Introduced" Species: are species that do not naturally occur in an area. They are also termed 'non-native', 'alien', 'invasive' or 'exotic'. They can be 'introduced' accidentally or on purpose, and they can cause major problems for native species and ecosystems that haven't evolved with them. Successful introduced species tend to have high reproductive rates and often can inhabit a wide range of habitat types. They are acknowledged as a significant threat to biodiversity values worldwide, often taking over from more specialised and unique local species.

In this work, the intention is not to fully describe the 'ecological health' of the Islands (although this would be the goal with unlimited time and resources), but to provide a more focused look at indicators that may be relevant to land use decision-making.

A list of potential indicators and species relevant to this work are summarised in Table 1. They were chosen in conjunction with the PTT, and tend to cover the coarse filter approach and represent a broad set of different types of species and elements (described in Box I and Box 2).

Not all potential indicators could be addressed at the same level of detail. Key indicators were chosen by considering:

- Key environmental variables or descriptors (e.g. key ecosystem or habitat types)
- Keystone species (e.g. salmon stocks, black bears)
- Species and ecosystems for which HG / QCI has large global responsibility (e.g. endemic / rare species). Rare species are identified by a number of different 'listing' agencies (see Box 2 for definitions) and by local ecological experts.
- Introduced species with major ecological impacts.

Indicators presented in Chapter II are those where sufficient information is available to allow trends to be projected through time, or where ecological values warrant a focus even if data are sparse. Additional Species and elements of management concern outlined in Chapter III are more relevant to a fine filter / single-species management approach (Box 1).

Table 1. Summary of Potential Indicators and Additional Species of Concern. Indicators are dealt with in additional detail in Chapter II, and may include modeling through time[3]. Additional Species of Concern generally would require fine filter management, and often lack comprehensive data on habitat requirements.

INDICATOR / SPECIES OF CONCERN	RATIONALE
INDICATORS: CHAPTER II	
ECOSYSTEMS / ELEMENTS	
Old Forest Abundance, and Old Forest Pattern for each ecosystem	• A 'landscape level coarse filter' analysis, referring to the majority of the landbase under natural disturbance conditions. • Indicator = abundance of old forest by ecosystem • Baseline = predicted natural old forest by ecosystem from two sources: a) predicted from natural disturbance regimes, and b) measured from the forest backcast model.
Wildlife trees and coarse woody debris	• Important stand level coarse filter elements. • Rate of decomposition in many ecosystems is high. Concern for mid / long term supply of these elements across the landscape. • Difficult to analyse across landscape because of scale differences between strategic planning and stand level work. However, highly relevant to ecosystem-based management in this ecosystem, but not modeled as an indicator.
Plant Species / Communities / Bryophytes	• Plant species capture energy from the sun and turn it into useable energy on earth. They provide the defining characteristics of the ecosystems of the Islands, and provide habitat for other species. Three types of vascular plant categories are included here: • A) Rare Species – 46 rare plant species listed by CDC for the Islands, and in excess of another 100 species considered locally rare on the Islands but which are unlisted provincially. In addition, a number of bryophytes are found endemic only to HG/ QCI. • B) Rare Ecosystems – there are 14 listed (2 red, 12 blue) plant associations on the Islands. They are generally difficult to map and so difficult to monitor strategically. In addition, there are a number of other broadly defined 'ecosystems' that could be considered rare or important on the Islands. • C) Typically common understory species – many of which were historically common in the forest understory but have been significantly reduced and / or extirpated as a result of deer browse. Many of these species are identified as culturally significant to the Haida Nation. • A summary of values is presented for each of the categories identified, but temporal modeling was not feasible for these indicators.
Watershed Condition & Hydroriparian ecosystems	• Watersheds are fundamental ecological unit to asses manage impacts to aquatic and hydroriparian ecosystems. • Indicator = extent of harvest in different watersheds • Indicator = road density + number of stream crossings per watershed unit • Baseline = no roads or stream crossings • Hydroriparian areas provides broad and significant ecological processes, plus high value habitat for many species • Indicators = extent of harvest in different hydroriparian areas • Baseline = no natural baseline possible due to complexities of riparian disturbance parameters.
Cedar	• Western red cedar and yellow cedar are key components, and defining species' of the temperate rainforests. Monumental cedar is of great cultural significance to the Haida Nation.

[3] Where feasible we model indicator trends through time a) using a backcast – what were conditions like in 1800, and b) using a forecast – what will conditions be like over the next 250 years, if current management continues. Additional details are found below and in Chapter IV.

Indicator / Species of Concern	Rationale
	• Cedar abundance and characteristics have been altered on Islands as a result of harvest (extensive removal of largest trees in certain areas) and low regeneration (conversion primarily to spruce in some cases, and impact of deer browse on cedar regeneration). • Indicators:a) amount of potential monumental cedar through time (from three different analyses). • Baseline: None available at this time.
BIRDS	
Marbled Murrelet	• Red-listed species + COSEWIC listed species. Also Provincial Identified Wildlife. Old forest associated (for nesting). Concern due to loss of nesting habitat over entire coastal range. • Indicators = amount of Marbled Murrelet habitat through time (defined by forest age class, canopy closure and height class). • Baseline = capability based on a backcast of the original forest cover.
Northern Goshawk laingi subspecies	• Red-listed, and COSEWIC listed subspecies. Old forest associated species. Concern due to loss of nesting habitat, and disturbance, and complicated by changing prey based as a result of introduced species. • Indicators = amount of productive /suitable territories through time (based on distance between nests and known likely suitable habitat) • Baseline = suitability based on backcast of original forest cover
Seabird Colonies (areas unprotected or under protected)	• Globally important populations of alcids, plus large number of other species using Islands as nesting and foraging habitat. Many nesting islands are included in Protected Area. However, pressures remain great from introduced species, and disturbance from facilities located on islands or adjacent and lights associated with them. Offshore oil exploration and infrastructure also a potential threat. Identify areas still in need of protection, or where existing protection still results in high risk to colonies.
MAMMALS	
Haida Gwaii Black Bear carlottae subspecies	• Provincially not listed, but endemic subspecies. • Indicators (landscape level) = Bear population density estimates through time, (based on seral stage refined by canopy closure, plus salmon biomass seasonally, roads, patch size, shoreline data.
FISH	
Salmonids	• Ecological keystone species. High value social species • Indicators = total stock trends for the Islands. • Baseline: no natural baseline available. Looking at trends over time using available data.
Salmonids (less information) Coastal Cutthroat trout Rainbow Trout (Steelhead)	• Blue-listed provincially. Coastal, not endemic to Islands – Alaska to California (some notion of watershed endemism). • Vulnerable to streamside harvest and siltation, combined with over-fishing. • Insufficient data to report over time.
Dolly Varden Salvelinus malma	• Blue-listed provincially. Watershed endemism • Sensitive to streamside harvest, siltation, warming, and over-fishing. Not included as an indicator due to weak data.
NON-NATIVE SPECIES	
Sitka Black-tailed Deer Beaver Rats Raccoon	• Extensive impacts and cascading impacts throughout ecosystems. • Modeling of impacts highly complex, and insufficient data are available. • Expert opinion or possible qualitative assessment to determine highest potential impacts and to provide direction on potential spatial mitigation options.

Indicator / Species of Concern	Rationale
Select introduced Plant species	• Five species have been identified as key plant species of concern for the Islands. These include Japanese knotweed, Scotch broom, gorse, marsh thistle and Canada thistle. • In addition, two species currently not highly invasive, but with the potential to do so are identified: wall lettuce, and English ivy. • Expert opinion or possible qualitative assessment to determine highest potential impacts and to provide direction on potential spatial mitigation options.
Additional Species of Management Concern: Chapter III.	
Northern Saw-whet Owl brooksi subspecies	• Blue-listed provincially. Breeding endemic subspecies. Lack of data on population size/ trends.
Great Blue Heron fannini subspecies	• Blue-listed provincially COSEWIC species of special concern (vulnerable). • Considered stable, or slightly declining. Very low density on Islands due to relatively low density of good quality feeding grounds.
Bald Eagle (Haliaeetus leucocephalus)	• Species / populations are not considered endangered, but there is concern for nesting sites around shoreline. High densities of eagles nest along HG / QCI shorelines.
Stellars Jay carlottae subspecies	• Provincially blue-listed. Endemic breeding subspecies (also found on Dall Island Alaska). Small local populations, total size unknown.
Hairy Woodpecker picoideus subspecies	• Blue-listed provincially, and this subspecies is endemic to the islands. • Local populations, total size and trends unknown.
Sandhill Crane Grus canadensis tabida	• Blue-listed provincially (due to sparse population). Inconclusive information re taxonomy (potential northern coast subspecies). • Nests in bog areas, but potential for impact of harvest and roads on nesting cover and for shoreline / estuary impacts.
Peregrine Falcon pealei subspecies	• Provincially blue-listed and COSEWIC species of concern. Locally distributed on Alaskan coast, north BC coast and HG. Typically resident (once breeding). Primarily cliff-dweller, feeds on colonial seabirds
Pine grosbeak carlottae	• Coastal endemic (Van Is, HG, possibly mainland coast). • Mid to high elevation forests, nest low to ground in coniferous trees. Widespread, but sparse distribution.
Haida Ermine subspecies Mustela erminea haidarum	• Red-listed provincially, COSEWIC Threatened species. Endemic subspecies (1 of 5 provincial subspecies); apparently restricted to Graham and Moresby Islands (Louise and possibly Burnaby Islands). Generally forages on mice and voles, but lack of native microtines on the islands likely result in generally sparse populations of ermine. • Trend data for populations unknown, but extensive trapping revealed current extreme scarcity of this species.
Keens Myotis	• Bat species - Red-listed provincially, COSEWIC species of concern, IWM species. Endemic to coastal BC. Inhabits low elevation coastal forests, but very little is known about specific habitat use. One known maternity colony is on Hotspring Island.
Marine Mammals	• Numbers of marine mammals under threat relating to the Islands (leatherback turtle, orcas – resident, transient and off-shore populations, grey, sperm, right and humpback whales, plus sealions. • Most species unaffected directly by land use, except for haul out and pupping areas for seals and sealions. Possible conflict with fishing. Identify areas of concern.
Giant Black Stickleback Gasterosteus sp.	• Red-listed provincially. Known from Drizzle and Mayer lakes on the east side of Graham Island, Queen Charlotte Islands. Considered stable, but highly localised. Threats include stocking of salmonids in lakes, and beavers altering water levels in relation to spawning. Possible impacts of sport fishing.
Haida Gwaii Jumping –Slug	• A number of gastropods are found in coast forests. A new species of Jumping Slug has recently been found on the Islands. In addition, two other species – Warty Jumping-slog and Dromedary jumping-slug are potentially present and of concern.

BOX 3: HOW MUCH IS ENOUGH? ECOSYSTEM ANALYSES

Understanding the elements that are likely needed to maintain biological diversity is relatively well understood. However, 'how much' is needed is less well understood.

Maintaining ecological integrity involves retaining sufficient areas to maintain viable populations of species across their natural ranges and to maintain natural processes (summarised in CIT 2004). Approaches for determining how likely something is to be maintained can include a comparison with a natural benchmark, or, a stand-alone assessment of how likely a population is to be maintained. Example approaches are shown below:

REPRESENTATIVE ECOSYSTEMS: HOW MUCH OF EACH ECOSYSTEM IS NEEDED?

- Comparing against a benchmark defined by natural processes is a widely used approach. For example, identifying how much old forest was present under natural conditions can be used to assess risks associated with the current amount of old forest on the landscape. This is called using a 'natural disturbance paradigm'. However, ecosystems are not static over time – they change at different rates and at different scales. This Range of Natural Variability (RONV) more fully describes the natural state of the environment, and represents the appropriate benchmark. It is assumed in this methodology that the higher the natural amount of old forest there is in a landscape, the higher the amount required to maintain fully functioning ecosystems. The range of natural variability has been used as a benchmark for old forest ecosystems in this report.
- Reference ecosystems can also be used as a benchmark. Geographic areas not impacted by industrial development provide a snapshot of a natural landscape. The difficulty in using a single reference ecosystem as a benchmark is that we don't know how representative that ecosystem is, and it also provides only a single timeframe for comparison, rather than the range.
- 'Recreating' the original landscape can also be used as a benchmark. For example, 'standing up harvested areas' can be used to provide a picture of the HG/ QCI landscape prior to the onset of industrial harvesting. This approach has been used as a benchmark for the primary indicators in this report, and is referred to as a 'backcast' of forest cover. Limitations of this methodology are summarised in Chapter IV.

HOW MUCH IS ENOUGH? SPECIES AND POPULATION ANALYSES

First it is necessary to define the goal more precisely. In conservation biology the objective is usually to maintain sub-populations across their natural range and over time (Caughley 1994). An example would be maintaining Marbled Murrelets in every watershed that was inhabited under natural conditions, but not in every stand (or cutblock) at all times.

- Population viability analysis (PVA) is a process of identifying the threats faced by a species or population, and then evaluating the likelihood that the population will persist into the future. PVA can range from simple to highly complex analysis, but to be robust, it tends to require detailed life-history information, including data on reproductive success, habitat use, survival of adults, strict definition of population size etc. Where data are unavailable, a range of expert opinion can be used to provide some assessment. PVA can show whether a population is increasing or decreasing, and can define the probability of it continuing over short, medium and longer timeframes.

- PVA can also help to identify which factors require more research effort, or management attention. Sensitivity analysis can help to identify whether habitat supply, food availability or some other factor has the largest impact on the population. Outcomes of PVA are usually presented in terms of the probability of a certain level of decline over some time frame.
- Population viability analysis is also highly impacted by external, or stochastic (random) events. Relevant events would include climate change, movement or impacts on fish stocks that change foraging behaviour, etc. Robust PVA's should include sensitivity analyses that consider potential outcomes of these events.
- Population trends. An analysis of population trends (is the population increasing or decreasing) can often be undertaken with less data than a robust PVA. Estimates of adult and juvenile survival, breeding rate and breeding success of females are the key variables. Population trends are usually presented in terms of a "lambda" value, which when greater than 1 shows an increasing population, while values less than 1 show a decreasing population. Again, uncertainties should be included in this modeling, but are often not known sufficiently to be included.
- Alternatively, where data are lacking, some surrogate of current populations can be compared to a historic benchmark. This may include comparing likely number of territories or habitat amounts for a particular species with the number or amount present historically. It is not possible from this information to assess whether the current number of territories is likely to maintain the population over time, but it does provide an indicator of the level of change, and therefore the potential level of impact for a population.
- For many species sufficient data are lacking to allow any of the above methods of assessment. For these species, the vast majority of species, it is important to assess a) the extent to which their habitat may be maintained by maintaining representative ecosystems (the coarse filter), and b) to identify key habitat requirements not included in the coarse filter and attempt to maintain them over time.

A combination of all these approaches above are used in this report.

SCIENCE, RISKS AND UNCERTAINTY.

Science cannot provide generic answers to the question of 'how much is enough'? Over the landscape, the range suggested necessary to maintain ecological integrity is from 4 – 99% depending on natural characteristics, landscape context, and level of risk taken (Noss and Cooperider 1994; CIT 2004). Science can only provide guidance as to the probability of survival, or probability of maintaining functioning of ecosystems. The probability of maintaining something can also be termed as the 'risk' to a species or function and can be outlined in scientific terms.

However, deciding what level of risk is acceptable is a social decision and cannot be answered by science.

1.2. BASELINE INFORMATION

Two pieces of information provide general background for this Environmental Conditions Report. The first is a summary of the ecosystems present on the island, in a format that can be used consistently throughout the LUP process. This 'base map' provides a consistent source of information on ecosystem states through time, and also drives the remainder of the models to ensure indicators can be tracked using a single data source.

The second is an overview of the natural disturbance regimes of the islands - the processes that have shaped the ecosystems. These two pieces of background information provide an environmental baseline for assessing the implications of change away from natural patterns and processes.

ECOSYSTEMS OF HAIDA GWAII

HG/ QCI is separated into two terrestrial Ecoregions, each with different physiographic characteristics: (1) Queen Charlotte (QC/HG) Ranges and (2) Queen Charlotte (QC/ HG) Lowlands. The QC/HG Ranges is further delineated into the Skidegate plateau and the Windward Queen Charlotte Mountains. The lowland areas feature low relief, cool wet weather and generally nutrient-poor bedrock, and is dominated by extensive blanket bogs, shallow lakes and scrub forest interspersed with patches of productive forest in better drained areas and on richer bedrock. The more mountainous areas, Skidegate Plateau and Windward Queen Charlotte Mountains, feature steep, rugged topography and cool, wet weather with deep snow at higher elevations. Steep headwater streams and gullies drain the mountainsides, carrying water, sediment and organic materials to the fans and floodplains that line valley bottoms. Lakes head some valleys and small wetlands are common on floodplains and wet mid-slopes; however, extensive wetlands are uncommon. The Skidegate Plateau is lower in relief and rainfall than the Windward Queen Charlotte Mountains and generally encompasses both the most productive forest lands and most productive fish-bearing streams on the Islands.

The ecosystems of the Islands are further divided into biogeoclimatic zones, subzones and variants, which describe ecological variation based on inferred climate information from topography, vegetation and soils. At a finer level of detail, each biogeoclimatic variant is separated into site series, which are areas capable of producing the same mature plant communities, and defined by gradients of moisture and nutrients. Further information on biogeoclimatic variants of the Islands is provided in the HG/ QCI Background Report.

BOX 4: REPRESENTING ECOSYSTEMS

Terrestrial ecosystem classification of forested ecosystems in British Columbia is some of the best in the world. The biogeoclimatic classification (BEC) system is a hierarchical system that uses regional climate to define biogeoclimatic zones, subzones and variants. Each subzone variant is broken into a series of sites that reflect variations in soil and physiographic properties. Sites reflect variation from ridge-top to valley bottoms and and named for the climax tree and plant communities typically found within them.

An appropriate scale for assessing ecosystem representation is using descriptions of ecosystems at a more detailed level than the BEC variant level. Within most BEC variants there are often between 10 – 20 different site series identified, which represent quite different ecosystems from drier ridge tops to very wet valley bottom areas. Site series are the most appropriate unit for evaluating ecosystem representation, but where unavailable surrogates for site series have been used. These can include descriptions of ecosystems based on productivity and / or leading species information.

A single standardised map of site series information is currently unavailable for the Islands, although most companies, the Ministry of Forests and Parks Canada has been in the process of undertaking detailed mapping projects for many years. Details of the mapping used by the PTT to support the ecosystem representation analysis is shown in Chapter II Old Forest Ecosystems and Chapter IV.

Aquatic / riparian ecosystems are also not always well described by BEC mapping. A comprehensive classification for wetlands has recently been completed, but is not yet available for use. For analysis here, we used available ecosystem information (a combination of stream data, buffers and more detailed ecosystem mapping where available) to identify hydroriparian ecosystem types. Details and limitations of this approach can be found in Chapter IV.

1.3. NATURAL DISTURBANCE AND ISLAND ECOSYSTEMS

WHY ARE WE INTERESTED IN NATURAL DISTURBANCE DYNAMICS?

“Natural disturbance dynamics” shape the character and condition of an ecosystem, or geographic area, under natural conditions, and provide a benchmark for ecological analyses.

Understanding geographic scales and time scales is important to understanding natural disturbance dynamics which is often termed the “Range of Natural Variability”.

Disturbances occur at all scales within forests, from individual trees impacted by insects, to larger areas of forests destroyed by fire or high wind. In general, in coastal forest, small disturbances within forest stands are very frequent and large disturbances that impact whole stands or watersheds are quite infrequent. As a result, the natural character of the forest is mostly one of a continuous blanket of old forest with many small scale gaps where single or small groups of trees have been blown down.

Much of British Columbia was glaciated as recently as 10,000 years ago, and so there was no soil, let alone stands of trees present. Ecosystems therefore change on a geological time-scale. Ecosystems also undergo natural disturbances on annual, decadal and centennial frequencies. This scale of change provides a more useful context for making forest management and land use decisions for the next 10, 20 or 100 years.

Understanding the scale being addressed by an analysis is key to understanding what the analysis really means.

Old forests dominate the landscape across most of HG/ QCI where stand-replacing disturbances[4] are uncommon and small gaps in the canopy are the primary drivers of stand dynamics. Although stand replacing fires, windstorms and landslides occur across coastal British Columbia, increasing evidence shows that they mostly occur over very long time-scales (hundreds or thousands of years) and that their influence on the landscape is minor. Instead, frequent fine-scale disturbance (death of individual trees) and subsequent recovery within small openings perpetuates the dominance of old forest cover at coarse scales, and maintains complex uneven aged structure at fine scales.

[4] Events such as large fires, or blowdown that remove most or all of the standing trees in an area

Large-scale disturbance is rare across much of the north and central coast, and may be particularly uncommon on Haida Gwaii. Severe blowdown has been reported on areas of the islands' outer coast that are exposed to oceanic storms, but Price and Daust (2003) found that the Haida Gwaii Mountains had the lowest proportion of natural young forest of any of the areas analysed in their study of disturbance across HG/ QCI, the Central and North Coasts of BC. The proportion of old forest in Hypermaritime areas throughout their study area ranged from 95-99% on upland sites and from 78-96% in ocean-spray ecosystems.

GAPS IN THE FOREST CANOPY

Small-scale canopy gaps involve the death of approximately 10 or fewer overstory trees but are often limited to one or two trees. In general, gaps are distinguished from stand-replacing disturbances by their small size: openings larger than one tree height are generally not classified as 'gaps'.

Gaps are part of a dynamic process in which new openings are created and filled on a continuous basis. Wind, together with pathogens such as root diseases and mistletoe is the primary cause of gap formation. In Alaskan coastal forests, the forest was estimated to be 'replaced' every 575 years (with a range of 230 to 920 years), with canopy gaps comprising approximately 9% of the forested area in these forests (Ott and Juday 2002). In Tofino Creek on Vancouver Island, almost twice this area of gaps (16%; Lertzman et al. 1996), and on Vancouver Island and North Vancouver, 39% the area of the forest was estimated to be 'gaps' (Arsenault 1995). The broad range reported in these studies may be due to differences in ecosystem characteristics or to different methods of defining gaps, but it is obvious that small scale gaps play an important role in maintaining and shaping stand and landscape structure across coastal forests.

WIND

Wind is a major factor in small-scale gap formation in coastal forests, yet catastrophic wind events are relatively rare. Large-scale, stand-replacing wind events have been recorded for Vancouver Island, the North Coast and Southeast Alaska. For example, it has been estimated that approximately 0.03% of the operable area in the North Coast Forest District was affected by stand replacing wind events on an annual basis between 1960 and 1996 (Mitchell 1998, in Wong et al. 2002). The exact topographic location of an area affects the chance of large blowdown events, with exposed positions often having more severe and more frequent catastrophic windthrow events: this effect has been documented for the windward side of HG / QCI (Pearson 2003 – in Price and Daust 2003). Catastrophic wind events probably have also occurred on the east coast of the Islands, and are likely smaller than those on the more exposed west side (K. Moore pers. comm.). Interactions between disturbance agents, particularly between windthrow areas and landslides are common.

LANDSLIDES

According to Dorner and Wong (2003), geomorphic disturbances are the most important naturally occurring high-severity, stand-replacing events in the wet, steep forests of the northern coastal rainforests. Geomorphic disturbances include debris flows, landslides, flooding and avalanches, which alter stands by dislodging trees and rocks, modifying stream channels, and transferring coarse woody debris over great distances. Many geomorphic disturbances are important in creating and maintaining early seral communities. In smaller openings like avalanche tracks and flood zones, these brush habitats provide forage in close proximity to forest cover.

Landslides (or mass wasting) are particularly important disturbance agents in the wet, steep mountainous areas of HG / QCI. Different terrain types have different natural rates of landslides, with a number of specific types on the Islands prone to sliding (Schwab 1998). These include bedrock slides cause by seismic activity, slow earthflows occurring in gullies filled with deep clay rich glacial till deposits, and glacial marine deposits all of which have a tendency to be prone to landslides. Characteristically, there are large volumes of natural landslides occurring on the Islands. These events appear to be triggered primarily by large rainfall events that saturate soils and increase the chance of an event occurring. The effect is amplified by slopes >30%, which have a higher chance of a slide occurring. Very high natural rates occur in some areas of the Islands (e.g. failure rate of 18/ km2 in Rennell Sound, 14/ km2 in Moore Channel).

However, human activities on the landscape have radically increased the probability of landslides occurring (Schwab 1998); the rate of failure was 15 times the natural rate on modified terrain compared with forested terrain, and 43 times and 17 times respectively higher for clearcuts versus roads. Rood (1984) showed that clearcuts had increased the landscape frequency by 34 times, over natural rates.

FIRE

Fire plays an important role in the dynamics of most coniferous forests in North America, but in the wetter climate of British Columbia's coastal areas, there is increasing evidence that fires are of minor importance to disturbance dynamics. Using radiocarbon analyses of soil charcoal, intervals between fires in the Clayoquot and Fraser Valleys ranged from hundreds of years to thousands and some wetter sites had experienced no fires for as long as 6000 years (Lertzman et al. 2002). In a study of fossil charcoal and pollen records on the west coast of Vancouver Island, Brown and Hebda (1998) estimated 3000-year fire return intervals. In the Clayoquot Valley, the median fire return interval reported was 2380 years with a maximum time since fire of 12,200. These intervals and times since fire suggest that on some sites, there is no evidence of fire since the time of glaciation. Fire return intervals also varied by topographic location, with more frequent fires on hill slopes as compared to terraces (Gavin 2000).

In coastal forests in southern British Columbia, Douglas fir is a key seral species that colonizes post-fire sites, and because it favours mineral soil for establishment, is a good indicator of past fires (Klinka et al. 2000). However, Douglas-fir does not occur as far north as Haida Gwaii, which several authors have used as evidence for the exceedingly rare occurrence of fire (e.g. Schmidt 1960 and Klinka et al. 1979 in Parminter 1983).

Records of natural fires are very rare for HG / QCI: Parminter (1983) examined the Provincial Fire Atlas of the Ministry of Forests for the period of 1940-1982 and only found four records of lightening-caused fires in the Queen Charlotte Islands. None of these fires exceeded 0.1 ha in size though fire suppression efforts may have reduced fire spread. Parminter (1983) also noted that there is little or no evidence of recent fire history along the former Coastal Cedar-Pine-Hemlock BEC zone, which occupies low elevation forests within a 25 km narrow band along the coast.

All this being said, there is evidence of at least one and possibly more large fires on the Islands, in the Tlell watershed during the 19th century. The cause of these fires are unknown, though local author Kathleen Dalzell (1989) suggested the major fire was caused by a discarded match. In any event, because of the evidence raised above it appears unlikely that fire caused stand-replacing disturbances have been a predominant disturbance agent through time as found in drier coastal ecosystems.

In addition, there have been a number of industrial forestry-related fires over the last century (K. Moore pers. comm.). A fire was started on north Moresby Island in the 1950's, another large fire in the Mamin River in the 1960's, and others on Louise and Lyell Islands in the 1980's. These forestry-related fires are not considered part of the natural disturbance regime for the Islands.

THE HAIDA PEOPLE

The Haida have lived within the ecosystems of the Islands for a long time (in excess of 10,000 years), and have therefore likely influenced different aspects of the ecosystems there, at different scales throughout this time.

The culture of the Haida typically focused on marine environments, and settlements appear to have been primarily in coastal regions. Potential influences on ecosystems would likely primarily include local impacts around village and settlement sites, small scale disturbance within the forests as cedar and other plant species were gathered for use, and local impacts on streams around fish traps etc.

Another possible agent was burning to increase productivity of berry plants. This activity is well documented for Mainland Interior First Nations' peoples, and is said to have occurred on the Islands. Areas of the drier east coast of the island may have been suitable for burning in drier years or seasons. There is some evidence that Haida burnt areas along Skidegate Inlet at some time (Turner 1995), and Limestone Island and Skungwaii may have seen deliberately set fires.

The oral history of the Haida may be able to shed further light on this subject.

ESTIMATES OF DISTURBANCE RATES

With stand-replacing intervals spanning thousands of years, small-scale disturbance processes take on an added importance in regulating stand dynamics. Yellow cedar is thought to be the longest lived tree species in Canada, and life expectancies range 600 to 1200 years for both and red cedar and from 400 to 500 years for hemlock. As a result, much of the forested area in coastal British Columbia and Haida Gwaii is actually much older than the oldest living trees.

The background provided above outlines that the majority of disturbance processes occurring on Haida Gwaii are small-scale disturbance events, or larger, repeatable events such a landslides, interspersed with very infrequent larger stand-replacing fires (e.g. the Tlell fire).

Translating disturbance rates into general predictions of seral stage distributions (e.g. the amount of forest greater than a particular age) is an approach used to compile an ecological baseline using the Range of Natural Variation. If the rates of disturbance are known, then we can estimate how much of the forest would be *expected* to be over a particular age such as 250 years old.

An analysis of natural disturbance regimes on the coast determined the frequency of stand-replacing events for both fine scale units (ecosystems) and broad units (BEC variants or hydroriparian units) (Price and Daust 2003). A similar methodology was used to re-analyse the HG/ QCI data without the rest of the coast, and the results of disturbance regime outputs is shown in Table 2.

The authors (Price and Daust) note a caution: "Neither biogeoclimatic variants nor hydroriparian sub-regions capture the variation in landforms (e.g. floodplains, steep uplands, wetlands) that is related to disturbance type on the coast". These measures then provide only rough guidance as to natural disturbance regimes.

In addition, we asked for the professional opinion of regional ecologist (Allen Banner), who has extensive experience with the ecosystems and their dynamics on the coast (Table 2).

Table 2. Stand-replacing disturbance frequencies for Haida Gwaii ecosystems from data (Price and Daust and Price pers. comm.) and expert opinion (Allen Banner). Predicted percent old forest associated with disturbance rate shown. Asterisks (*) show the return interval and associated percent old forest.

Analysis Unit	BEC Groups	Return Interval (years) (Price) *	Highest likely return interval / years /(Banner) **	Lowest likely return interval /years (Banner) ***	Predicted percent forest >250 years *	Predicted percent old forest >250 years **	Predicted old forest >250 years ***
Cedar high/ medium Hemlock high/ medium Spruce high/ medium	CWHwh1	1470	600	800	84	66	73

Analysis Unit	BEC Groups	Return Interval (years) (Price) *	Highest likely return interval / years /(Banner) **	Lowest likely return interval /years (Banner) ***	Predicted percent forest >250 years *	Predicted percent old forest >250 years **	Predicted old forest >250 years ***
Hemlock high/ medium Spruce high/ medium/ low	CWHvh2	4000	1500	5000	94	85	95
Cedar low Hemlock low Spruce low	CWHwh1	4000	1500	5000	94	85	95
Spruce high / medium	CWHwh2	4000	1500	5000	94	85	95
Cedar high / medium Hemlock low Spruce low	MHwh	4000	1500	5000	94	85	95
Cedar high/ medium Pine low	CWHvh2	Undisturbed since last ice age	5000	7000	100	95	96
Cedar high/ medium / low Hemlock high/ medium Spruce low	CWHwh2	Undisturbed since last ice age	5000	7000	100	95	96
Cedar high/ medium/ low	MHwh	Undisturbed since last ice age	5000	7000	100	95	96

To understand this table: the first line says that for high and medium productivity cedar sites, in the CWHwh1, one analysis (Price) suggests these stands are disturbed on average every 1470 years, while expert opinion (Banner) suggests they are disturbed at a maximum of once every 600 years and a minimum of once every 800 years. The implications of these different rates in terms of the amount of old forest you would expect to see in these sites is quite small: 84% old forest for the low rate (1470 years), and minimum of 66% for the highest rate suggested.

Although the results differ quite considerably from the two sources (Banners disturbance rates are always higher than Price and Daust), the implications in terms of the amount of old forest predicted to occur is quite small (see last three columns in **bold** above).

CLIMATE CHANGE

Climates change over long periods of time as a result of natural changes over the globe. However, we appear to be in an unprecedented period of rapid change, at least in part caused by human actions over the last few hundred years[5]. Many people are studying the potential changes of this global warming, for continents and for local areas.

Currently, it is easier to predict temperature effects than precipitation or other affects, because the latter tend to be more complex factors. For coastal BC, including HG/ QCI, the amount of heat available for plant growth has increased by 13% over the last century on the coast of BC. This change has potentially far reaching consequences including affecting fundamental factors such as basic ecology of the forests on the Islands, salmon use of streams and spawning success, ocean currents and subsequently forage available for a wide variety of animals, such as seabird colonies etc.

In addition, models suggest that we may be entering a period of increased severity, or unpredictability in severe events. If this occurs, the Islands would likely have higher occurrences of 'natural' disturbances, including landslides, windthrow events, and a drying trend may result in more fires occurring on the Islands. In combination with this, an aspect that makes predictions of global

[5] Intergovernmental panel on climate change: http://wlapwww.gov.bc.ca/air/climate/

warming scenarios particularly difficult is the potential for sudden changes to occur, such as sudden changing of ocean currents that would radically affect local climates in a matter of years.

It is difficult to consider how the potential for climate change affects could be incorporated into a current land use plan. In the absence of unambiguous predictions some authors (e.g. Noss 2001) have suggested that retaining options over the landscape may be wise in the face of such potentially large uncertainties.

1.4. REFERENCES CHAPTER 1

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Chapter 2. RESULTS

This section outlines the results for the major indicators used in this report.

Detail for each indicator is laid out in a systematic fashion where possible, and overviews:

Contributors: where appropriate, the primary person or document used as a basis for the Section is identified.

Indicator Relevance: Why the indicator was chosen

Background information: A quick summary of essential features of the indicator

Model Approach and Assumptions: a quick summary of key approach facets of the approach. Additional information on methodology is available in appendices.

Ecological Baseline: what did the indicator look like in 1800 to the present day?. Assess 'historic' (pre-industrial development) indicator condition. Using this 'natural baseline' provides context relevant to future decision-making. The intention is not to suggest that all indicators should be 'restored' to a natural condition, rather that this provides guidance as to extent of current and future change, and can provide an indication of the risks associated with current and future conditions.

Current Condition: what does the indicator look like today?. Todays reference point gives the overview of the current status of a particular indicator.

Predicted Future Condition: what do we think the indicator will look like over the next 250 years, if current management continues. The condition of indicators can be modeled out into the future, based on the current approach taken to forest management. This analysis is based on the assumption that current management will remain constant through time, and is simply a projection of current harvest rates and patterns (as used in timber supply analysis) interpreted for each indicator. This is a useful tool because it provides information on how indicators will be impacted by the current approach to management. As land use scenarios are developed through the LRMP process the implications of different scenarios can be compared.

Trends Summary: where appropriate, a graphical summary of ecological baseline, current condition, and predicted future condition is shown.

Primary Information Sources: the key source documents for the background text and modeling. This is an attempt to make the text more 'readable' reducing the need to cite references throughout. Where required additional specific references are cited in the text.

2.1. OLD FOREST ECOSYSTEMS

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INDICATOR RELEVANCE

Maintaining representative ecosystems and old forest in suitable abundance and distribution is a coarse filter approach to maintaining the biodiversity and ecological processes that make up ecological integrity (Franklin 1993; Nally et al. 2002). Following the natural disturbance paradigm, landscapes more closely resembling natural landscapes in the abundance and distribution of old forest have a higher probability of maintaining ecological integrity, or in other words, are at a lower risk.

BACKGROUND INFORMATION

OLD GROWTH FORESTS

British Columbia coastal forest ecosystems are globally unique, and provide habitat assemblages and stand structures that are locally and globally important for maintenance of biodiversity. HG/ QCI is part of the perhumid temperate rainforest, which occurs from S.E. Alaska to the northern tip of Vancouver Island and which differs ecologically from the drier Douglas-fir dominated forests of southern coastal BC and the US. The perhumid temperate rainforests are ancient, structurally complex and act as reservoirs for biological diversity. Studies of arthropod diversity in tree canopies in coastal British Columbia have found that some species rely on microhabitat features that are only found in intact old growth (Winchester and Ring 1999). Animal species associated with old forest tend to rely on habitat requirements such as large diameter snags and trees or an abundance of coarse woody debris; in general, these structural attributes are not readily available in younger forests or managed stands and are not easily or quickly created. On HG/ QCI some coastal endemic and rare species are associated with old growth forests, and the Haida Nation use many attributes of these old forests for a wide variety of cultural uses.

Definitions of “old growth” range from simple descriptions based solely on forest age (e.g. “forests greater than 250 years old”), to definitions based on broad principles of forest stand development. Many authors have endorsed the use of definitions based on multiple structural attributes (known as ‘old-growthness indices’), since the structures contained in old forests represent some of the unique functional aspects of older forests (e.g. Spies and Franklin 1988). Attributes used in some ecological old growth definitions include: large old trees, a multi-layered canopy, numerous large snags and logs, diverse tree community, canopy gaps, hummocky micro-topography, complex structure, wider tree spacing, and increased understory production. Quantitative approaches to defining old growth tend to focus on these structural elements since they are easily measured, are often linked to biodiversity and have the potential for manipulation through forest management. Structural attributes are key elements in defining old forests, but additional elements are also key. These include the great age of some trees, the microclimate created by the partially closed canopy, the abundance of habitat features for particular wildlife species (e.g. marbled murrelet nesting platforms), well developed forest floor with diversity of bryophytes, diversity and abundance of wildlife trees (snags) throughout the stand.

In British Columbia, the definition of old growth used by forest planners is based on estimated stand age class determined from forest cover inventory. For all coastal ecosystems present on HG/ QCI, old growth is defined as those forests greater than 250 years old. Age-based definitions allow “old forests” to be identified from existing data without the expense of field sampling. However, this simple working definition does not consider differences in stand structure or other attributes within stands. Two major limitations of available data for identifying old growth forest are that a) the two oldest age classes (AC8 =141-250 years, and AC9 = 251 years plus), are often incorrectly labeled (apparent AC 8 stands can often be >251 years), and b) that the oldest age-class (>250 years) is inadequate for assessing the true age of forest stands on the coast, where individual trees can be 1000 years old, and the stand itself may be multiple thousands of years old. The current inventory is therefore unable to distinguish between stands of trees averaging 251 years old, with those averaging 1000 years old.

A widely used conservation strategy for biological values is to employ a 'coarse filter / fine filter' approach. The Coarse Filter is used as a way to manage for key habitat or ecosystem values that maintain the untold number of unknown species and processes. A fine-filter strategy identifies elements not captured by the coarse filter and identifies separate strategies for these elements. A coarse filter strategy for coastal ecosystems would contain two elements:

i) Ecosystem representation in Protected Areas, irrespective of seral stage. This gives an overview of the types of ecosystems that are protected for the long-term in Parks, irrespective of their current condition.

ii) Old growth Ecosystem representation across the landscape through time. This gives a more detailed overview of the condition of ecosystem representation over the landscape at different time periods. In general, the abundance and representativeness of old forest are the two primary factors affecting the ability of remaining old forest to maintain ecological values across a landscape. In addition, the distribution and patch sizes (i.e. the extent of fragmentation) can also be important by varying the quality of habitat remaining. Small or linear patches differ in microclimate, may lack structural attributes, or the interior condition required to maintain some species and ecological functions. In addition, patches tend to have increasing likelihood of experiencing windthrow if they are small or narrow in shape or size.

The analysis provided below summarises both i) and ii) for HG/ QCI.

OLD FOREST STRUCTURES: STAND LEVEL

The idea of describing old forests in terms of the 'structural attributes' present in them (e.g. large trees or large coarse woody debris) has resulted in a suite of management approaches that attempt to maintain some level 'old forest attributes' in stands after harvest. This has been variably termed 'new forestry', partial harvesting, variable retention, heli-select etc. The objective is to provide 'legacies' of the old forest in the new stand, which likely increases the biological value of the stand in the short-term and perhaps in the long-term. It can be thought of as managing for 'old forest' values on a smaller scale, rather than maintaining entire stands at the landscape level. The analysis presented here is primarily focused on maintaining landscape level forests, though has a resolution down to 0.25 ha, so small patches maintained within cut-blocks are included in the analysis. Retention of stand structures at smaller spatial scales than 0.25 ha (i.e. single trees or small patches) are assumed in this analysis to not provide additional 'old forest ecosystem', though they likely provide local stand level values.

MODEL APPROACH AND ASSUMPTIONS

Key steps in the model include:

Task 1: Define a set of 'ecosystems' for the Islands. The finest scale feasible below biogeoclimatic variant was used, and identifies ecosystems based on their leading tree species and productivity, within biogeoclimatic variants (e.g. cedar leading on high productivity sites in the CWHwh1).

Task 2: Create a historic map of ecosystems, estimating distribution and abundance of ecosystems in 1800.

Task 3: Overlay past, current and predicted future harvesting on ecosystem map.

Results in: An analysis of the representation of ecosystems in Protected Areas (irrespective of the age of the forest)

Results in: A summary of the extent of old forest for each ecosystem type in years 1800, 2000 and 2500. The comparison of 1800 – 2000 can be interpreted as the current level 'change from natural'. The comparison of 1800 – 2250 can be interpreted as the predicted future 'change from natural' based on current management strategies.

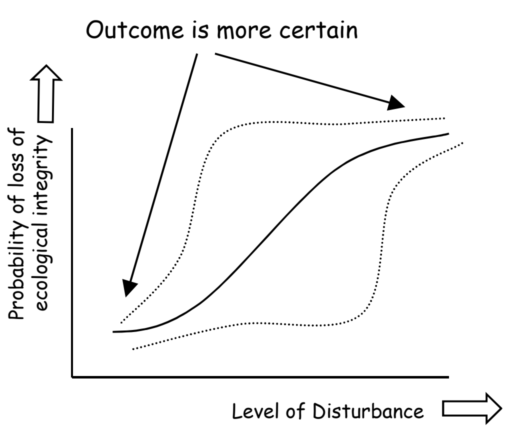
Additional model details and model results are shown in Chapter 4.2.

The approach used is based on the assumption that the current and future state of ecosystem representation can be assessed by comparing the current amount of old forest present in an ecosystem to that predicted to have occurred under natural disturbance conditions. Key assumptions include:

- For each ecosystem, the closer the amount of old forest to the range of natural variability, the lower the risk and the higher the likelihood that the diversity of ecological values provided by old forests will be maintained.
- The Analysis Unit map of the Islands adequately represents ecological variability within old growth forests. The extent to which this is true depends on the scale of consideration. Biogeoclimatic mapping alone would provide insufficient resolution of different ecosystem types. Site series mapping would allow a more ecologically based description of ecosystems, but is unavailable for the entire Islands.
- Old forest ecosystems as described by Analysis Units within BEC variants are assumed to be an appropriate indicator of the functioning of the 'coarse filter' protection mechanisms.
- The scale of analysis considers only clearcut logging, and does not include a) old A-frame harvesting of select trees or b) more recent partial harvest / variable retention where retention remains but is of too-fine a scale of resolution to be shown on Forest Cover maps (<0.25 ha).

RISK LEVELS AND THRESHOLDS

It is well accepted that in general, the further away an ecosystem is from natural patterns the higher the 'risk' to that ecosystem, where 'risk' is defined as the probability that the ecosystem is not fully functioning (Province of BC 1995; Landres 1999). However, identification of clear thresholds where a risk level becomes ecologically significant is more complex. In a series of documents addressing the scientific basis of Ecosystem Based Management, the Coast Information Team identified that at a subregional scale EBM could be defined by undertaking 'low risk' management at that scale.



For coastal BC they identified that 'certainty' should affect how retention targets are derived, particularly when using a precautionary approach. For coastal BC they identify that targets towards the ends of the possible spectrum of choices (i.e. closer to zero and 100% retention) are more certain in terms of their outcomes, and that uncertainty increases dramatically closer to the middle of the range (e.g. around 50%).

Within this paradigm they associated low risk management for coastal BC with maintaining 70% of the **naturally occurring levels of old forest** at that scale, and high risk management as maintaining 30% or less of the naturally occurring levels of old forest at that scale.

Applying the low risk target to Table 1 (also see Section 1 , and Section 4.2) this would result in levels of old forest retention in HG / QCI ecosystems varying between 46 – 70% (i.e 70% of the range 66 – 100%; Table 1). The EBM Handbook also identified that higher risks (lower levels of retention) at smaller scales were still within the bounds of EBM provided that the total risk level at the subregional level remained low.

In the results below, ecosystems are ranked in terms of the percent change from 1800 (equivalent to the percent change from natural), to give the reader a relative ranking of the potential risks to each ecosystem. In addition, reference points of 30 and 70 percent change are highlighted to identify which ecosystems may be more at risk than others.

Note when reading all tables that 'percent change' is the inverse of 'percent of natural', i.e. 70% of natural = 30% change.

RESULTS: ECOLOGICAL BASELINE

An ecological baseline is available from two sources:

a) Predicted from known information about natural disturbance regimes, using the negative exponential equation. Section I of this report summarises information known about natural disturbance regimes that occur on HG/ QCI. As outlined there, knowing the rate of stand–replacing disturbances allows us to predict how much forest of different ages would have occurred on the landscape as a result of natural disturbances. If the disturbance interval (the time between disturbances) is short, then a relatively low percent of the landbase becomes 'old' and a high percent would be relatively young. Conversely, if stands are rarely disturbed, then much of the forest would be found, at any given time, as old forest. On HG/ QCI the actual age of stands is often even older than individual trees because the stands are disturbed over a longer timeframe than the life-span of individual trees. Table 2 in Chapter 1 (and Table 1 below) summarises the predicted percent of old forest that would be found in each ecosystem under natural disturbance regimes.

b) Measured from the predicted 'backcast' of forest cover on the islands. This alternate methodology uses a 'backcast' map of the islands, created from using a GIS program to 'stand up' the harvested areas (see Section 4.1 for methodology), back through time, based on their harvest date. In 1800 all 'industrially' harvested forest is returned to old growth state.

COMPARISON OF THE TWO BASELINE ESTIMATES

In Table 1 (below) the two ecological baselines are compared. The predicted old forest values based on natural disturbance regimes (column A) and the derived old forest values in 1800 from the backcast map (column B) are shown.

From Column A, high productivity analysis units are predicted to have the lowest amount of old forest occurring in them, with the lowest estimate being 66% (maximum estimate 85%). All the other ecosystems are predicted to have very high minimum levels of old forest occurring at any one time, with the lowest estimate being 85% of the landscape as old forest. From Column B, there is less variability in old forest predicted, and higher productivity units don't appear to have higher disturbance rates. In general however the two predictions are similar.

Column C shows, for reference, the implications of the CIT 'maintain 70% of natural' threshold, based on the two estimates of 'natural'.

Table 1. Comparison of two methodologies of predicting historic condition. As a reference, in the last column the '70% of natural' target identified by the Coast Information team is identified based on the two estimates of natural levels of old forest.

Analysis Unit	BEC Groups	Estimated Old from natural disturbance regimes Column A	Estimated Old from Backcast Map Column B	Threshold: 70% of natural levels Column C	
				From Column A	From Column B
Cedar high/ medium; Hemlock high/ medium; Spruce high/ medium	CWHwh1	66 - 84%	93 – 99%	65-69%	46 – 59%
Hemlock high/ medium; Spruce high/ medium/ low	CWHvh2	85 - 95%	88 – 94%	61-66%	59-66%
Cedar low; Hemlock low; Spruce low	CWHwh1	85 - 95%	91 – 97%	64-68%	59-66%
Spruce high / medium	CWHwh2	85 - 95%	97%	68%	59-66%
Cedar high / medium; Hemlock low; Spruce low	MHwh	85 - 95%	86 – 98%	60-67%	59-66%
Cedar high/ medium; Pine low	CWHvh2	95 - 100%	95%	66%	66-70%
Cedar high/ medium / low; Hemlock high/ medium; Spruce low	CWHwh2	95 - 100%	92 – 99%	64-69%	66-70%

Note that typically the '**range** of natural variability' (RONV) is used as a benchmark (see Section 1.0). For the ecosystems of HG/ QCI, the 'ranges' are relatively narrow, and so a single value based on the estimated amount of old forest present in each ecosystem in 1800 is used as a surrogate for RONV. Throughout the results, trend lines are provided for old forest for different areas of the Islands through time. In addition, the 'percent change' from the time period 1800 is also provided. The trend lines and the percent change can be interpreted throughout as being a 'change from the natural levels' of old forest.

ECOSYSTEM DESCRIPTIONS

Results are provided for ecosystems in different areas of the Islands. Results are provided by:

i) Ecosections – Skidegate Plateau, Queen Charlotte Lowland, Queen Charlotte Ranges.

ii) Landscape Units – 24 Landscape units have been identified on the Islands. Although these are not ecological boundaries (though are based on grouped watersheds) these areas are administrative boundaries within which old growth targets are set currently. They are used as a way to distribute old growth forest retention across the landscape

iii) Analysis Units - Ten Analysis Units[1] (9 excluding the deciduous type which is not reported on further here) are used to describe key forest types. Analysis Units that reflect the 1800 forest cover map have been derived (see Section 4.2 for detail). A description of AU's is provided in Table 2, and their relative distribution in Fig. 1.

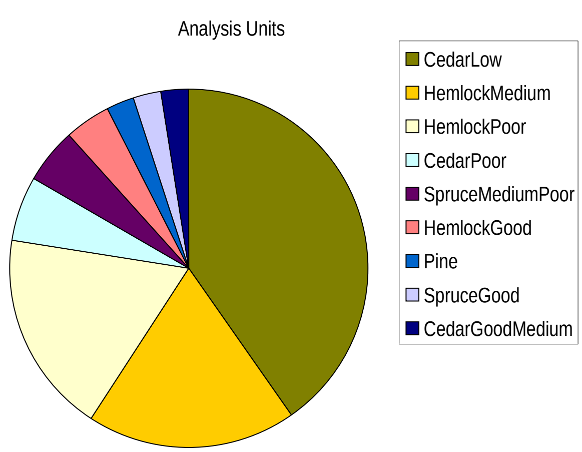
iv) Ecosystems – Analysis units within the 5 biogeoclimatic variants are the surrogate for ecosystems being used (i.e. site series surrogate). This results in a total of 45 possible ecosystem types within the productive forest landbase on the Islands.

Table 2. Analysis Units and Comments.

Analysis Unit	Percent*	Comment
Cedar – Good Medium	2.4%	Productive cedar-leading sites are relatively rare on the Islands. Cedar can be a significant component of Hemlock and Spruce leading ecosystems. At higher elevations some productive yellow cedar sites remain.
Cedar – Poor Cedar – Low	5.8% 40.2%	Lower productivity cedar sites are common on the lowlands of eastern and northern Graham Island, and on parts of the west coast. Some yellow-cedar may be mixed with redcedar at low elevations, especially on the west coast. At higher elevations yellow-cedar replaces western redcedar
Hemlock Good Hemlock Medium Hemlock Poor	4.3% 19% 18.3%	Hemlock is very abundant on the Islands, resulting in many Hemlock-leading stands. Most mature hemlock stands have a cedar component, and some have a spruce component. Second-growth stands are often hemlock / spruce mixtures. At higher elevations mountain hemlock replaces western hemlock.
Spruce Good Spruce medium poor	2.5% 4.9%	Spruce does occur as a leading species in mature stands, particularly in productive alluvial stands and less productive shoreline ecosystems (primarily medium / poor productivity). Second growth stands are often spruce-dominated.
Pine	2.5%	Pine leading stands are generally low productivity bog forests or woodlands. Second growth productive pine stands occur in the old burn on the east coast of Graham Island.

* of forested landbase.

These analysis units (AU's) are a tool derived to analyse condition and trends for ecosystems on the Islands. However, it is expected that strategic and operational direction would be based on site series rather than AU's. Site series provide a more detailed and field tested description of ecosystems, and also allow 'rare' ecosystems (red/ blue listed) types to be identified in the field. Although AU's are being used as a surrogate for site series on the Islands, they do not identify the all the typical differences, especially those of the understory plant associations that define site series differences.



The abundance of Analysis Units differs across different areas of the Islands: about 40% of the Islands is described as cedar leading/ very low productivity (cedar low) types, followed by hemlock leading stands in both medium and poor productivity sites (see Fig 1 below).

Figure 1. Relative distribution of Analysis Units on HG / QCI.

The remaining quarter of the forested landbase consists of a mixture of cedar poor, medium and high productivity sites, and spruce medium and good productivity sites. Distribution of the Analysis Units is shown in Maps 14 a, b and c.

The relative area of BEC variants is shown in Fig 2; more than half the forested area of the Islands is described as CWHwh1 (found primarily in the north east of the Islands in the QC Lowlands), and about one quarter is CWHvh2 (found primarily on the West Coast of the Islands in the QC Ranges). The distribution of the BEC variants is shown in Map 13.

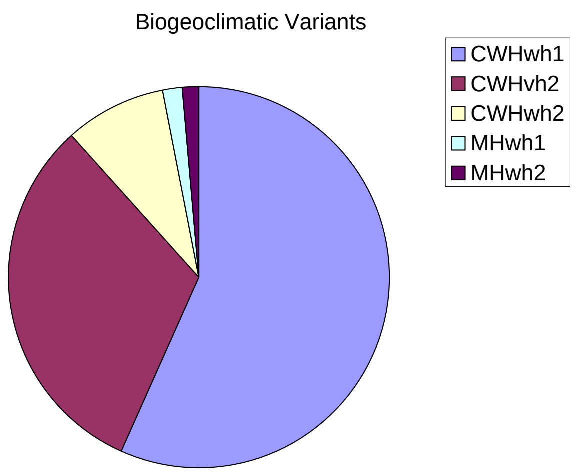


Figure 2. Relative distribution of biogeoclimatic variants across the Islands.

Figure 3 examines the distribution of BEC variants within three ecosections (limited to ecosystems that reflect >5% of each ecosection). The figure demonstrates two main things: a) that three ecosystems dominate the landscape, one in each ecosection (a cedar/ low productivity type, a hemlock/ poor productivity type and a spruce medium / poor productivity type), and b) that different ecosystems are primarily found in different ecosections, with little overlap occurring. In particular, four ecosystems are found primarily in the QC Ranges, and a different four ecosystems are round primarily in the Skidegate Plateau, though the main ecosystems in the QC Lowland are also found on the Skidegate Plateau.

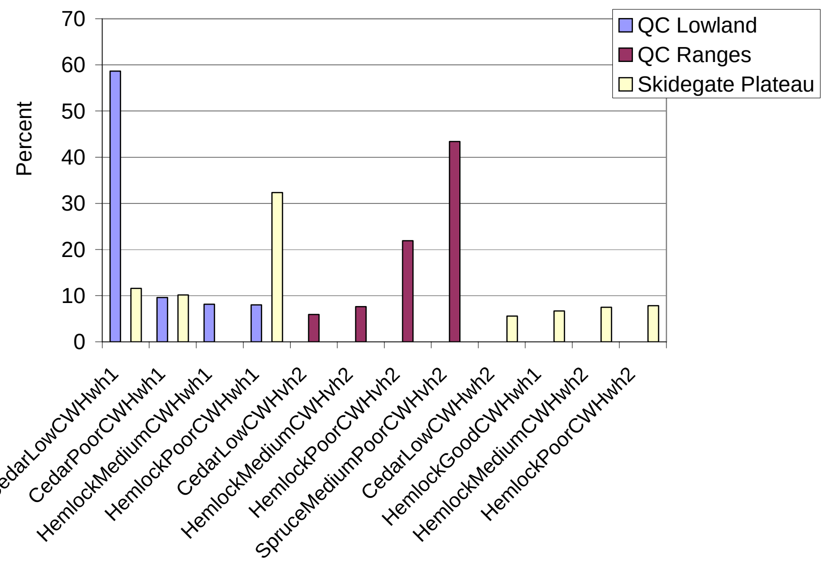


Figure 3. Distribution of major ecosystems (representing >5%) within the three ecosections.

Ecosystem Representation in Protected Areas

Determining the level of ecosystem representation in Protected Areas is a first step in assessing the likely effectiveness of a conservation strategy.

Overall, 22% of the forested landbase is currently in federally or provincially legislated Protected Areas. However, this varies widely for individual ecosystems, and within ecosections. Table 3 summarises the amount of each ecosystem existing on the landbase and the area and percent in Protected Areas, for Analysis Units separated by three ecosections. Forest types that are under-represented compared with the average are highlighted in grey. The full table of ecosystem (AU x BEC) representation is shown in Table 2, Chapter 4.2.

Table 3. Representation of ecosystems in federally or provincially legislated protected areas, separated by three Ecosections.

Ecosection	Analysis Unit	Total Area	Area Protected	Percent Protected
QC Lowland	SpruceMediumPoor	12857	7809	61
QC Lowland	SpruceGood	6039	2039	34
QC Lowland	CedarLow	151296	33337	22
QC Lowland	Pine	8592	1685	20
QC Lowland	CedarGoodMedium	7283	1264	17
QC Lowland	CedarPoor	21061	2951	14
QC Lowland	HemlockGood	5336	674	13
QC Lowland	HemlockPoor	24734	2270	9
QC Lowland	HemlockMedium	20568	345	2
QC Lowland Total		257,765	52,373	20
QC Ranges	Pine	11544	9572	83
QC Ranges	CedarGoodMedium	4018	1913	48
QC Ranges	CedarLow	127349	53780	42
QC Ranges	CedarPoor	12440	4042	32

Ecosection	Analysis Unit	Total Area	Area Protected	Percent Protected
QC Ranges	SpruceMediumPoor	17693	5425	31
QC Ranges	SpruceGood	6862	1612	23
QC Ranges	HemlockMedium	22802	4529	20
QC Ranges	HemlockPoor	69003	13077	19
QC Ranges	HemlockGood	6766	728	11
QC Ranges Total		278475	94677	34
Skidegate Plateau	CedarGoodMedium	8478	4632	55
Skidegate Plateau	Pine	554	185	33
Skidegate Plateau	SpruceGood	7386	2167	29
Skidegate Plateau	HemlockGood	23346	4946	21
Skidegate Plateau	HemlockMedium	112554	14980	13
Skidegate Plateau	CedarLow	51676	5781	11
Skidegate Plateau	SpruceMediumPoor	9747	962	10
Skidegate Plateau	CedarPoor	14096	1058	8
Skidegate Plateau	HemlockPoor	56841	2390	4
SKP Total		284677	37100	13
Overall Total		820917	184150	22

The QC Ranges are over-represented (34%) in Protected Areas, compared with the average of 22%, and the Skidegate Plateau is under-represented (13%).

Within the QC Lowland, hemlock-leading and cedar-leading ecosystem types are under-represented compared with the average, and there is an over-representation of pine and cedar–low productivity types, compared with the average. Within the QC Ranges, hemlock-leading sites are generally under-represented, with an over-representation of pine and cedar-leading types, compared with the average. In the Skidegate Plateau there is an under-representation of hemlock-medium and poor sites, plus cedar poor and spruce medium / poor sites, compared with the average.

The representation of ecosystems in Protected Areas can be examined in more detail by assessing representation of AU's within BEC variants. A complete table of these data is available in Section 4.2 – Table 2, and that table shows that individual ecosystems vary from 83% protected for pine-leading forest types in the CWHvh2, down to less than 1% protection for a number of forested types. For ease of reading only the under-represented ecosystems (<22% - the average) are highlighted in Table 4 below.

Table 4. Representation of ecosystems in federal or provincial Protected Areas. Under-represented ecosystems (<22%) only are shown.

Analysis Unit**	BECv	Area in Protected Area	Total Area	% PA
CedarGoodMedium	CWHwh2	284	1,357	21
CedarLow	CWHwh1	38,996	184,663	21
HemlockMedium	CWHvh2	4,381	21,285	21
Pine	CWHwh1	1,973	9,189	21
HemlockPoor	MHwh1	1,342	6,976	19
HemlockPoor	CWHvh2	11,695	61,168	19
HemlockGood	CWHwh1	4,786	26,635	18

Analysis Unit**	BECv	Area in Protected Area	Total Area	% PA
SpruceGood	CWHwh2	94	579	16
CedarPoor	CWHwh1	4,065	31,109	13
HemlockMedium	CWHwh1	13,729	112,651	12
HemlockMedium	MHwh1	129	1,111	12
HemlockGood	CWHvh2	715	6,564	11
SpruceMediumPoor	MHwh1	100	896	11
HemlockMedium	CWHwh2	1,612	19,537	8
HemlockPoor	CWHwh1	4,101	53,543	8
CedarLow	CWHwh2	517	16,414	3
HemlockPoor	CWHwh2	579	23,455	2
SpruceMediumPoor	CWHwh2	46	3,007	2
CedarPoor	CWHwh2	45	3,719	1
CedarLow	MHwh2		2,689	0
CedarPoor	MHwh2		466	0
HemlockMedium	MHwh2		1,321	0
HemlockPoor	MHwh2		5,222	0
SpruceMediumPoor	MHwh2		662	0
Grand Total		184,150	820,917	22

**Ecosystems with less than 500ha are not included in this summary

The ecosystem types identified in Tables 3 and 4 represent considerably different percentages of the landbase. For example, the hemlock medium and poor sites represent a very large actual area, while other units are relatively rare on the landscape (e.g. spruce types in the CWHwh2). In general, ecosystems should be equally represented across the landscape. However, 'rare' ecosystems are usually expected to be over-represented. In this analysis red and blue-listed ecosystems could not be identified (due to the scale of the analysis and the lack of detailed inventory), but could be considered within General Management Direction based on site series information.

TRENDS

The potential volume of results from these analyses is very large. In order to help focus the reader the results of this analysis are presented at three levels, with an increasing level of geographic focus:

a) overall ecosystem trends for the Islands.

b) overall ecosystem trends within different Ecosections

c) ecosystem trends within the 24 Landscape Units

A) OVERALL ECOSYSTEM TRENDS

The trends in the amount of old forest in each ecosystem over time are shown in Figure 4. Note that the graphs represent greatly differing areas of forest. A list of all ecosystems and the area and percent change of old forest is shown in Chapter 4.2 – Table 3.

Of the 32 ecosystems greater than 500ha, considering all the old forest remaining on the landscape in year 2000, 24 ecosystems are at low risk (>70% of natural old forest remaining), 4 are at low-moderate risk, 1 is at high-moderate risk and 3 are at high risk (Table 5). Over the whole time period (1800 – 2250), once current management decisions are played out on the landscape, 13 ecosystems are predicted to be at low risk, 12 at low-moderate risk, 6 are at high-moderate risk and 1 is at high risk (Fig. 4). **Note that these results assume that all areas currently located in the unprotected 'non-contributing' landbase (or the inoperable) will remain unharvested**. See discussion of this assumption at the end of this chapter.

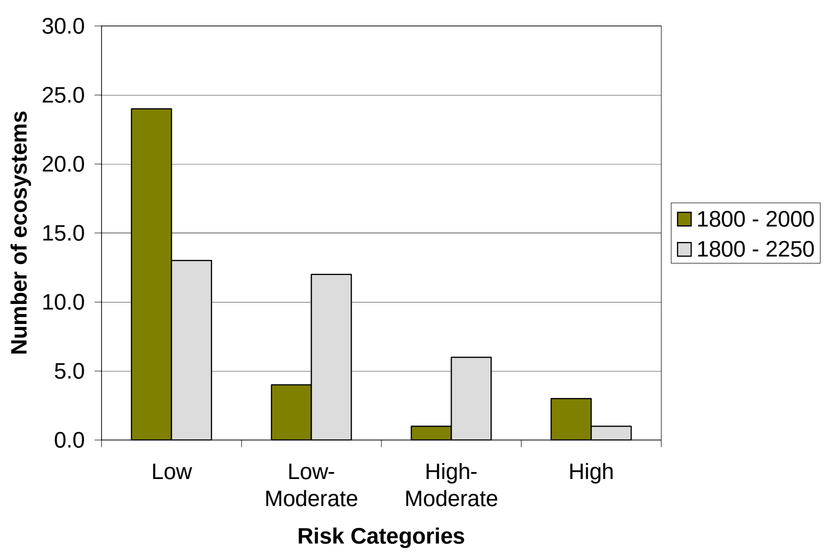


Figure 4. Number of ecosystems in each risk category in 2000, and in 2250, assuming that current management continues over the landscape and assuming that the current inoperable landbase remains unharvested. This latter assumption is likely to be incorrect.

Ecosystems are grouped into those which are predicted to see a greater than 30% decline in old forest from historic condition to long-term future (1800 - 2250) (**on left**), and those with a less than 30% decline over this period (**on right**). In other words, those ecosystems on the right are retained at more than '70% of natural levels' between 1800 – 2250 and these tend to include low and poor productivity ecosystems, or higher productivity ecosystems found at higher elevations (e.g. in spruce medium / good in the mountain hemlock zone). Ecosystems shown in the graphs on the left have less than '70% of natural' levels of old growth remaining over this time period. Most of these ecosystems show a relatively sharp decline in the area of old forest generally between 1950 – 2100, and which then either levels off or continues to decline at slower rate after this period. These ecosystems primarily include the good and medium productivity ecosystems, plus some lower productivity types (e.g. lower elevation cedar and spruce sites).

For some forest types the long term prediction (after year 2100) is for a slight increase in old growth forest (particularly for spruce types and some hemlock medium / hemlock good types), as areas that have already been harvested are allowed to regrow into old growth. This includes those areas currently in a park, or in riparian areas that have been harvested in the past but are not predicted to be harvested again.

The ecosystems showing greater than 30% change are likely at higher risk than those showing less than 30% change in the amount of old forest since 1800. Within these, using the CIT threshold at the regional scale, all ecosystems in Table 5 have moved out of the 'low risk' category (<30%), and a number of them far exceed this figure. For example hemlock medium and good sites which have currently seen a greater than 70% reduction from natural levels of old forest.

The current condition of ecosystems differs. Some ecosystems (e.g. Hemlock Medium in the CWHwh1 and CWHwh2, and Hemlock Good in the CWHwh1) currently approach the 'high risk' CIT threshold of old forest being reduced to 70% of original old forest levels (72%, 67% and 61% respectively). Options for reducing risk in these types would primarily involve identifying second-growth ecosystems to be retained in the long-term. Other ecosystems (e.g. Hemlock Poor in the CWHwh1 or Cedar Poor in the CWHwh1) are currently close to the 'low risk' threshold (maintaining 70% of original old forest), but are forecast to move towards the high risk threshold (56%, 55%, 53%) in the future. For these ecosystems, strategies to lower risk could involve both protection of old forest ecosystems now, and longer term strategies to increase old forest through restoration of second growth.

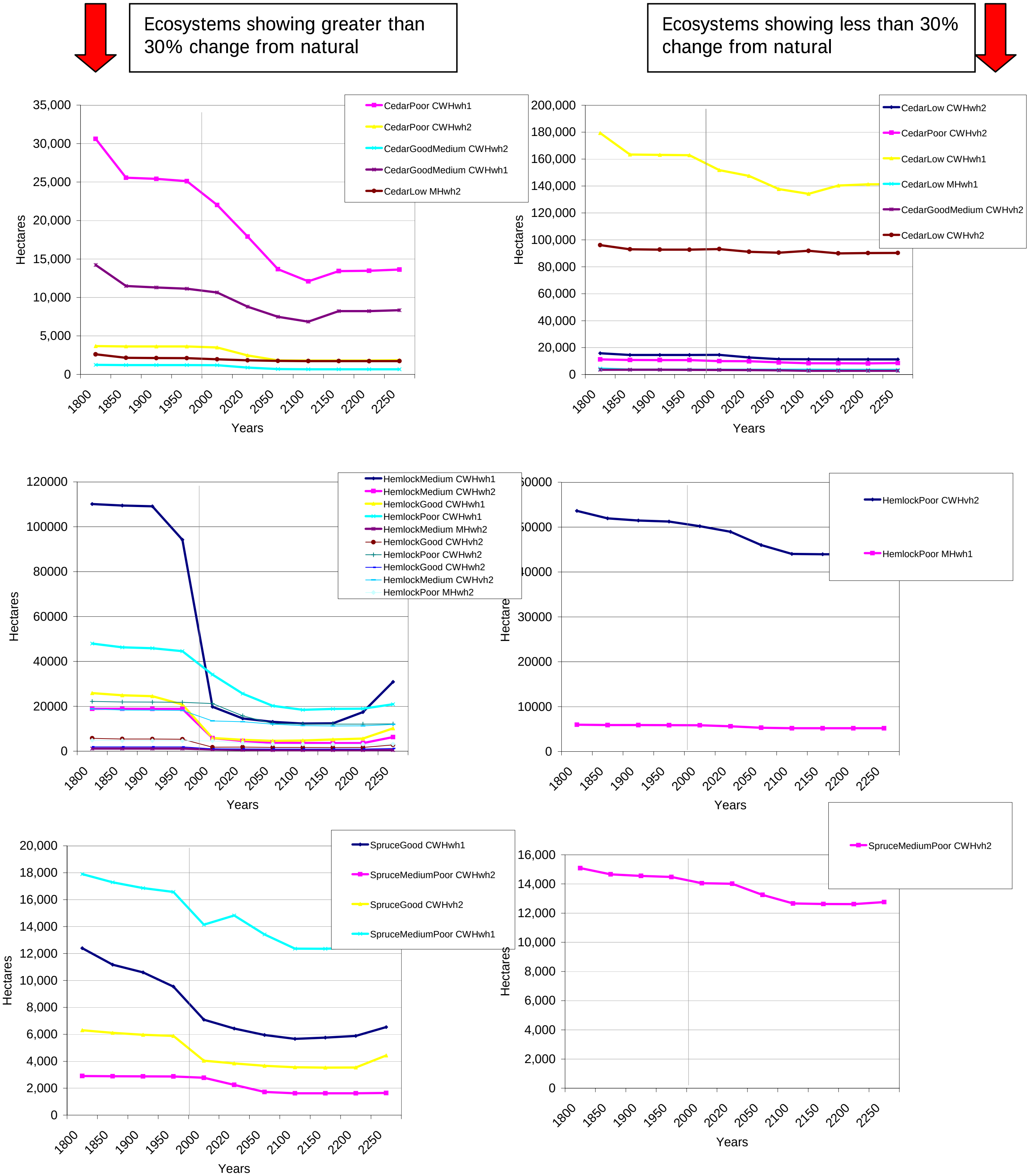


Figure 5. Overall trends for area of old forest for different ecosystems between years 1800 and 2250. Graphs are separated into those ecosystems showing greater than 30% decline (on left) and those showing less than 30% decline (on right) in the period 1800 – 2500.

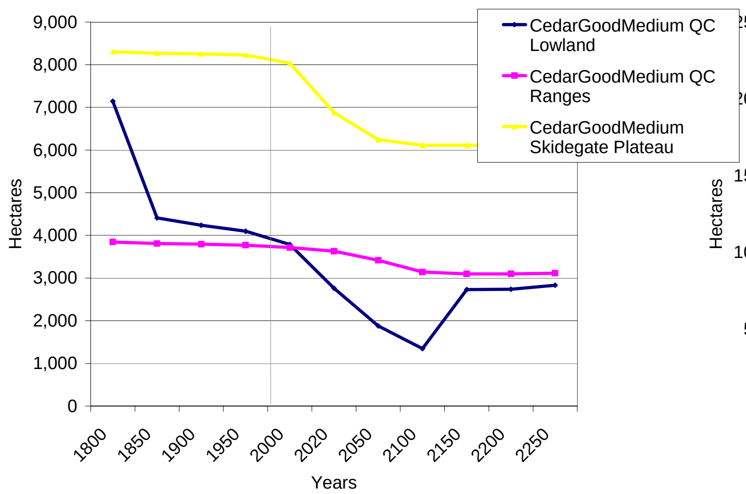
B) Ecosection Trends

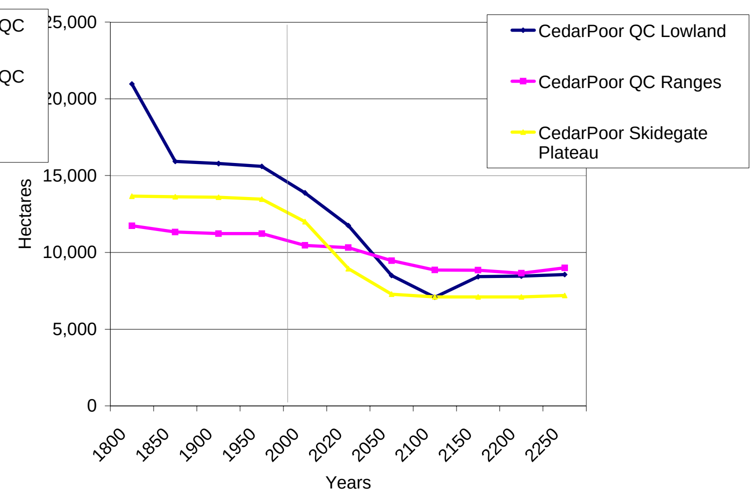
Ecosystem trends are shown for each of the three ecosections (see Fig 6 and Table 5), and can help to identify which geographic areas of the landscape are at higher risk than others. Within the three ecosections, ecosystems are impacted less in the QC Ranges than in either the Skidegate Plateau or in the QC Lowland. Table 5 shows the area of old forest for Analysis Units within different ecosections in 1800, 2000 and 2250, plus area change and percent change over three time periods (1800 – 2000, 2000-2250 and 1800 – 2250). Considering the Coast Information Team thresholds of 70% of natural (i.e. allowing change of 30%), 11 of 24 ecosystems, have already exceeded this level of change (see shaded ecosystems), while others exceed it in future (16 of 24). The majority of the ecosystems that are at higher risk are in the Skidegate Plateau (7 of 8 have less than 70% of old historic old forest remaining), and in the QC Lowland (6 of 8 have less than 70% of the historic old forest remaining). Impacts affect fewer ecosystems in the QC Ranges (3 of 8 have less than 70% of historic old forest remaining). In addition, the extent of the impact is larger for some ecosystems. For example in 4 of 24 forest types (specifically hemlock medium and good sites in the Skidegate Plateau and in the QC Lowland) currently exceed the CIT high risk threshold by having less than 30% of historic old forest remaining.

Table 5. Area of old forest in 1800, 2000 and 2250 for analysis units within ecosections. Area and percent change is shown over three time periods. Those types where percent change is >30% (i.e. exceeds the low risk target of 70% of natural) are shaded.

Eco-section	Analysis Unit	Area old forest			Change* 1800 – 2000		Change* 2000-2250		Change* 1800 – 2250	
		1800	2000	2250	Area	Percent	Area	Percent	Area	Percent
QCL	HemlockMedium	20,365	5,130	4,390	15,235	75	740	14	15,975	78
QCL	HemlockGood	5,154	880	1,691	4,274	83	+811	+92	3,463	67
QCL	CedarGoodMedium	7,147	3,788	2,833	3,359	47	955	25	4,314	60
QCL	CedarPoor	20,964	13,875	8,558	7,089	34	5,317	38	12,406	59
QCL	HemlockPoor	20,587	13,447	9,337	7,139	35	4,111	31	11,250	55
QCL	SpruceGood	6,424	4,161	4,524	2,264	35	+363	+9	1,900	30
QCL	CedarLow	146,837	120,800	119,684	26,037	18	1,117	1	27,154	18
QCL	SpruceMediumPoor	16,145	15,032	13,587	1,113	7	1,445	10	2,558	16
QCR	HemlockGood	5,961	1,865	2,867	4,096	69	+1,002	+54	3,094	52
QCR	SpruceGood	5,733	3,673	3,252	2,061	36	421	11	2,481	43
QCR	HemlockMedium	20,281	14,686	12,905	5,596	28	1,781	12	7,377	36
QCR	CedarPoor	11,728	10,455	8,992	1,273	11	1,463	14	2,736	23
QCR	SpruceMediumPoor	11,968	9,039	9,279	2,929	24	+240	+3	2,689	22
QCR	CedarGoodMedium	3,844	3,715	3,114	129	3	602	16	731	19
QCR	HemlockPoor	60,310	56,744	49,894	3,566	6	6,850	12	10,416	17
QCR	CedarLow	101,353	97,579	94,637	3,774	4	2,942	3	6,716	7
SKP	HemlockMedium	109,447	21,013	33,139	88,434	81	+12,126	+58	76,309	70
SKP	HemlockGood	22,755	6,096	9,786	16,659	73	+3,690	+61	12,969	57
SKP	HemlockPoor	53,767	45,822	26,414	7,944	15	19,409	42	27,353	51
SKP	SpruceGood	7,289	3,887	3,662	3,402	47	225	6	3,627	50
SKP	CedarPoor	13,659	12,000	7,194	1,659	12	4,806	40	6,465	47
SKP	SpruceMediumPoor	9,243	8,225	5,229	1,018	11	2,996	36	4,014	43
SKP	CedarLow	50,005	46,748	33,823	3,257	7	12,925	28	16,182	32
SKP	CedarGoodMedium	8,303	8,035	6,127	268	3	1,908	24	2,176	26

*"Change" is a reduction in old growth forest, unless a + sign is present – in which case there is an increase in old forest


CedarGoodMedium QC Lowland
CedarGoodMedium QC Ranges
CedarGoodMedium Skidegate Plateau
Hectares
Years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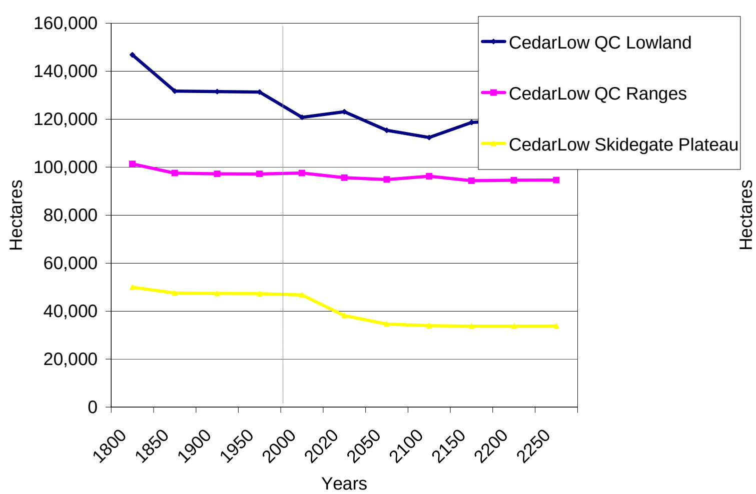
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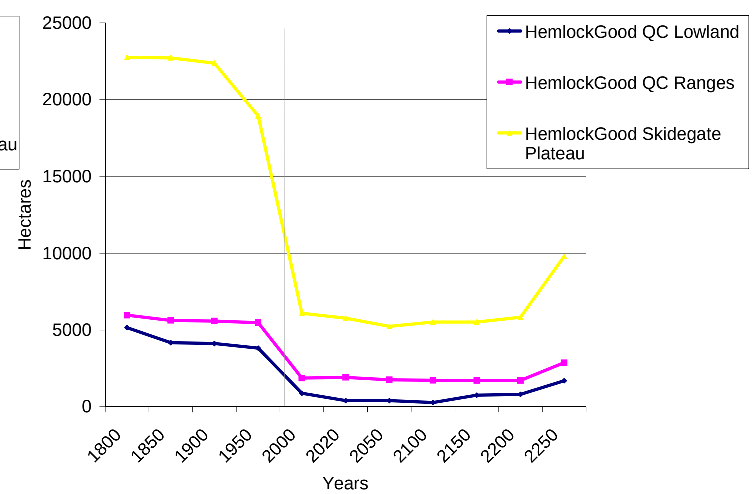
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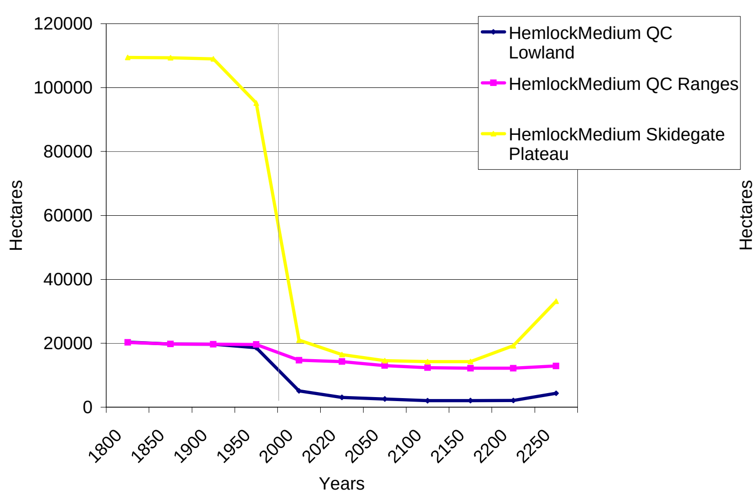
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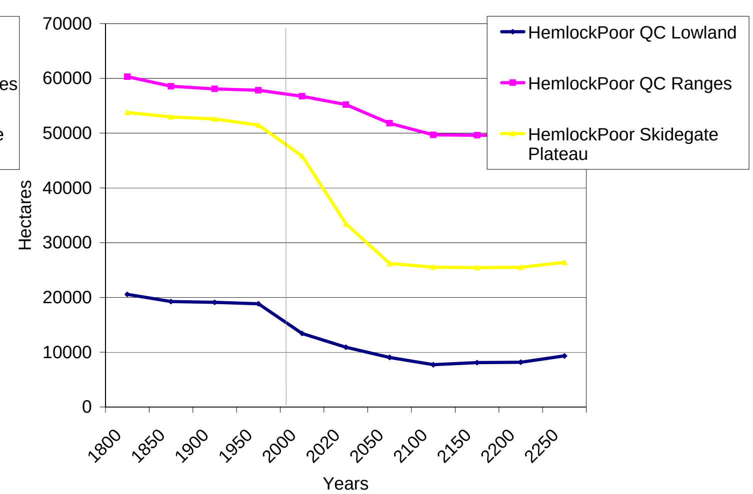
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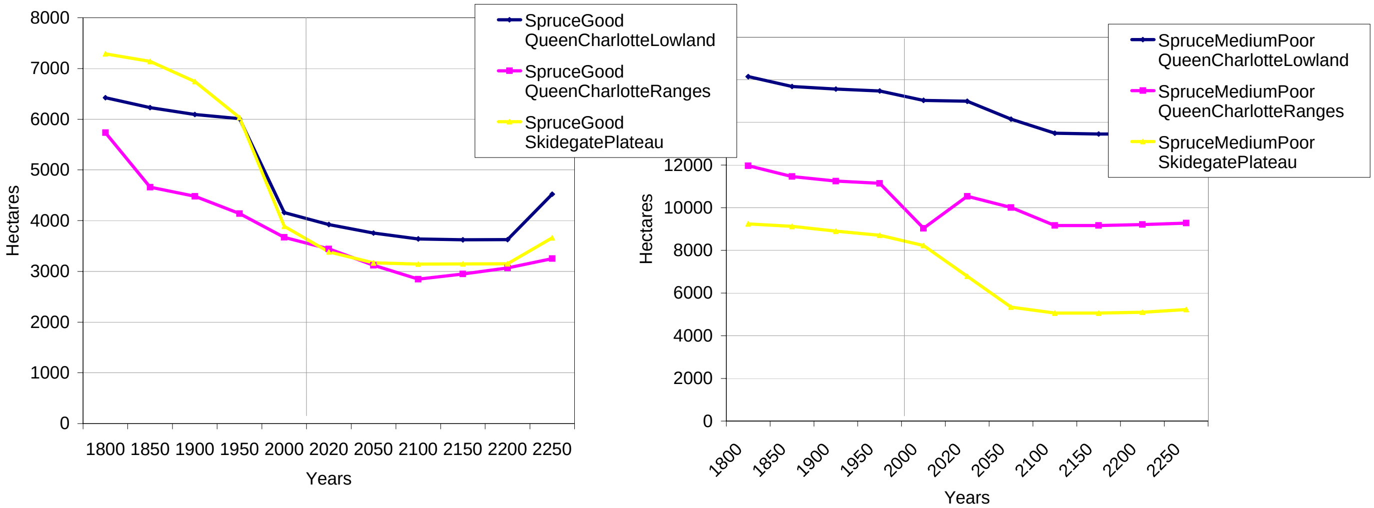


Figure 6. Trends in old growth abundance for Analysis Units within Ecosections between years 1800 and 2250. (Eight Graphs Above).

C) Landscape Unit Trends

The trends for ecosystem condition varies by Landscape Unit. There are 24 landscape units (shown in Map 0 acetate overlay), which provides a manageable number of geographic units for which to assess trends. This analysis helps to identify which areas of the landscape are at higher risk than others currently, and where options may remain to lower risk for individual ecosystems.

Most landscape units contain about 8 Analysis Units, and between 8 and 37 ecosystems (defined by analysis units within biogeoclimatic variants), with an average of 22 ecosystems per landscape unit. The full table showing all analysis units within landscape units is shown in Chapter 4.2-Table 4.

Landscape units vary in terms of their current and predicted future condition. For some LU's, e.g. Bigsby, none of the ecosystems move outside of the low risk range of maintaining 70% of natural levels of old forest, now and into the future (Shown in Chapter 4.2). Others, e.g. Athlow Bay have only single AU's that don't meet the 'maintain 70% of natural' target, in this case current old growth in hemlockgood types has been reduced by 62% from 1800 . While other landscape units have a larger number of AU's that have all seen significant reductions in the amount of old forest either now or in the future. For example, in Eden Lake two analysis units have already exceeded the high risk threshold of maintaining 30% of natural levels of old forest (hemlock medium and hemlock good have currently seen a 80% and 92% reduction respectively. Others, which represent a much smaller area, currently show little reduction (<5%), but over the future timeframe are reduced by between 47 and 64%. This pattern can be contrasted slightly by the Lower Yakoun LU in which most of the ecosystems have already seen significant reductions (37% to 83% reductions), although the reductions do continue in future.

In Table 6 below only those Analysis Units within Landscape Units that show >30% change (i.e. have less than 70% of natural levels remaining) are shown. In addition, those LU's that surpass 50% of natural are highlighted in grey (50% of natural is the CIT threshold at the landscape level, assuming 70% is maintained at the regional level). All analysis units within landscape units which are 'shaded' in the table show which ecosystems are currently at highest risk and in which particular landscape units.

The total area of old growth reduction to date is shown in this table ("Area" under 1800 – 2000). Beware that small changes in small areas can result in a high percent change.

Table 6. Analysis units within Landscape units. Only those types with >30% change predicted from 1800 – 2250 are shown. Those types where there is currently in excess of 50% change (1800 – 2000) are highlighted. A full table for all ecosystems in all LU's is shown in Chapter 4.2-Table 4.

Landscape Unit	Analysis Unit	Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
		1800	2000	2250	Area	Percent	Area	Percent	Area	Percent
AthlowBay	HemlockGood	605	229	221	376	62	8	3	384	63
Beresford	HemlockGood	387	14	37	373	96	+23	+158	350	90
Beresford	CedarGoodMedium	1,426	1,421	796	5	0	625	44	630	44
Beresford	HemlockMedium	4,954	4,151	2,920	803	16	1,231	30	2,034	41
Beresford	SpruceGood	776	712	460	63	8	253	35	316	41
Beresford	SpruceMediumPoor	3,058	2,940	1,915	118	4	1,025	35	1,143	37
Beresford	CedarPoor	3,118	2,875	2,015	244	8	860	30	1,103	35
EdenLake	HemlockMedium	12,707	2,482	2,654	10,226	80	+172	+7	10,054	79
EdenLake	HemlockGood	1,158	92	257	1,067	92	+165	+180	902	78
EdenLake	CedarPoor	1,427	1,409	509	18	1	901	64	919	64
EdenLake	CedarGoodMedium	1,269	1,269	523	0	0	746	59	746	59
EdenLake	SpruceMediumPoor	1,478	1,454	722	24	2	733	50	757	51
EdenLake	SpruceGood	773	737	381	37	5	356	48	393	51
EdenLake	HemlockPoor	7,576	7,169	4,019	406	5	3,151	44	3,557	47
Honna	HemlockGood	5,177	180	953	4,997	97	+773	+429	4,225	82
Honna	SpruceGood	2,905	720	750	2,185	75	+30	+4	2,155	74
Honna	HemlockMedium	1,918	758	531	1,160	60	227	30	1,386	72
Honna	CedarGoodMedium	837	615	249	222	27	367	60	589	70
Honna	CedarPoor	1,501	1,388	719	113	8	669	48	782	52
Honna	HemlockPoor	3,656	3,014	1,876	642	18	1,138	38	1,780	49
Honna	SpruceMediumPoor	2,619	2,327	1,577	293	11	750	32	1,042	40
Ian	HemlockMedium	3,980	698	690	3,282	82	9	1	3,290	83
Ian	CedarPoor	2,247	1,761	483	486	22	1,278	73	1,764	79
Ian	HemlockPoor	5,842	4,328	1,293	1,514	26	3,035	70	4,549	78
Ian	HemlockGood	475	206	123	269	57	83	40	352	74
Ian	CedarLow	11,163	11,114	3,649	49	0	7,465	67	7,514	67
Ian	SpruceMediumPoor	381	323	134	58	15	190	59	248	65
Jalun	CedarPoor	1,804	1,804	801	0	0	1,003	56	1,004	56
Jalun	CedarGoodMedium	494	494	231	0	0	264	53	264	53
Jalun	HemlockMedium	1,433	1,408	678	26	2	730	52	756	53
Jalun	SpruceMediumPoor	991	962	479	30	3	483	50	512	52
Jalun	HemlockPoor	3,306	3,246	1,927	61	2	1,318	41	1,379	42
LouiseIsland	HemlockGood	2,521	16	489	2,504	99	+473	+2,908	2,032	81
LouiseIsland	HemlockMedium	7,504	827	1,599	6,677	89	+772	+93	5,905	79
LouiseIsland	SpruceGood	333	111	81	222	67	30	27	252	76
LouiseIsland	SpruceMediumPoor	435	399	214	37	8	185	46	221	51
LouiseIsland	CedarPoor	1,429	1,220	738	209	15	482	40	691	48
LouiseIsland	HemlockPoor	5,223	4,233	2,708	991	19	1,525	36	2,516	48
LouiseIsland	CedarLow	4,176	4,081	2,467	94	2	1,615	40	1,709	41
LowerYakoun	CedarPoor	2,400	1,202	505	1,198	50	698	58	1,895	79

Landscape Unit	Analysis Unit	Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
		1800	2000	2250	Area	Percent	Area	Percent	Area	Percent
LowerYakoun	HemlockMedium	7,995	1,345	1,855	6,650	83	+509	+38	6,140	77
LowerYakoun	HemlockPoor	3,886	1,763	1,049	2,123	55	715	41	2,837	73
LowerYakoun	HemlockGood	1,154	96	406	1,058	92	+310	+324	748	65
LowerYakoun	CedarLow	9,361	5,895	3,596	3,466	37	2,299	39	5,765	62
MassetInlet	HemlockMedium	21,576	3,417	5,440	18,159	84	+2,023	+59	16,136	75
MassetInlet	CedarLow	5,495	5,433	1,694	61	1	3,739	69	3,800	69
MassetInlet	CedarPoor	2,145	1,730	673	415	19	1,057	61	1,472	69
MassetInlet	HemlockGood	2,593	459	999	2,134	82	+540	+118	1,595	61
MassetInlet	HemlockPoor	12,072	10,049	4,864	2,023	17	5,185	52	7,208	60
MassetInlet	SpruceMediumPoor	741	628	319	113	15	310	49	423	57
Naikoon	HemlockMedium	731	386	326	345	47	60	16	405	55
Naikoon	HemlockGood	1,507	144	766	1,363	90	+622	+431	741	49
Naikoon	CedarGoodMedium	2,050	673	1,252	1,378	67	+580	+86	798	39
Otun	HemlockGood	885	318	134	567	64	185	58	751	85
Otun	HemlockMedium	475	403	116	72	15	287	71	359	76
Otun	CedarGoodMedium	1,372	1,249	467	123	9	782	63	905	66
Otun	CedarPoor	3,201	3,172	1,138	29	1	2,034	64	2,063	64
Otun	HemlockPoor	2,451	1,994	1,000	457	19	995	50	1,452	59
Otun	SpruceGood	1,239	1,059	611	180	15	448	42	629	51
Otun	SpruceMediumPoor	1,323	1,281	724	43	3	557	43	600	45
Rennell	SpruceGood	1,639	388	954	1,251	76	+566	+146	685	42
Rennell	HemlockGood	2,367	569	1,385	1,798	76	+816	+143	983	42
Sewell	HemlockMedium	12,263	1,030	1,609	11,233	92	+579	+56	10,654	87
Sewell	HemlockGood	2,742	627	742	2,115	77	+115	+18	2,000	73
Sewell	HemlockPoor	8,516	7,193	5,073	1,322	16	2,121	29	3,443	40
Sewell	SpruceMediumPoor	1,620	1,336	989	285	18	347	26	631	39
Sewell	CedarLow	10,962	8,140	6,793	2,822	26	1,347	17	4,168	38
Sewell	CedarPoor	1,315	1,068	870	247	19	198	19	445	34
SkidegateLake	HemlockMedium	30,872	2,302	3,681	28,571	93	+1,380	+60	27,191	88
SkidegateLake	HemlockGood	2,296	121	503	2,176	95	+382	+317	1,794	78
SkidegateLake	HemlockPoor	3,872	1,661	865	2,212	57	796	48	3,007	78
SkidegateLake	CedarGoodMedium	1,257	1,207	407	50	4	800	66	850	68
SkidegateLake	CedarPoor	4,508	3,575	1,752	933	21	1,823	51	2,756	61
SkidegateLake	CedarLow	1,857	1,608	863	249	13	745	46	994	54
SkidegateLake	SpruceGood	458	237	221	222	48	16	7	237	52
Tasu	HemlockGood	1,174	74	121	1,100	94	+47	+64	1,053	90
Tasu	HemlockMedium	4,241	413	519	3,829	90	+106	+26	3,722	88
Tasu	CedarPoor	1,589	617	542	972	61	76	12	1,047	66
Tasu	SpruceGood	473	304	222	169	36	82	27	251	53
Tasu	CedarLow	8,998	6,636	4,430	2,361	26	2,207	33	4,568	51
Tasu	SpruceMediumPoor	1,190	826	623	364	31	203	25	566	48
Tasu	HemlockPoor	3,800	3,201	2,599	600	16	602	19	1,201	32
Tlell	HemlockMedium	3,963	1,175	724	2,788	70	451	38	3,239	82
Tlell	HemlockPoor	4,210	3,868	1,132	342	8	2,736	71	3,078	73

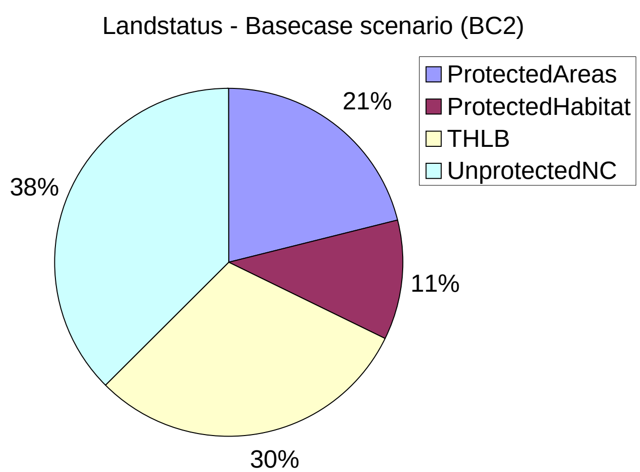
Landscape Unit	Analysis Unit	Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
		1800	2000	2250	Area	Percent	Area	Percent	Area	Percent
Tlell	CedarPoor	5,299	1,702	1,496	3,597	68	206	12	3,803	72
Tlell	HemlockGood	390	35	110	356	91	+76	+220	280	72
Tlell	CedarGoodMedium	2,168	533	616	1,635	75	+83	+16	1,552	72
Tlell	SpruceGood	1,240	516	417	724	58	100	19	824	66
Tlell	SpruceMediumPoor	1,371	1,133	487	238	17	646	57	884	64
Tlell	CedarLow	14,684	7,077	9,041	7,607	52	+1,964	+28	5,643	38
YakounLake	HemlockMedium	9,619	1,909	2,591	7,710	80	+682	+36	7,028	73
YakounLake	SpruceMediumPoor	565	541	268	24	4	273	50	297	53
YakounLake	HemlockPoor	4,723	4,189	2,358	534	11	1,831	44	2,365	50
YakounLake	HemlockGood	1,751	556	1,079	1,195	68	+523	+94	672	38
YakounLake	CedarLow	3,137	3,104	2,206	33	1	898	29	931	30

*"Change" is a reduction in old growth forest, unless a + sign is present – in which case there is an increase in old forest

OLD GROWTH LANDSTATUS AND OLD GROWTH QUALITY

Landstatus

In the analysis and information presented above it is assumed that old growth forest is retained in the landscape in the future for different reasons; as part of Protected Areas, as part of areas maintained within the timber harvesting landbase as Protected Habitat (e.g. riparian corridors of wildlife tree patches), as part of the inoperable landbase which is assumed to remain uneconomic to harvest in future, and old forest remaining in the timber harvesting landbase. Figure 7 shows the distribution of forest in each of these four categories.



The implications of the different landstatus relates to the certainty that old forest currently existing there will remain into the future.

Figure 7. Landstatus resulting from Current Management (BC2).

Old forest in Protected Areas is likely to be retained into the future, with the exception of loss due to natural disturbances. It tends to occur with a natural distribution of patch sizes. Figure 7 shows that 21% of the forested landbase is described as Protected Area under current management.

Old forest within Protected Habitat (i.e. forest within the timber harvesting landbase which is 'excluded' from harvest by policy. This forest is likely to be retained from harvesting, but its quality and long-term viability is unknown. Stand level and riparian corridors are likely to exist as smaller patches and may be impacted by windthrow, edge effects and lack of interior forest. Figure 7 shows that 11% of the forested landbase is described as protected habitat under current management.

Old forest in the timber harvesting landbase: some old forest remains in the THLB (see figure 4 above for trends for individual ecosystems) but remaining old forest is forecast to have been fully harvested between 10 and 40 years from 2000. Figure 7 shows that 30% of the forested landbase is described as THLB under current management.

Old forest in the 'inoperable' landbase tends to exist in larger contiguous patches. It is identified as 'inoperable' as a result of current economic conditions, however there are no constraints from harvesting (i.e. it is not 'protected') except by the current economic climate. There is currently significant harvesting occurring in areas classed as 'inoperable' and it is likely that this trend will increase in future as large volume old growth becomes scarce and as new markets are developed. This has been the trend to date across BC. Figure 7 shows that 38% of the forested landbase is described as inoperable under current management.

Making different assumptions about the future status of the 'inoperable' non-contributing landbase makes significant differences to the results and assumptions about risk levels for the different ecosystems. Figure 8 shows the difference in numbers of ecosystems in each risk class between assuming that the inoperable landbase remains in place into the future (as assumed in all the time series graphs presented in this chapter so far), and alternatively assuming that only areas that are actually protected (i.e. Protected Areas and Protected Habitat) will provide habitat values into the future (i.e. 'forest assumed remaining – Fig 8 and 9). There is clearly a very large difference in risk for most ecosystems depending on which assumption is made.

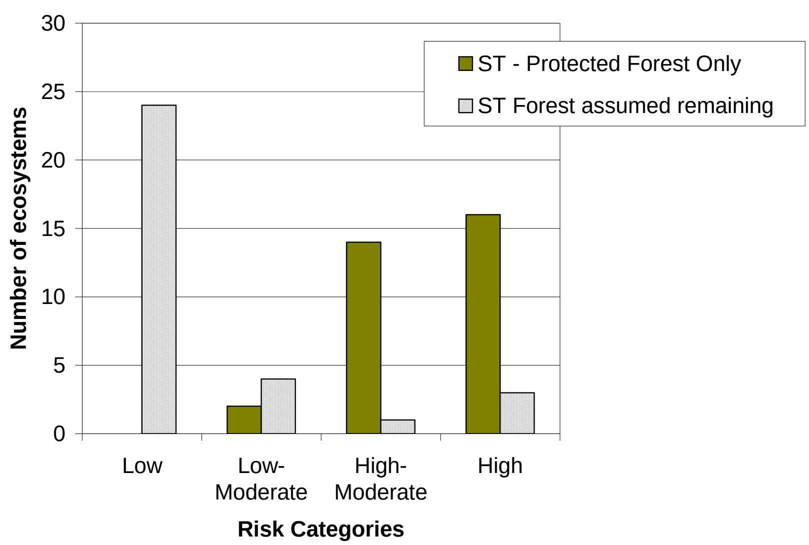


Figure 8. Number of ecosystems in each risk category **in the short-term**, under two assumptions: a) protected forest only maintains values and b) that all inoperable forest will remain over time and contribute to biodiversity maintenance

In the short-term, the number of ecosystems at low risk varies between 24 and zero depending on which interpretation of the inoperable is used. This means that all the ecosystems at low risk in the analysis presented in this chapter exist in the non-contributing landbase and ***under current economic conditions***, it is assumed they will not be logged in the short-term. Conversely, 16 ecosystems are considered at high risk based on the amount of old growth forest retained in Protected Areas and Habitat, compared with only 3 at high risk when assumed all the areas in the non-contributing landbase are maintained.

Similarly, in the long-term (over 250 years), in the basecase analysis when it is assumed that all the current inoperable landbase remains, 11 ecosystems remain at low risk whereas none are at low risk based on the amount that are protected in Protected Areas or by policy as Protected Habitat (Figure 9). Conversely, 16 ecosystems are at high risk based on the amount of protection they are afforded, whereas only one is at high risk when it is assumed that all the current inoperable forest remains through time.

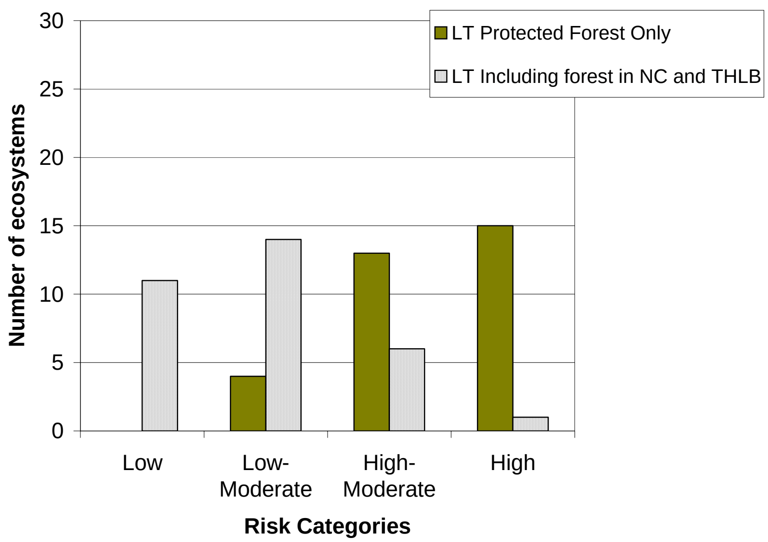


Figure 9. Number of ecosystems in each risk category **in the long-term**, under two assumptions: a) protected forest only maintains values and b) that all inoperable forest will remain over time and contribute to biodiversity maintenance.

In reality, it is most likely that the true situation will be somewhere between these two extremes. In the short-term the inoperable is relatively intact, though as much as 40% of the AAC may already come from this forest in some management units. In the long-term, the uncertainty is much greater that the non-contributing forest will remain for any ecosystems: for the lowest productivity ecosystems they may remain 'inoperable' into the future however others are already being harvested today and this trend is very likely to increase in future. Past experience shows that as resources become less available previously uneconomic areas become economic and technology allows increasingly difficult areas to be accessed.

For the majority of the analysis in this chapter, we use the assumption that the current inoperable/ non-contributing forest will remain in place over the next 250 years. This uncertainty should be considered when assessing the results. If an area is to contribute to biodiversity values in future ***with any certainty*** it must be protected (as Protected Area or Protected Habitat).

Old Forest Quality

The quality (or functioning) of old forest maintained on the landscape will vary depending on a number of factors. Patch size and shape are thought to influence the functioning of forest areas, and although we have not directly included a patch size analysis for old forest, assessing the amount of each Analysis Unit that is included in riparian management areas (RMAs) provides some guidance as to the amount of the future old forest that may be found in linear strips (Table 7).

Table 7. The amount of old forest on the Islands associated with Riparian Management Areas in Year 2250, in areas outside existing Protected Areas.

Analysis Unit	Total Area of old forest	Area in RMA	Percent in RMA
SpruceGood	11,438	3,935	34
HemlockGood	14,344	4,036	28
SpruceMediumPoor	28,106	6,890	25
CedarPoor	24,751	5,691	23
CedarGoodMedium	12,073	2,633	22
HemlockMedium	50,441	11,012	22
HemlockPoor	85,800	16,041	19
CedarLow	248,235	38,144	15
Grand Total	487,617	89,461	18

A significant percent (mean 18%, range 15 – 35% for AUs) of the remaining old forest on the landscape in 2250 is found within riparian management areas (RMAs). Although this analysis does not directly assess the size of these areas, or the extent to which they are joined to other old growth in Protected Areas, it suggests that a significant portion of remaining old growth for some forest types will be found in isolated narrow strips with little interior habitat values.

Similarly, Figure 7 shows that 11% of the landbase (one third of the protected forest land) is identified as 'protected habitat' which includes riparian management areas, stand level retention within blocks etc. As a result this area may tend to be comprised of relatively small areas and may be influenced by early seral species, edge effects, windthrow, lack of interior habitat etc.

In addition, this whole analysis assumes that protecting old growth forest from harvest results in a functioning ecosystem being maintained. On HG/ QCI this assumption is impacted by the presence of introduced species on the Islands that affect may aspects of ecosystem functioning. Perhaps the most important species is the introduced deer species which are highly abundant and have very significant impacts on understory vegetation and therefore all associated species within the stand (see Chapter 2.10 for additional discussion). Maintaining old growth forest without managing introduced species will not produce the desired results if ecosystems continue to be impacted by the wide range of introduced species.

SUMMARY

The relative risks to ecosystems of HG/ QCI have been identified at a number of different scales.

First, the representation of ecosystems within federally and provincially legislated Protected Areas is shown, and under-represented ecosystems identified – this identifies the potential of the Protected Areas system to maintain ecological values in different ecosystems. Although the percent of Protected Areas on the Islands is relatively high, some ecosystems (particularly within the Skidegate Plateau) remain significantly under-represented in Protected Areas.

Second, Coast Information Team thresholds are used as an approach to identify and rank those ecosystems potentially at risk from those likely not at risk under current management – this focuses on the amount of old forest remaining in different ecosystems compared with the amount of old forest under natural conditions as defined by forest cover in 1800. This analysis assumes that landstatus remains constant over the next 250 years, and that area identified as inoperable / non-contributing today will remain so. The implications of this assumption are large and are discussed above.

The percent reduction in old forest from natural conditions allows identification of those with a higher probability of being at risk, now and into the future. Today, a significant number of ecosystems do not meet the 'maintain 70% of natural old forest' threshold identified by the CIT at the regional or ecosection scale for representing low risk EBM in coastal ecosystems. In addition, some ecosystems have less than 30% of natural levels remaining, which was identified by the CIT as representing a high risk scenario for those types.

In addition, at the landscape unit scale, many ecosystems currently do not meet either the ‘maintain 70% of natural (for regional scale) and or maintain 50% of natural old forest (for landscape scale) thresholds. The identification of areas where the change has already occurred to date (1800 – 2000) from those where it is predicted to occur in the future, identifies geographic areas where options remain to lower risks immediately, and identifies those ecosystems for which restoration strategies would be needed to reduce risk.

The analysis summarised above assumes that areas currently identified as inoperable/ non-contributing areas are actually not being harvested today and remain free from harvest for the next 250 years. This assumption is clearly incorrect as even today areas outside the timber harvesting landbase are harvested. However, into the future the probability that currently uneconomic areas become economic to harvest greatly increases and a second analysis that assumes only official Protected Areas or Protected habitat (those areas defined as protected under policy) actually remain to provide biodiversity values gives considerably different risk outcomes. Under this assumption the vast majority of ecosystems are at high risk today and remain so into the future. Clearly, the existing inoperable forest does provide biodiversity protection while it exists -—but the certainty that these areas remain untouched is only high if they are designated as ‘protected’ under a Land Use Planning process.

Finally, this ecosystem representation analysis assumes that the old forest that remains on the landscape represents fully functioning natural ecosystems. However, as outlined in Chapters 2.4 and 2.10, the presence of non-native deer on the Islands has significant impacts on the functioning of remaining old forest. A successful strategy to maintain representative old forest ecosystems must consider both protection from harvest and management of non natural levels of browse impacts on constituent plant communities and regenerating tree species.

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2.2. PLANT SPECIES AND COMMUNITIES

PRIMARY ANALYST / INFORMATION SOURCE

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Margaret Edgar – Haida Nation: Communication to CPF.

Jim Pojar – formerly Ministry of Forests Research Branch.

Barb Wilson, Parks Canada (review).

INDICATOR RELEVANCE

Plant species and communities are integral components of ecosystems and they are an expression of ecosystem characteristics as created by soil and topography. Vegetation also modifies soil forming processes and microclimate and creates habitat that other organisms rely on. Changes in plant abundance or species richness can have significant and often hard to predict influences on ecosystem processes and functions. Many plant species are integral with and critical to the culture of the Haida Nation.

BACKGROUND INFORMATION

The temperate rainforest is highly diverse with respect to plant species and communities. Typically, plant communities are associated with regional climate and geology, and at a site level with conditions of soil moisture and nutrients. Understory plant diversity and abundance, combined with overstory tree species makes up the characteristics of individual ecosystems. They provide food and habitat requirements for other species, they influence soil processes, water transport, microclimate, nutrient cycling and many other ecosystem functions.

An assessment of ecosystem representation (Old Forest analysis in Section 2.1) is assumed to assess general plant community representation. However, for HG/QCI there are at least three reasons to consider groups of plants in addition to the Old Forest assessment. The first is that HG/QCI harbours a large number of rare and/or endemic plant species; one of these species is found no where else on earth and others are found only in the local area of HG/QCI and other local coastal islands/areas. Second, there are a number of plant communities (associations of understory and overstory plants) which exist on the coast of BC but are rare (often as a combination of natural scarcity and impacts of forest harvesting). Thirdly, on HG/QCI the understory of practically all ecosystems has been significantly altered as a result of browse from introduced deer. This understory typically was responsible for providing habitat for a large number of species, and the Haida used many of these historically common plant species for traditional uses. The implications of significant changes to the understory are therefore large. A number of other introduced species are also impacting ecosystems (see Chapter 2.10), and in particular the beaver is changing hydrology patterns particularly in lowland areas resulting in flooding and loss of habitat for some species.

We consider each of these three categories separately below:

a) Rare and / or endemic plant species.

b) Rare ecosystems (plant associations).

c) Historically common understory herbs and shrub species, particularly those of interest to the Haida, which have become locally or regionally uncommon as a result of extensive deer browse.

AGENTS OF CHANGE

The range of species outlined above differ in their susceptibility to threats, depending primarily on their habitat requirements, the local and regional abundance and their distribution across the

Islands. The two primary agents of change for plant abundance and distribution on the Islands are forestry activities and browse by introduced ungulates.

Forestry activities can have a variety of impacts: harvesting results in a rapid change from old-growth forest to first open ground and then young forest. Changes in light availability, temperature and moisture availability occur at least in the short-term. Species associated with older forests will be removed from this part of the landscape temporarily or permanently, depending on the ability of the species to remain locally viable, or to disperse back into the area, as conditions become amenable again. Post-harvest silvicultural activities can also impact the process of plant community succession; application of chemical treatments (e.g. herbicides), brushing, spacing and thinning will impact vegetation re-establishment and favour some plant communities over others. In addition, forestry activities can result in a higher chance of spread of non-native species that may dramatically impact plant communities in some circumstances.

On HG/ QCI ungulates currently exist at much higher densities than historically seen. Often, this situation arises as a direct result of management designed to encourage ungulate species, however on HG/ QCI the only native ungulate, Dawson's Caribou, was extirpated 100 years ago. The current population of ungulates result from a series of introductions through the first half of the 1900's and dramatic population growth and range expansion throughout the Islands since that time. An overabundance of ungulates can have significant impacts on the vegetation and cascading effects on many other species, including birds and invertebrates. Browsing effects can be so significant that ungulates have been termed 'ecosystem engineers', or 'keystone herbivores'.

A number of studies on HG/ QCI have used islands with and without deer to try and quantify potential changes in vegetation due to deer. Results are fairly consistent and conclude that in forested ecosystems of HG/ QCI, deer have significantly altered understory composition, abundance, distribution and changed the growth patterns and forms of remaining understory species. The extent of impact increases with time since ungulate colonisation.

In general, over-browsing tends to shift the vegetation towards an increase in unpalatable species or otherwise browse-tolerant species. On HG / QCI browsing has virtually eliminated the understory in many areas, resulting in tree/ moss communities. Additionally, on the Islands it known that cedar does not have the phytochemicals seen in individuals on the mainland that usually deter deer browse. Plants on the Islands may therefore also be particularly sensitive to browsing impacts.

In shoreline ecosystems, the abundance of vegetation on islands with deer was significantly lower than on islands without deer in the two lowest vegetation types (ground layer<50cm and transition layer (50 – 150cm)). The shrub layer (50 – 400cm) patterns were more variable. In addition, the number of species found was significantly lower on islands with deer than on those without deer, with approximately half the number of species where there was significant deer browse. In areas with deer browse, some herbaceous species were maintained but tended to be locally clumped in patches of Salal (*Gautheria shallon*) or found in crevices or on logs where there was physical refuge from browse. Deer therefore have a very significant impact on species abundance and species richness in shoreline communities, and similar patterns have been observed throughout Island ecosystems.

A 'browse-line' appears in many areas, at a height of about 1.1m above which vegetation is largely unaffected, for example there are few individuals of salal or Sitka spruce regeneration lower than this line in some areas. In deer-affected areas, shrubby species such as red huckleberry (*Vaccinium parvifolium*) are often found only as old individuals, with no recruitment of younger shrubs. As a result, when the older shrubs die, they are not replaced and entire species may be extirpated from local areas. For some species, such as Western red cedar, the browse-line is higher (approximately 1.5m) because the tops of the branches can be pulled down and browsed.

The local extent and severity of impacts from deer has not been studied Island-wide, but likely depends on a number of factors, including a) local deer density, b) local deer movement (e.g. deer on small islands may have increased impacts on vegetation because they cannot easily disperse elsewhere as forage supplies diminish), c) tolerance of the plant community to browse effects. Deer mortality (and hence density) is thought to be linked to distance from ocean (which provides year-round food supplies), road / community proximity (hunting pressure), island size and bear density.

Forest harvesting and ungulate browse can act independently, or in conjunction with each other to change plant communities slightly through to severely, and in the short-term through to the long-term.

MODEL APPROACH AND ASSUMPTIONS

It was not possible for the PTT to 'model' condition and trends for these species of concern in the same way as undertaken for some other key indicator species. However, given the central role plants play in maintaining ecosystems and other species, and as a result of the special concern of the Haida Nation regarding cultural use species, we present a broad picture of current and historic condition where possible for each of the three groups. A predicted future condition based on the two primarily impacts is briefly discussed.

A) RARE AND / OR ENDEMIC PLANT SPECIES

The number of vascular plants found on the Islands currently numbers at 672 (local botanist M. Cheney has recently collected seven more species new to the Islands), with approximately 20% of these being introduced species (see Section 2.10). There are 46 plant species currently listed as rare / threatened or endangered by the BC Conservation Data Centre (10 red, 36 blue; Section 4.3). In addition, another 76 have been compiled as being locally rare on HG / QCI. A full list of these species is shown in a Table in Section 4.3.

The historic distribution and abundance of most of these 'rare' plants is unknown. Some were likely historically more common, while others could have naturally been rare. However, the 'listing' procedure identifies these species currently (irrespective of their historic condition) because they are thought to be more or less at risk as a result of their current population size, distribution and threats. Note that the 'listing' of species in BC into rare, threatened and vulnerable categories does not translate into any automatic protection in legislation.

In addition to locally rare plants, there are 10 locally 'endemic' plant taxa on the Islands; that is they are found only on the Islands or the northern coast area[1] (Table 1). Many of these insular endemic taxa probably result from isolation and survival in Pleistocene glacial refugia, as on Haida Gwaii and the Brooks Peninsula (Calder & Taylor 1968). One species, Newcombe's butterweed is truly endemic to the Islands - the only place it is found in the world is on HG/ QCI. Many of the 'endemic' species are found at higher elevations and either are locally common in alpine meadows, or in inaccessible areas.

In addition to vascular plants, HG / QCI has a diverse array of Bryophyte (mosses or liverworts) species, the diversity of which almost matches the diversity of vascular plants – 395 known species of mosses and 180 known species of liverworts (Parks Canada 2004). Of these, there are a number of which are rare. Thirteen mosses have their only Canadian location on the Islands of which four are endemic (i.e. found only on the Islands); and 3 liverworts have their only Canadian location, 1 of which is endemic (Parks Canada, 2004).

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[1] The *Enemion* (formerly *Isopyrum*), *Saxifraga*, *Geum*, *Ligustichum, Senecio, Lloydia*, *Salix*, and *Viola* have all been found elsewhere on the coast. *Enemion savilei, Saxifraga taylori, Geum schofieldii, Senecio moresbiensis, Ligustichum calderi, Lloydia serotina* ssp. *flava,* and *Viola biflora* ssp. *carlottae* have been found in mountains of northern Vancouver Island, including Brooks Peninsula. Brooks Peninsula thus has 7 of the 9 taxa formerly known as "QCI endemics." *E. savilei* is also known from Porcher Island. *L. calderi* has been found in southeast Alaska and on Kodiak Island; on Porcher, Banks, Dewdney, Campania, and Calvert islands; and on Knobb Hill, northern Vancouver Island. *S. moresbiensis* also occurs on Prince of Wales and Coronation islands in southeast Alaska, Dewdney and Calvert islands, and near Port Hardy on northern Vancouver Island. *L. serotina* ssp. *flava* also occurs on the central mainland. *S. reticulata* ssp. *glabellicarpa* and *V. biflora* ssp. *carlottae* also occur in southeast Alaska.

Table 1. Plant taxa endemic to HG / QCI and local area.

Common Name	Latin Name	BC listing	General Habitat
Queen Charlotte isopyrum	*Enemion savilei*	Blue-listed	Shady, rocky habitats; usually high elevations
Dotted saxifrage	*Saxifraga nelsoniana carlottae*	Blue-listed	
Taylor's saxifrage	*Saxifraga taylori*	Blue-listed	Cliffs and rocky slopes
Queen Charlotte avens	*Geum schofieldii*	Red-listed	Rocky slopes, esp. high elevations
Calder's lovage	*Ligustichum calderi*	Blue-listed	Peaty & rocky slopes, heaths
Queen Charlotte butterweed	*Senecio moresbiensis*	Blue-listed	Bogs and peaty slopes
Newcombe's butterweed	*Sinosenecio newcombei*	-	Rocky & peaty slopes, open forests
Yellowish alp lily	*Lloydia serotina ssp. Flava*	Blue-listed	Rocky slopes, esp. high elevations
Smooth-fruited net-veined willow	*Salix reticulata ssp. Glabellicarpa*	Red-listed	Rocky high elevations
Twinflower violet	*Viola biflora ssp. Carlottae*	Blue-listed	Moist rocky slopes & meadows

B) RARE ECOSYSTEMS

There are a 14 ecosystems as defined by plant associations that are listed as being rare by the BC Conservation Data Centre (Section 4.3). Many of these are associated with wetter riparian sites, and others with natural early succesional habitat (e.g. alder tracts) and so likely would never have dominated the landscape. The exception being western hemlock – sitka spruce - lanky moss, which is a zonal site series and is commonly distributed in the Islands. Currently, most of these communities are listed as being rare as a late structural stage (i.e. the old forest structural stage has been significantly harvested), though this analysis is currently being updated by the CDC and is not included in the list in Section 4.3 (CDC pers. comm.).

In addition, there are a number of additional 'ecosystems' or 'features' of the landscape that are locally rare, uncommon or unique on the Islands (Jim Pojar, communication to the CPF). Some of these ecosystems are represented in protected areas, in proposed protected areas / ecological reserves, while others are unique and are unprotected.

Table 2. Rare 'ecosystems/ features ' defined in general terms for the Islands (J. Pojar pers. comm.).

Ecosystem type / Comment	General Status
Floodplains dominated by Sitka Spruce, open parkland	Most of these are 'listed' by the CDC, but this does not result in direct protection. Likely some representation in current protected areas. Primary impact = harvest and deer.
Fans located at the base of ravines with big Sitka spruce (some taller than 60 metres) and at the base of steep unstable slope with lots of gullies. As the fans build up they provide really productive soils and therefore support really productive forests	Likely 'listed' by the CDC, but not necessarily protected. Likely some representation in current protected areas. Primary impact = harvest and deer.
Beach forests - sitka spruce / moss / grass	Some of these types are listed by CDC, but not all. Likely some representation in current protected areas. Primary impacts = harvest and deer.
Crabapple woodland.	Some of these types 'listed' by CDC, but this does not result in direct protection. Primary impacts deer and beaver.
Young, unmanaged forest, that have had no silviculture treatments (within the timber harvesting landbase). These stands would naturally be rare, and are disappearing from the landscape. May be losing this reference point that may be key to implement EBM.	Naturally rare, and disappearing due to pervasive silviculture treatments. Primary impacts = harvest and deer.

Ecosystem type / Comment	General Status
Bogs. Though common on the Islands, the diversity of bogs found is globally unique. An important ecological feature, they also provide habitat for a wide range of species.	Some are protected within Naikoon Park. Many other examples are not protected. Primary impacts = road-building, deer and beaver.
West coast almost savanna-like forest, with bonsai trees and grasses, e.g. Gowgaia Bay area. Regionally common habitat type, but globally significant.	Some areas are included in Protected Areas, others are not. Primary impacts = deer.
Wetlands that are mostly sedges & grasses. Rare on the islands.	Some areas are included in Protected Areas, others are not. Primary impacts = sedimentation / deer / beaver.
Tlell pontoons. One of a kind ecosystem. - the vegetation type - sitka sedge hairgrass - is not uncommon but the complex is really unusual for the north coast	Not protected. Primary impacts = harvest, sedimentation, deer, beaver, impact of hunters using four wheel buggies to get in and out of the area, presumably to traverse the pontoons also.
Low energy beach ecosystems with non-forested vegetation. E.g. east coast Graham Island, Naikoon Park, E. N. Moresby.	Provincially rare ecosystem, with listed plant species and communities. Many included in existing PA's, but not all. Primary impacts = deer, erosion from big tides and storms.
Limestone geology (karst – terrain with limestone bedrock and sinkholes, dissolving of the limestone). Often contains rare & endangered plants.	Karst is not listed with CDC because it is not a plant association. Some of these karst ecosystems are regionally rare. Primary impacts = harvest and deer.
Estuaries. They represent a tiny proportion of landscapes but are keystone ecosystems.	Rare ecosystems, particularly on the Islands. Some not protected. Primary impacts = logbooms, bilge, oil spills, uncontrolled developments (e.g. lodges in sensitive sites etc, erosion of sand dunes).

C) HISTORICALLY COMMON UNDERSTORY SPECIES

It is difficult to quantify what the forests of the Islands looked like in 1800. An estimation of forest cover attributes has been made for the Islands in 1800 (see Section 4.1), which predicts the age, height and canopy closure of the trees in the forest at that time based solely on 'standing up' trees that have been harvested since that time. However, a detailed assessment of the abundance and distribution of understory attributes prior to the various ungulate introductions that have occurred over the last century is more difficult if not impossible.

Historic records are sparse but information available from Haida, from the journals of explorers, and visually from sources such as Emily Carr paintings and old photographs of village sites suggests there was commonly a luxuriant understory of huckleberry, salal, devil's club, salmonberry and many other species throughout the forests. Some of these species may have been most common in 'gaps' in the forest canopy, where more light reaches ground level, but detailed information on abundance and distribution of species prior to deer introduction is lacking. It is clear though that many species important as medicinal plants (any plant used for food or medicine) for the Haida have been significantly affected by a combination of forest harvesting and deer browse, including Huckleberries, salmonberries, wild strawberries, salal, elderberry, blueberries, cloudberries, devil's club, fairy slipper and cranberries (Margaret Edgar communication to the CPF). Although these effects have not been specifically documented in literature, it is likely that many of these species have been locally impacted. A similar list is provided by Nancy Turner, U. Victoria (pers. comm.) for species thought to have been reduced, at least in some local areas, from historic levels (Table 3).

Table 3. Example Medicinal plants thought to have been reduced by deer browse, at least in some areas.

Common Name	*Latin Name*
Yellow cedar	*Chamaecyparis nootkatensis*
Western Red cedar	*Thuja plicata*
Western crabapple	*Pyrus fusca*
Pacific Yew	*Taxus brevifolia*
Highbush cranberry	*Viburnum edule*
Seaside strawberry	*Fragaria chiloensis*
Northern riceroot	*Fritillaria camschatcensis*
Devils Club	*Oplopanax horridus*
Salal	*Gaultheria shallon*
Single delight	*Moneses uniflora*
Miners lettuce (subspecies)	*Montia sibirica ssp.bulbifera*
Cloudberry	*Rubus chamaemorus*
Oval-leaved blueberry	*Vaccinium ovalifolium*
Grey Berry	*Ribes bracteosum*
Bog cranberry	*Vaccinium oxycoccus*

In addition to direct understory changes, it is speculated that the significant reduction of the shrub layer may have fundamental impacts on the nutrient cycling processes within the forests of HG / QCI because of the links between shrubs and specific mycorrhizae in the soil (Pojar 2003).

PREDICTED FUTURE CONDITION FOR PLANT SPECIES AND COMMUNITIES

Both forest harvesting and ungulate browse can have significant impacts on plant species and communities in the short and the long-term. Potential future forest harvesting patterns can be predicted to some degree, and can be used to assess the likely extent of ecosystem representation and old forest community representation in the future (Section 2.1).

Ungulate browse activity, depending on its severity, can result in a more select removal of preferred browse species than forest harvesting but the distribution and extent of impacts is very difficult to predict. It is known that browse impacts vary across the Islands as outlined above, and in some areas significant understory continues to exist. It has been noted (e.g. Margaret Edgar CPF Dec 11th) that maintaining forests with a significant understory intact is an important first step in managing for culturally significant plants.

Typically, in broad assessments of this kind, the level of ecosystem representation in Protected Areas is used as a surrogate to assess the likely representation of rare plant species, communities and understory species over the landscape. For HG/ QCI this analysis provides a starting point, but fails to assess whether the understory community is actually present. Protection of plant species and communities that occur within the timber zone will depend on the level of protection for those areas of old forest (e.g. for rare plant associations / red and blue-listed species), in combination with effective management strategies for controlling deer browse and other introduced species for specific ecosystems (e.g. beaver in the Tlell pontoons and muskrats all over the Islands).

Table 4 shows the current level of representation of each ecosystem in provincially and federally legislated Protected Areas (see Section 2.1 for more detail).

Table 4. Representation of ecosystem in Protected Areas. Relatively under-represented types are shown as 'shaded'. Minimum area included is 200ha.

Analysis Unit	BEC variant	Area in Protected Area	Total Area	% PA
Pine	CWHvh2	9,389	11,331	83
CedarGoodMedium	CWHvh2	1,695	3,730	45
SpruceMediumPoor	CWHwh1	8,724	19,177	45
CedarLow	CWHvh2	51,632	120,790	43
HemlockGood	CWHwh2	834	2,008	42
CedarGoodMedium	CWHwh1	5,762	14,423	40
CedarPoor	CWHvh2	3,840	11,934	32
SpruceGood	CWHwh1	4,112	12,786	32
SpruceMediumPoor	CWHvh2	5,326	16,527	32
CedarLow	MHwh1	1,744	5,573	31
CedarPoor	MHwh1	96	362	27
SpruceGood	CWHvh2	1,595	6,735	24
CedarGoodMedium	CWHwh2	284	1,357	21
CedarLow	CWHwh1	38,996	184,663	21
HemlockMedium	CWHvh2	4,381	21,285	21
Pine	CWHwh1	1,973	9,189	21
HemlockPoor	MHwh1	1,342	6,976	19
HemlockPoor	CWHvh2	11,695	61,168	19
HemlockGood	CWHwh1	4,786	26,635	18
SpruceGood	CWHwh2	94	579	16
CedarPoor	CWHwh1	4,065	31,109	13
HemlockMedium	CWHwh1	13,729	112,651	12
HemlockMedium	MHwh1	129	1,111	12
HemlockGood	CWHvh2	715	6,564	11
SpruceMediumPoor	MHwh1	100	896	11
HemlockMedium	CWHwh2	1,612	19,537	8
HemlockPoor	CWHwh1	4,101	53,543	8
CedarLow	CWHwh2	517	16,414	3
HemlockPoor	CWHwh2	579	23,455	2
SpruceMediumPoor	CWHwh2	46	3,007	2
CedarPoor	CWHwh2	45	3,719	1
CedarLow	MHwh2		2,689	0
CedarPoor	MHwh2		466	0
HemlockMedium	MHwh2		1,321	0
HemlockPoor	MHwh2		5,222	0
SpruceMediumPoor	MHwh2		662	0
Grand Total		184,150	820,917	22

Many of the rare plants found on the Islands are located primarily at higher elevations and are not current subject to forest harvesting. In the past, deer browse has also been lower in higher elevations, but there is increasing evidence that deer are moving into higher elevations. This distribution and abundance of species in higher elevation areas may be reduced to very isolated / inaccessible local sites, such as rocky ledges, when their original distribution may have been wider (J. Pojar 2003 pers. comm.). Other species are also located primarily on outer Islands, within current Protected Areas, or in scrub / bog forests where forest harvest pressure is currently low or non-existing. All these species will primarily be affected by deer browse and would require a deer management strategy to significantly improve their population status.

SUMMARY

On HG/ QCI there are concerns about many different plant species, from both an ecological perspective and a cultural perspective. The two main sources of concern are from forest harvesting which can alter plant communities over significant periods of time (from harvest through to recovery of older forest conditions), and from the extensive browsing of introduced ungulate species which have colonised the entire archipelago. The effects of each activity result in an exacerbated impact on some plant species, since after harvest it can be difficult for recolonisation of some species due to the deer browse. Maintaining and restoring plant species and communities will require an integrated strategy that considers a) the level representation of ecosystems in protected areas, b) local detection and management of cultural plants in areas accessible to the Haida and c) associated management of ungulates.

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2.3. WATERSHED CONDITION

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INDICATOR RELEVANCE

Watersheds are a fundamental ecological unit and are defined by the movement of water resources, which in turn creates unique sets of biological conditions and values.

'Watershed condition' is a highly complex concept that includes interlinked ecological, biophysical and hydrological functioning. In this chapter we focus on two separate but inter-related aspects of watershed condition.

First, 'watershed condition' can be thought of strictly as the **hydrologic functioning** – or the 'state of the water resources' within a defined drainage area. Water resources can be described by volume and timing of water flows, plus water quality.

Second, 'watershed condition' can also be thought of as the **biological functioning**[1] of water-related ecosystems of a watershed – in particular, the riparian or hydroriparian ecosystems. Hydroriparian ecosystems are created by the movement of water through a watershed, and are important to broader ecosystem functions (CIT 2004) because they store and move water, filter sediment, stabilise banks and reduce erosion from flooding, and maintain water quality. In addition, they provide habitat for a large number of freshwater aquatic and terrestrial species, contain rare ecosystems, and contain biodiversity hotspots due to high productivity. Hydroriparian[2] zones include the aquatic zone and terrestrial area around it that either influences or is influenced by water.

Of course, these two aspects of watershed condition are fully linked together – hydroriparian systems are intimately involved in providing hydrological functioning as well as biological functions, and hydrology directly affects the functioning of the biological values. We discuss these two facets of watershed condition separately because they respond to and recover from disturbances differently.

BACKGROUND INFORMATION

Biological Functioning: Hydroriparian zones are the key aquatic-related ecosystems of a watershed. Hydroriparian zones are highly diverse and productive ecosystems and are associated with a very high percentage of the biodiversity in British Columbia. They are also associated with high occurrences of rare species and ecosystems (BC CDC[3]). Hydroriparian ecosystems include river floodplains, areas along lakes and wetlands, and estuary and ocean shorelines. They extend below ground into the water-saturated zone, and above ground into the canopy. Especially in wet climates such as HG/ QCI defining the edge of the hydroriparian zone can be difficult.

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[1] In this chapter, we refer to 'biological functionning' to represent the biotic and abiotic functionning of water related ecosystems, and are considering this separately from strictly hydrologic functionning which refers simply to the movement of water.

[2] In this chapter, hydroriparian, riparian, and riparian fish forest (RFF) zones are used interchangeable to describe this broad ecosystem associated with water.

[3] BC Conservation Data Centre

The CIT (2004) provides a practical definition of the hydroriparian zone as:

" the area of aquatic habitat and adjacent riparian plant communities obviously influenced by water (i.e. low to high-bench floodplains, wetland forested fringes, swamp forests and salt-spray shoreline forests), plus the area extending one and a half tree heights[4] (horizontal distance) beyond".

In this analysis, an equivalent concept – the Riparian Fish Forest zone was identified (J. Broadhead pers. comm.), and used to assess broad impacts to riparian ecosystems.

On HG / QCI, the hydroriparian zone has a complex biological functioning which is typified by the interaction between salmon, bears and the forests. Large amounts of nutrients are moved throughout the hydroriparian zone – from salmon in the streams, through bears, and into the forests – which has large and long-term effects on nutrient levels and productivity of the ecosystem as a whole. The area provides a crucial part of the black bear's annual food supply, and travel and rest through riparian zones is key. The rate of recovery of each part of this system after a disturbance such as forest harvesting will differ, and the system will not be fully functional until all aspects (e.g. water quality, salmon biomass, plant species, travel corridors for bears etc) are recovered.

Hydrological Functioning: from a hydrologic function perspective, 'water resources' can be characterised by the volume and timing of flows, and the quality of water. Water resources are controlled by climate at the regional and local level, by the effects of vegetation on precipitation and runoff, by the characteristics or capabilities of a drainage network to evacuate water from the land (i.e. routing efficiency), and the input of sediment and debris to watercourses from hill slopes and adjacent landforms.

Linkages: Biological functioning and hydrological functioning are complexly intertwined, and together provide an index of watershed condition. Hydroriparian ecosystems influence watershed and landscape functioning in many ways, including by transporting water downstream both above and below ground and so affecting the entire watershed; transporting sediment downstream which may increase and/ or decrease productivity of areas downstream; by transporting small organic material from headwaters to downstream areas; by transporting woody debris throughout the system, which influences flow and sediment transportation ultimately resulting in habitat diversity and complexity; and by providing corridors for animal and plant movement. In this chapter, we try to focus on the major effects on both biological components and hydrologic components separately – but the reader should always remember the linkages between hydrology and biological effects.

POTENTIAL LAND-USE EFFECTS ON WATERSHED CONDITION

Biological Effects

Effects of land-use on biological functions and values associated with watershed condition are both simple and complex, depending on the particular values in question. As outlined above, the hydroriparian zone provides a unique ecological zone, usually of high productivity, that tends to produce diverse and large-structured forests. These forests themselves often represent rare plant communities (either naturally rare, or listed as rare as a result of previous harvest). Riparian forests also provide habitat for a large number of other terrestrial and aquatic species. For these values, land use impacts tend to be related directly to disturbance of the hydroriparian forest in relation to the natural level of disturbance[5], and rate of recovery is dependent on the speed of

[4] Site-specific tree height as derived from the tallest trees present, however if the stand is not mature then an approximation derived from the site capability (forest cover inventory) should be used.

[5] As noted in the thresholds section, the level of 'disturbance' must be considered in relation to natural disturbance levels. For example, some riparian zones tend to remain in mid seral conditions, dominated by alder, and may not often reach the climax state of coniferous forest types. In this discussion we are considering the riparian forest in general, with expected percentages in old growth, mature, mid and early stages naturally.

regeneration to natural state. For example, harvest of riparian forest removes the natural habitat values of that forest for as long as it takes to recover natural forest. The period of recovery is likely to be considerably longer than for many of the hydrologic indicators – for example streamflow levels can be expected to return to near-normal once regeneration in harvested areas reaches about 9m in height. However, the habitat values of the vegetation do not return until plant communities are restored, or until trees are large enough to provide cover, nesting cavities, or downed wood in the stream - depending on the particular value in question.

For key biological values such as salmon spawning habitat, removal of vegetation from the hydroriparian zone can have complex impacts. For example, loss of riparian forest removes sources of woody debris that creates instream and overbank habitat, and may discourage bears from accessing the riparian area as a food source because of they tend not to travel through dense forest types where plant food resource are lacking. Recovery of these sorts of values may take at least a century.

Individual trees within riparian zones can grow to immense proportions, and it is likely that riparian areas provide high quality denning habitat for species such as black bears. Recovery of these values may take many hundreds of years after harvest.

Hydrologic Effects[6]

The effects of land use on water can occur at many scales. Globally, land-use can affect regional climate patterns, which then affects regional and local water resources. More locally, land-use activity can affect water resources through the alteration of vegetative cover on the land surface, increase or decrease in the rate of movement of water (flow routing efficiency) through a drainage system or network, or change in the volume and timing of sediment and debris inputs to channels. It is these more local effects that are relevant to Land Use Planning decision-making on HG / QCI.

When it rains or snows, vegetation on the land affects the volume of water that reaches the soil surface or forest floor, and therefore the amount that may be available for runoff. A proportion of incoming precipitation is intercepted by vegetation, stored and evaporated depending on the storm intensity and duration. Water is also taken up by vegetation from the soil for plant transpiration.

Removal of vegetation, particularly forest cover, decreases the volume of water that is intercepted and used by vegetation, making more water available for runoff and streamflow. The greatest effect of loss of forest cover on stream flow is thought to occur during low interval, high frequency events (i.e. bankfull events or smaller; Beckers et al. 2005) decreasing with increasing storm magnitude (Hudson 2002). The effects of a reduction in forest cover on runoff decrease with regeneration on disturbed sites. General recovery of these ‘interception’ and ‘transpiration’ effects are thought to return to near pre-disturbance levels once forest regeneration of about 9m with good canopy closure has occurred (Province of BC 1999).

The flow of water (routing efficiency) through a watershed can be increased through road construction that intercepts shallow sub-surface water flow, diverting water through ditchlines to streams. This process effectively increases the drainage density on the landscape, and can speed the rate of runoff and increase streamflow magnitude as more water arrives at stream channels over a shorter period of time. The effects of runoff interception and diversion are thought to decrease with increasing storm intensity and duration (Beckers et al. 2005), as subsurface flows become less important with respect to runoff contribution to channels. Road related effects on runoff depend upon initial construction methods, and can be minimised by maintaining natural

[6] Forest development activity is focus of the following discussion, but other industrial land-use activities such as land development, mining, or oil and gas exploration that require similar access and/or effect vegetation, soils, and runoff in a similar manner, can be expected to have similar effects on water resources.

surface drainage patterns before and after construction. Rate of recovery of these effects will depend upon whether the road is fully deactivated; however, without effective deactivation these effects may persist indefinitely.

Water quality is affected by the volume of sediment and debris carried by channels. Sediment loads are affected by landslides which can cause high sediment input into streams, road related erosion which can generate and transport sediment to channels, reductions in stream bed or bank stability resulting from reductions in riparian function, or changes to the levels of instream woody debris. Increases in peak streamflow magnitude can also contribute to reductions in stream stability, altering water quality.

HG / QCI are subject to high rates of natural landslide activity resulting from a combination of high rainfall and unstable geology. The frequency and magnitude of landslides can be increased by forest development activities conducted on steep and/or gullied terrain. A portion of these landslides will reach stream channels causing sediment and debris loads to increase beyond natural levels and which can result in channel aggradation[7], bank erosion, and widening. Special assessment, road construction and harvesting methods on steep terrain can be used to minimise the likelihood of landslide activity during and after development.

Road related erosion can increase under various circumstances: during wet weather hauling activities, on roads surfaced with erodable material, or where surface and sub-surface runoff is intercepted and diverted by ditchlines. The input of road related sediment to streams can cause water quality impairment and infilling of channel bed materials (i.e. gravels and cobbles). Increasing volumes of road related sediment input can lead to aggradation, bank erosion, and channel widening.

Accessing and harvest of timber in riparian areas can reduce the channel stabilising effects provided by standing and downed trees. If stream channels are large enough to undergo bed and bank scour under high flow conditions, channel destabilisation may occur with the removal of riparian vegetation, resulting in an increase in sediment load and loss or reduction in channel complexity. Retention of timber in riparian areas can be used to minimise development-related effects on water resources where mature timber is required for stream bed and bank stability. Recovery rates depend upon stream power, adjacent landform type and pre-disturbance dependency upon riparian vegetation for stability.

HISTORY OF LAND USE IMPACTS ON WATERSHED CONDITION ON HG / QCI

Forest development and mining have been the two dominant forms of industrial activity on HG / QCI. Mining activity began in the late 1800's but slowed considerably around 1960, whereas rates of forest development increased steadily over time to a peak in the late 1980's. The effects of these two land-use activities on water resources have changed over time according to methods used for access and resource extraction. Records of historical forest development activities are widely available and as a result they will form the basis for the following discussion. However, there are several mining related events worth noting.

Industrial forest development activity began on the Queen Charlotte Islands in the late 1800's. A-frame equipment was used until the early 1930's to yard timber down from steep slopes to foreshore areas around the islands. From the 1930's until the early 1950's, ground-based methods (i.e. skidding and dragging) were used to extract timber from alluvial fan and floodplain areas on easily accessed areas. Other areas of relatively benign terrain were also developed at this time, such as the area around Skidegate Lake. Steam powered yarders and crawler tractors or early railway and plank road systems were used to move timber to the beaches and timber was often skidded down mainstem or tributary stream channels. All woody debris naturally

[7] A progressive buildup or raising of the channel bed and floodplain due to sediment deposition

present in the stream would have been removed to facilitate movement down the channel – significantly impacting instream values such as fish habitat plus all other aquatic habitat values. This period of forest development impacted some of the most sensitive water-related sites on the Islands, and resulted in serious effects on both direct water resources and biological values associated with the hydroriparian ecosystems that are clearly visible today. Examples are discussed in Section B that examines the condition of two watersheds in detail.

Mining also factored into water resource disturbance in the early 1900's. One notable event occurred around 1912 when all of the debris jams on the Yakoun River were demolished to provide barge access for mining around the Wilson Creek area. Some of these jams were reported to be greater than 2 km in length (Ells 1905). Stability on the Yakoun River system would have been largely dependent upon these instream structures for their moderating effects on runoff and control of sediment storage and transport processes. The system would have become much less complex with jam removal, with obvious effects on sediment load and turbidity, plus obvious huge impacts on habitat values and functioning of the riparian associated ecosystems.

After 1950, forestry activity moved towards conventional road access with tower and grapple yarding methods. Roads were constructed using caterpillar tractors and road surfacing material was often derived from stream channels in close proximity to road headings; the lower Mamin and Yakoun River systems were used extensively for this purpose. Rates of forest development increased sharply in the post-war period and increased access into steeper terrain was occurring by the late 1960's. At this time there was a trend toward less site disturbance associated with improved grapple yarding systems and better suspension of timber from 1960 on, but at the same time movement into steeper terrain resulted in landslides and water impacts becoming more common.

Most of the mainstem and tributary channel systems not logged pre-war were harvested to both banks between 1960 and the late 1980's. The result was a significant reduction in the extent and function of hydroriparian ecosystems associated with larger streams, combined with a widespread reduction in channel bed and bank stability that increased erosion and turbidity levels on most systems, while decreasing channel complexity. In steeper terrain, landslides within openings and along roads became common as root strength deteriorated in logged areas and buried organic debris in road fill materials began to fail. The rate of development during this period was high, resulting in widespread effects on water and the related biological values.

In 1988 the Coastal Fish Forest Guidelines were introduced to improve forest practices around water. Protection was afforded to anadromous fish streams through the provision of narrow riparian reserves, or a sequence of logging that saw one side of a stream logged with plans to return to the other bank once regeneration had reached a size sufficient to provide for stability. However, with the exception of some narrow riparian reserves that now dot the landscape, there were only minor improvements relating to hydrology, and no real improvements to maintain broader biological values around streams were made during this time.

In 1995 the Forest Practices Code (FPC) was enacted. Major changes in management practices with the FPC included: the management of forest surrounding most fish-bearing streams through the establishment of riparian reserve and management zones, requirement for terrain stability field assessments on steep and/or gullied terrain, improved road construction and deactivation methods, and use of lower site disturbance harvesting methods such as helicopter yarding. Significant improvements with regard to forest management related effects on water resources have resulted from the implementation of the FPC, though there remain questions about the extent to which the buffer widths identified in the FPC adequately protects functioning hydroriparian ecosystems for some streams.

Also in 1995, the Forest Renewal BC (FRBC) program was initiated to plan and undertake watershed restoration activities to address past forest development related effects on water and other forest resources. A massive road deactivation effort was initiated through this program to reduce old road related effects on slope stability, fish access, and stream sedimentation. An instream restoration program was also initiated under FRBC, designed to follow-up on completed deactivation work in upslope areas. As a result of the upslope and then instream priority process, few instream restoration projects were completed before the demise of FRBC in late 2001. The FRBC program was replaced by the Forest Investment Account (FIA) program in 2002. The latter program has a similar mandate but smaller budget. With this limitation, road deactivation and instream restoration projects are ongoing on HG / QCI.

In the early spring of 2005, the Forest and Range Practices Act (FRPA) will replace the FPC. Guidelines and regulations around water resources are similar between the two pieces of legislation; however, under the FRPA there will be increased reliance on professionals to achieve goals and objectives outlined by government.

In summary, when considering current condition as we do in this chapter, it is important to remember that effects are a result of a long period of development. For example, there is no question that many practices have improved as a result of the FPC, however biological and hydrological functioning may remain in poor condition because of the overshadowing effects of past management practices. This is the legacy of forest development and water resources on HG /QCI.

MODEL APPROACH AND ASSUMPTIONS

Additional details provided in Chapter 4.4. Two levels of information are being provided to give an insight into current watershed condition on HG / QCI:

A) Watershed level indicators that are derived from GIS modeling exercises and

B) A more detailed overview of the condition of two example watersheds based on field-derived data. This analysis compares predictions from A with field-based information.

In addition, watershed condition directly affects fish habitat and populations. Data on trends for fish populations are provided in Chapter 2.9. However, insufficient time was available in this process to attempt to align fisheries data with trends in watershed condition.

ECOLOGICAL BASELINE THRESHOLDS

Interpretation of analyses is key to providing meaningful information to the CPF. In other analyses in the Environmental Conditions report, we have identified an ‘ecological baseline’ which has been used to compare with current or predicted future condition of a particular indicator.

In the case of watershed condition, for some indicators the idea of an ecological baseline cannot easily be applied. For example when looking at road densities, no roads occurred prior to development so the ecological baseline is zero – however knowing this does not help in understanding the significance that roads have on watershed condition. For other indicators, such as disturbance rates within hydroriparian ecosystems, a natural baseline exists, but is hard to identify because these systems tend to be more prone to relatively small-scale natural disturbances than the remainder of the forest on the landbase. Floods and movement of debris down channels result in high levels of often local disturbances in riparian systems, which usually does not result in removal of the entire canopy layer but which can create larger gaps of localised disturbance. It is therefore not appropriate to assume that the long time scales for disturbance observed in the remainder of the landbase occurs evenly throughout the different riparian systems (see Chapter 2.1 for old forest disturbance rates).

Any ‘thresholds’ for where significant impacts occur for a particular indicator will likely vary depending on the particular value of interest (e.g. biological functioning versus hydrological functioning), therefore determining specific thresholds for most values is extremely difficult. For example, the harvest of a small percentage of the hydroriparian zone may have only a small and short-term effect on biological functioning, however, if that small area is key for the provision of channel bed and bank stability and spawning habitat for salmon the direct and cascading on impacts may be large and long-term.

It would be useful to identify what level of disturbance – e.g. how many roads / km of stream, or how much disturbance in a riparian area is ecologically significant, and what 'risks' does it infer. However, there is a lack of specific thresholds for most of these indicators. In lieu of definitive and comprehensive thresholds for the variety of indicators presented here, we summarise the results by ranking watersheds based on the **potential risks** associated with the total level of development. We use a system for ranking watersheds based on work developed for the Bulkley LRMP (Wilford and Lalonde 2004). These authors identified the level of potential risk to aquatic resources that would occur from certain levels of existing or planned forest development (Table 1).

Table 3. Percent of current and proposed future harvest[8] associated with potential risks to aquatic resources (Wilford and Lalonde 2004).

Level of Current and Proposed Future Harvest	Level of risk to aquatic resources
>30 %	High risk
20 – 30%	Moderate risk
<20%	Low risk

In identifying when effects in watersheds become significant, Church and Eaton (2001) identified a likely impact on hydrology after about 20% of the watershed has been harvested. This level is consistent with the threshold for moderate potential risk identified in Table 1.

Using a single key indicator to evaluate watershed condition is simplistic since many factors combine to influence different aspects of condition, however, for this process, thresholds in Table 1 are used to rank watersheds into priority areas for immediate future detailed assessment.

In addition to ranking watersheds solely on the percent watershed harvested, we also examine the percent of the riparian forest area that has been harvested. In most cases, there is a direct relationship between these two indicators, but not in all cases (see results). The Coast Information Team (CIT 2004) developed some recommendations intended to maintain broad ecological functioning of riparian zones, and suggested that between 97 – 70% of the natural riparian forest was needed to maintain functioning at the subregional level. At the watershed level they suggested between 90% and 30% of natural riparian forest was required, depending on stream type and location within the watershed (though noting that subregional targets also had to be met to maintain functioning). We do not here have an assessment of the 'natural' condition of riparian systems, so cannot directly apply these targets as thresholds in our analyses. In lieu, we provide a breakdown of watersheds with >30% total disturbance of riparian areas, >10%, and <10% harvest of RFF zones.

A: OVERVIEW WATERSHED INDICATORS

Watershed condition reporting requires the use of both landscape level indicators and site level analysis. Landscape level indicators provide a summary of the extent of past land-use activity within a defined study area, and the potential for detrimental effects on water and associated ecosystems. The following forest development related indicators were selected for PTT

[8] Note it does not specify whether they used percent of forested landbase or total watershed area. We assume they used the latter variable since that is the most commonly used term in hydrologic assessments (M. Milne pers. comm.).

watersheds HG / QCI in an attempt to identify which watersheds are of highest potential risk with respect to watershed condition.

1. Primary biological functioning indicators[1]

a) Percent of riparian areas harvested

Likely hydroriparian areas were identified on the basis of being 'Riparian Fish Forest' (John Broadhead pers. comm.; Chapter 4.4). Different classes of streams were identified using a combination of TRIM streams, TEM floodplain attributes where available, plus information on known fisheries information for the Islands, augmented by information on known barriers within streams which prevent fish movements. Streams were then categorised on the basis of their size and the number of resident or anadromous fish. These definitions were then used to identify 'buffer widths' that identify the likely area of 'riparian fish forest' occurring around that stream. Definitions for each zone are identified in Table 2. Methods for this layer are shown in Chapter 4.4, and a Map of the RFF layer is available (Map 16).

Table 4. Riparian Fish Forest (RFF) Zone definitions. Details on methodology in Chapter 4.4.

Riparian Fish Forest (RFF)	Definition	Buffer width (both sides)**
RFF – 1	Small streams with no fish	20 m buffer
RFF – 2	Smaller streams with resident fish	30 m buffer
RFF – 3	Moderate sized streams with a few salmon	40 m buffer
RFF – 4	Moderate to large streams with many salmon	60 m buffer
RFF – 5	Large streams with lots of salmon	80 m buffer

** this is the amount of area 'mapped' to create the Riparian Fish Forest (RFF) layer for analysis.

The RFF layer was then overlaid with harvesting on the Islands (see 4.4 for details) and summarises the cumulative sum of all harvesting that has occurred in riparian (RFF) areas since approximately 1900. Only 'harvested' areas are summed – and the model does not include the level of regeneration in this areas over time.

The thresholds identified by the CIT (2004; listed above) are used to categorise watersheds into different risk classes based on percent RFF zone harvested. This is then compared to the priority ratings for watersheds based on the hydrologic indicators.

2. Primary Hydrological Functioning Indicators

a) Percent watershed area logged

Percent of the watershed that has been logged influences the potential flow of water through the entire system (as described above). As described in the 'thresholds' section, percent watershed harvested is a useful broad indicator for assessing potential risks to watershed functioning, and the thresholds identified by Church and Eaton (2001), and Wilford and Lalonde (2004) are used in this analysis to prioritise watersheds for further inquiry (Table 1).

Rate of harvest is also thought to be a key variable affecting overall functioning (rather than total amount harvested); Church and Eaton 2001; CIT 2004, but we cannot determine specific rates of harvest in this analysis.

The total amount of each watershed harvested was determined from a GIS overlay of PTT watersheds (See 4.4) combined with the harvest history layer determined from forest cover and updated using Landsat (see 4.4).

3. Secondary hydrological functioning indicators

- length of road
- road density
- road and harvested areas on unstable terrain (class IV and V)
- number of stream crossings / km of stream channel

Roads in a watershed, road density, stream crossings and roads on unstable terrain link to the probability of unnatural sediment sources for watercourses. In general, more roads, and the more unstable the terrain, the higher the likelihood of increased stream sedimentation

In general, roads result in increased storm runoff which is caused by the extension of the surface drainage network produced by road ditchlines and by the increase in the impervious surface area (Church and Eaton 2001). They note that

> "Effects are particularly marked on slopes where roadcuts intercept downslope subsurface drainage and the compact road berm itself acts as a dam against reinfiltration. Road effects appear to be permanent and they affect storms at all times of the year."

Again, as outlined above, the extent of the problem raised will depend on the location and the road building or harvesting methods – however, in general, the higher these indicators, the higher the potential for sediment related effects on stream and stream environments

The indicators outlined as secondary indicators are important, but highly related to the primary indicators (e.g. percent watershed harvested). The graphs provided in the results highlight the relationships between these variables, and show how detrimental may be magnified in watersheds with higher levels of development because increased harvesting tends to lead to increased roads, increased stream crossings etc..

Each of these indicators were generated using GIS overlays of harvest history with the data layers outlined below in Table 3.

DATA

Results for these indicators were generated from combining a number of different information layers in GIS and are summarised in Table 3.

Table 5. Layers used in the analysis of overview watershed indicators.

Layer	Comment	Date
Forest harvest layer	Produced by Gowgaia Institute using satellite imagery, showing harvest dates up to 2001. Licensee updates used to update file to 2003. First harvest date is approximately 1900; Last harvest date is 2003	2003 (last update)
Roads	Island-wide road coverage built by QCI Forest District and updated in 2002 using orthophoto imagery (2001 or 2002 photography, - maybe both years – not sure). Coverage not complete – roads and spurs missing in some areas	1997 orthophoto, updated with licensee info
Terrain stability	Terrain stability classes IV and V were selected and assembled from the various terrain classification coverages for the islands. (TFL 39 includes Class VI, which was grouped with Class V in the aggregate coverage) TFLs are covered by levels C, D and E terrain classification mapping. The TSA was done to reconnaissance level and level D mapping	Various dates (mid to late 90's?)

Layer	Comment	Date
Watershed layer	PTT Watershed Units were developed by the LUP Process Technical Team. Watershed Units nest within landscape units. Note that some 'watersheds' are combinations of several watersheds, others are face units (i.e. no single defined drainage network). See Map 17.	2004
Streams	TRIM streams (1:20,000) were used All stream orders were included. As with RFF zones below, very small streams are not present in the file In calculating total stream lengths, 'connector' streams (used in lakes to connect the stream network) were excluded.	Unknown
Riparian Fish Forest Zones	Combines fisheries information, barriers, and TRIM stream information. Does not include many very small streams not mapped at 1:20,000 / ephemerals etc. Map 16.	John Broadhead December 2004.

Indicators were selected for their ease of calculation using available information (Table 3), and ability to provide some idea of how water resources in PTT watersheds may have been affected by forest development. Forest licensees and government provided information, but it is important to note that limitations with regard to currency and accuracy exist. Results are summarised for all watersheds in Table 4.

B: Detailed Watershed Analysis for example Watersheds

Two HG/QCI watersheds, within which field-based information was available, have been selected for more detailed description. The purpose of this section is to review the broad landscape level indicators that are presented for all watersheds in Section A, in the context of actual effects on watershed condition that have been observed in the field. Field-based information was collected from Coastal Watershed Assessment Procedures, hydrologic assessments, and other field review activities conducted in the subject watersheds. The Awun River and Deena Creek watersheds have been selected for analysis in this section; both are identified in the Haida Land Use Vision (HLUV).

Results: Overview Watershed indicators

Results for all indicators are shown for all 145 watersheds in Table 4. Key trends in results are identified below. Results for HLUV watersheds (which are often multiple PTT watersheds) are separated out in Chapter 4.4.

Note that many of these indicators are not independent from one another (amount harvested is often related to percent riparian logged, length of road, road density etc.).

The 145 watersheds differ in size from having an area of approximately 1600ha (Skidegate Channel) to approximately 20,000 ha (Hancock River watershed). Average size is approximately 7,000 ha. Some larger watersheds on the islands are split into multiple components (e.g. the Yakoun), and the watershed units can be seen on Map 16.

1. Primary Biological Functioning Indicator[1]

a) Percent of riparian areas harvested

Of the 145 watersheds identified, there is a wide range in the total amount of area within Riparian Fish Forest zones (i.e. hydroriparian areas) that has been harvested; (Table 4).

Forty-four of 145 watersheds are apparently undeveloped, and in these none of the RFF zones have been harvested. This represents approximately 370,000ha of the approximately 1,000,000ha of area on the Islands.

A total of seventy five watersheds have less than 10% of their RFF area harvested, which means that approximately 570,000ha of 1,000,000ha of watersheds on the Islands have RFF zones in the low risk category. An additional 28 watersheds have between 10 – 30% harvested (an area of 156,000ha of watersheds). Forty watersheds have between 30 and 70% of their RFF areas harvested (representing watersheds totalling 240,000ha), and six watersheds have more than 70% of riparian areas harvested to date (representing watersheds totalling 36,500ha). These six watersheds are Skidegate Lake (84% riparian harvested), Aero Camp, Buckley Bay, Alliford Bay, PacofiBay and Towustasin Hill. The range of potential impacts on different watersheds is shown graphically in Figure 1, which shows extent of riparian harvest against overall percent watershed harvested, for all 145 watersheds.

Table 4 'ranks' watersheds based on the percent of RFF values harvested, and watersheds are given a 'colour' ranking based on percent harvested (>30% harvested = red; 10 – 30% harvested = yellow, <10% harvested = green). A map of watershed condition based on potential risk, based on percent RFF logged, is available (Map 17).

This analysis does not consider the regeneration of riparian conditions in these areas post-harvest. However, in the timeframe of harvest (mostly over the last 30 years, and some over the last 60 years), it is clear that fully functional riparian forest is not present over large areas of the higher impacted watersheds. The precise impacts of this are unknown, but significant impact on plant communities, riparian habitat for bears, salmon habitat, movement corridors etc. will all have occurred as a result of this activity in the watersheds with highest levels of RFF zones harvested. The significance will depend on actual level of harvest, rate of recovery and significance of values prior to harvest.

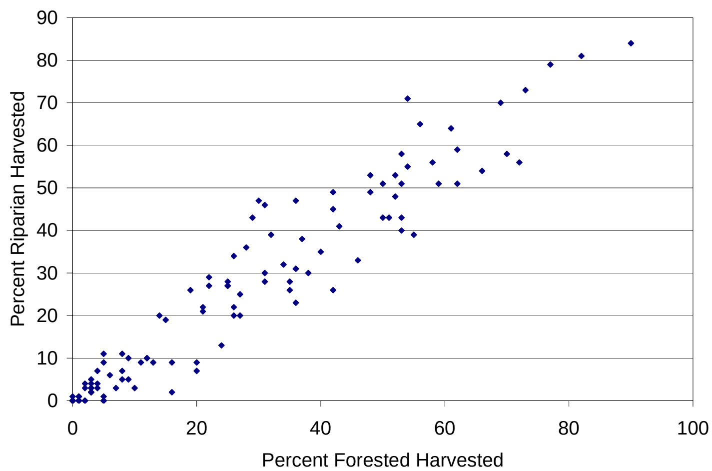

Figure 2. Percent forest harvested, and percent riparian forest harvested, for all 145 watersheds on HG / QCI.

With respect to channel bed and bank stability some of the most serious effects of harvest can be seen from logging on alluvial fans and floodplains adjacent to larger streams in particular (note that this analysis does not differentiate between streams of different sizes). Most streams greater than approximately 1.5 m in width require at least a portion of the mature timber in riparian areas to allow for bank stability and to maintain instream complexity; streams smaller than 1.5 m in width may not require this buffer. The latter channel type is found most frequently and represents the largest proportion of total channel length on the landscape.

Natural movement of stream channels maintains aquatic and riparian habitats, and this typically occurs along the valley floor. When this area is disturbed the intermediate to long-term renewal and maintenance of hydroriparian habitat is placed at risk (Church and Eaton 2001).

Removal of riparian vegetation can significantly alter microclimate around streams which can also impact suitability of habitat for aquatic species, and food sources can also be significantly altered (Carver 2001). Narrow buffer strips do not maintain either of these functions – rather the entire hydroriparian zone is required to maintain these functions. Riparian vegetation also reduces or regulates sediment input to streams, whether the source is within, or outside of the riparian zone (Carver 2001).

2. Primary Hydrological Functioning Indicator

a) Percent of watershed area logged

The 145 watersheds vary in terms of percent logged – ranging from 0 to 83% of the total watershed area logged (90% of the total forested area) most of which has occurred primarily over the last 50 years (Table 4). Results for HLUV watersheds (which are often multiple PTT watersheds) are separated out in Chapter 4.4.

Thirty-five watersheds have no industrial harvesting in them, representing 340,000ha of the 1,000,000ha of watershed area; another 46 watersheds have between 0 – 20% harvested to date which represents an additional 310,000ha of area that is in the low potential risk category (as outlined in Table 1). Seventeen watersheds have between 20 – 30% harvested (84,000ha) and are in the moderate potential risk category. The remaining 43 watersheds (267,000ha) have more than 30% harvested, and so are in the high potential risk category. Of these 43, four watersheds have more than 70% harvested representing 32,000ha of forested landbase (Skidegate Lake, Aero Camp, Buckley Bay, Aliford Bay).

2. Secondary hydrological functioning indicators:

a) Length of road and road density:

Watersheds range from having 0km to 370 km of roads. Thirty-six watersheds are unroaded, and another 35 have less than 20km of road in total. Forty-seven watersheds have more than 50km of road, which results in road densities ranging between 0.01km of road per hectare to 0.03km of road per hectare. Skidegate Lake has the highest length of road (370km), followed by Mamin River, Alliford Bay, Lower Yakoun River, Davidson Creek and Gray Bay Cumshewa.

The following watersheds have highest road densities (all greater than 0.025 km road/ ha): Upper Yakoun, Cowhoe Bay, Towustasin Hill, Buckley Bay, Brent Creek, Florence Bay and Alliford Bay. This does not directly match those watersheds with highest levels of harvest, but Figure 2 shows the general relationship between percent watershed harvested and road density.

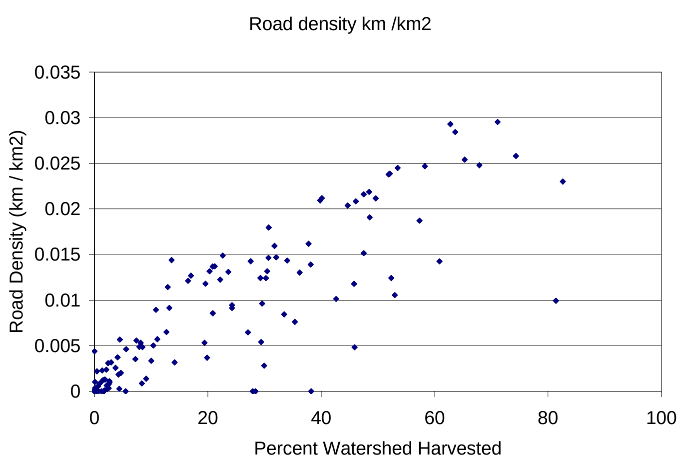

Figure 3. Percent watershed harvested and road density (km / km2) for all 145

watersheds on HG / QCI.

Forest roads can also affect subsurface drainage, runoff rates, and streamflow magnitude, as described above. In general terms, increasing road length and density increases the potential for subsurface drainage alteration, acceleration of runoff and effects on streamflow. The specific effects are also a function of road location with regard to hillslope position, road cut and fillslope heights, soil type and subsurface flow depth, cross-drain frequency, deactivation, and precipitation levels.

A general increase in exposed soil area associated with road construction, use, and deactivation can be expected to increase erosion and the potential for sediment input to streams. However, these indicators do not account for road construction methods, use levels, maintenance practices, or deactivation – all important considerations with regard to realised erosion and stream sedimentation.

Valley bottoms have typically been the preferred routes for road access, and many roads have been built along valleys adjacent to streams. It has been suggested that to maintain hydroriparian functioning, roads should be eliminated from hydroriparian zones so far as is practical (Church and Eaton 2001); otherwise, they need to be constructed with special care to ensure that the disturbance remains minor.

b) Harvested areas and roads on potentially unstable terrain (class IV and V)

The watersheds differ greatly in the amount of mapped potentially unstable terrain (Class IV and V) – with areas varying between zero and 6,200ha. Of this, the area of potentially unstable terrain that has been harvested also differs widely: from none to approximately 1000ha of unstable terrain harvested in each of Renner Pass, Talunkwan Island and Deena Creek watersheds.

The percent of potentially unstable terrain that has been harvested should be interpreted with caution (since a small amount of harvest on a small amount of potentially unstable terrain can result in a large percentage), but in some watersheds large areas of mapped potentially unstable terrain have been harvested (e.g. Deena Creek, Talunkwan Island, Renner Pass, Shields Bay, Skidegate Lake, Pacofi Bay, Sialun Creek, Newcombe Inlet, Naden River - which have the highest areas of unstable terrain harvested).

The length of road built on potentially unstable terrain also differs widely by watershed. The maximum length of road built within a watershed on potentially unstable terrain is 30km, with 12 watersheds having more than 10km of road built on unstable terrain. As would be suggested by the amount of harvesting on mapped unstable terrain, the three watersheds with most road built on unstable areas are Renner Pass, Talunkwan Island and Deena Creek watersheds.

The length of forest road constructed on terrain stability class IV and V terrain can be an indicator of potential slope instability following road construction. It is important to note that terrain stability class IV and V information is completed at the overview level and is generally conservative with regard to actual terrain conditions as determined through site level review (M. Milne pers. comm.). Also note that methods of road construction are not captured by this indictor, nor are activity or deactivation levels.

c) Number of stream crossings by roads

Based on available information on stream density, the number of road / stream crossings varies between 0 and approximately 300 across the watersheds. Skidegate Lake, Mamin River and Alliford Bay have the most crossings, with more than 200 crossings in each watershed. Note however that the layer used to identify streams in this analysis may underestimate the density of streams on the landscape by a factor of 5 to 10.

Number of crossings per km of stream is difficult to interpret (because watersheds have such variable lengths of stream) – but numbers range from 0 to more than 2 crossings / km of stream.

Sediment input to streams can occur at road crossing locations. Hence, the number of forest road crossings on streams can be an indicator of potential sediment contribution to channels. Actual sediment contribution to streams depends on road construction methods and drainage adequacy, as well as activity levels, maintenance methods and frequency, and deactivation.

Table 6. Results from overview indicators. Watersheds are sorted on the basis of forest area harvested.

The coloured columns show the potential risk levels based on two indicators: Percent watershed harvested (using Wilford and Lalonde Thresholds), and percent RFF harvested (loosely using CIT thresholds); See section on thresholds for further explanation. Potential risks for each watershed are coded as Red = high, yellow = moderate, green = low.

Watershed	Primary hydrologic indicator Watershed Area harvested				Primary biological indicator: Riparian Fish Forest Harvested				Secondary hydrologic indicators: Road / Stream Crossings				Secondary hydrologic indicators: Potential sediment sources – unstable terrain		
	Total Area	Forest Area	% Watershed Logged	Potential Risk level based on % watershed logged	Area	Logged	% logged	Potential Risk level based on % RFF Logged	Road Length (km)	Road Density km/ha (forest area)	# of Road Stream Crossings	# of Crossings per km of stream	Area of Unstable (4/5) Terrain harvested	% of Unstable (4/5) Terrain harvested	Road Length on Unstable (4/5) Terrain (km)
SkidegateLake	16,090	14,805	83		3,154	2,640	84		370	0.023	326	1.04	602	87	12.21
AeroCamp	4,131	4,095	81		774	628	81		41	0.010	38	0.44	79	95	0.92
BuckleyBay	3,100	2,973	74		416	329	79		80	0.026	109	1.79	321	74	8.82
AllifordBay	6,806	6,653	71		1,221	889	73		201	0.030	222	1.36	351	53	9.29
CowhoeBay	2,219	2,081	68		151	84	56		55	0.025	38	2.25		0	
TowustasinHill	4,529	4,239	65		687	480	70		115	0.025	115	1.48	349	62	11.16
BrentCreek	3,447	3,131	64		559	323	58		98	0.028	48	0.92	44	37	1.29
FlorenceCreek	5,393	5,144	63		817	438	54		158	0.029	96	1.19	20	68	0.00
RennerPass	4,912	4,831	61		574	338	59		70	0.014	57	0.61	943	48	20.54
UpperYakounRiver	6,036	5,702	58		1,476	756	51		149	0.025	144	1.1	183	62	4.76
DeenaCreek	7,003	6,612	57		1,728	1,108	64		131	0.019	175	0.87	1,407	42	29.63
PacofiBay	3,979	3,870	53		604	431	71		42	0.011	63	0.67	579	36	11.52
KingCreek	2,287	2,127	53		347	193	56		56	0.024	61	1.05	120	26	2.97
BlackwaterCreek	3,435	3,195	52		515	337	65		82	0.024	97	1.13	280	35	8.19
TalunkwanIsland	4,347	4,185	52		679	371	55		54	0.012	106	0.8	951	40	20.90
WasteCreek	3,363	3,279	52		484	247	51		80	0.024	71	1.07	223	51	4.93
MaminRiver	11,057	10,330	50		1,998	1,161	58		234	0.021	244	1.02	409	19	12.87
GoldCreek	3,250	3,009	49		582	309	53		62	0.019	64	0.86	196	24	4.12
DinanBay	4,666	3,844	48		592	304	51		102	0.022	105	1.08	395	40	9.25
SkidegateChannel	1,651	1,565	47		311	160	51		25	0.015	28	0.66	301	35	5.36
HaansCreek	7,315	6,508	47		987	427	43		158	0.022	81	0.69	156	33	6.05

Watershed	Primary hydrologic indicator Watershed Area harvested				Primary biological indicator: Riparian Fish Forest Harvested				Secondary hydrologic indicators: Road / Stream Crossings				Secondary hydrologic indicators: Potential sediment sources – unstable terrain		
	Total Area	Forest Area	% Watershed Logged	Potential Risk level based on % watershed logged	Area	Logged	% logged	Potential Risk level based on % RFF Logged	Road Length (km)	Road Density km/ha (forest area)	# of Road Stream Crossings	# of Crossings per km of stream	Area of Unstable (4/5) Terrain harvested	% of Unstable (4/5) Terrain harvested	Road Length on Unstable (4/5) Terrain (km)
HonnaRiver	4,751	4,518	46		694	370	53		99	0.021	105	1.18	190	30	5.08
SewellInlet	5,577	5,382	46		863	426	49		27	0.005	8	0.15		0	
SlatechuckCreek	4,923	4,508	46		687	298	43		58	0.012	55	0.46	262	17	5.75
McClintonBay	6,185	5,232	45		901	360	40		126	0.020	135	0.96	421	28	14.19
MosquitoLake	8,689	7,090	43		1,724	822	48		88	0.010	109	0.44	399	18	5.96
GhostCreek	4,863	4,261	40		934	312	33		103	0.021	83	0.71	136	38	4.14
CanyonCreek	2,724	2,552	40		392	102	26		57	0.021	25	0.56		0	
SkedansCreek	5,189	3,917	38		1,031	443	43			0.000		0		0	
RockfishHarbour	4,748	4,190	38		544	224	41		66	0.014	132	1.37	368	21	6.36
GrayBayCumshewa	10,449	7,204	38		1,767	697	39		169	0.016	107	0.62	134	77	4.36
BeattieAnchorage	2,995	2,591	36		352	159	45		39	0.013	48	0.74	311	22	8.59
GogitPassage	11,301	11,094	35		1,461	687	47		86	0.008	130	0.57		0	
NewcombeInlet	8,784	7,957	34		1,340	515	38		126	0.014	175	0.83	545	18	9.77
MathersCreek	8,411	6,749	33		1,395	682	49		71	0.008	90	0.44	464	14	10.61
LowerYakounRiver	12,425	9,920	32		2,718	941	35		198	0.016	101	0.65	59	28	2.33
SurveyCreek	5,444	4,918	32		850	219	26		80	0.015	34	0.47	39	39	2.49
DavidsonCreek	11,888	10,813	31		2,243	708	32		174	0.015	176	0.74	434	32	13.35
AinRiver	4,119	3,543	31		832	193	23		74	0.018	34	0.59	11	8	0.11
AtliBay	8,891	8,841	30		1,050	494	47		25	0.003	35	0.2		0	
BegbiePenninsula	5,198	5,003	30		307	140	46		50	0.010	30	0.66	96	11	2.62
BotanyInlet	8,225	7,754	30		1,682	654	39		102	0.012	187	0.79	467	16	5.95
NadenRiver	12,690	10,683	30		2,139	666	31		167	0.013	141	0.6	537	35	18.55
CrescentInlet	4,067	3,855	29		531	162	30		22	0.005	27	0.28	155	17	1.94
ThreeMileCreek	2,818	2,349	29		377	104	28		35	0.012	20	0.47	3	22	0.00
TangilPenninsula	2,484	2,411	28		424	181	43			0.000		0	202	17	

Watershed	Primary hydrologic indicator Watershed Area harvested				Primary biological indicator: Riparian Fish Forest Harvested				Secondary hydrologic indicators: Road / Stream Crossings				Secondary hydrologic indicators: Potential sediment sources – unstable terrain		
	Total Area	Forest Area	% Watershed Logged	Potential Risk level based on % watershed logged	Area	Logged	% logged	Potential Risk level based on % RFF Logged	Road Length (km)	Road Density km/ha (forest area)	# of Road Stream Crossings	# of Crossings per km of stream	Area of Unstable (4/5) Terrain harvested	% of Unstable (4/5) Terrain harvested	Road Length on Unstable (4/5) Terrain (km)
IanLake	9,394	6,782	28		1,189	361	30		134	0.014	109	0.97	220	24	6.21
Tanu	3,634	3,599	28		449	126	28			0.000		0		0	
BreakerBayCreek	2,938	2,527	27		435	124	28		19	0.006	25	0.36	113	12	2.79
BonanzaCreek	4,450	4,197	24		757	260	34		42	0.009	74	0.62	304	21	6.60
SewallCreek	4,965	4,640	24		522	143	27		65	0.013	103	0.73	286	18	8.66
RoyLake	4,927	4,353	24		571	145	25		45	0.009	45	0.5	244	21	4.22
DatlamenCreek	6,179	5,346	23		872	189	22		92	0.015	63	0.58	224	13	9.21
StanleyCreek	6,128	5,217	22		1,071	218	20		75	0.012	44	0.41	4	9	
ShieldsBay	7,006	5,385	21		1,177	418	36		96	0.014	156	1.06	732	35	16.18
TrounceInlet	2,686	2,330	21		683	209	31		23	0.009	52	0.65	201	15	3.66
RileyCreek	3,142	3,022	21		542	145	27		43	0.014	74	0.82	255	19	8.68
LongInlet	5,710	4,559	20		980	269	27		21	0.004	27	0.16	312	16	2.89
QueenCharlotteSkidegate	6,443	6,077	20		541	120	22		76	0.012	57	0.65	35	13	1.18
AwunRiver	7,216	5,514	20		910	186	20		95	0.013	43	0.35	133	7	6.75
LagoonInlet	3,191	2,816	19		594	175	29		17	0.005	25	0.27	166	9	1.84
PhantomCreek	1,894	1,605	17		360	34	9		24	0.013	19	0.35	30	6	1.68
BoultonLake	7,679	5,365	16		870	111	13		93	0.012	42	0.56		0	
NewcombePeak	7,255	5,337	14		1,230	323	26		23	0.003	42	0.21	161	5	0.38
BlackbearCreek	1,738	1,448	14		303	7	2		25	0.014	15	0.53	0	2	
LawnHill	7,988	7,426	13		584	119	20		73	0.009	32	0.51	5	18	0.05
TartuInlet	6,615	5,594	13		1,019	191	19		43	0.007	62	0.34	140	6	2.28
WatunRiver	8,572	5,457	13		1,379	91	7		98	0.011	50	0.35		0	
BillCreek	3,496	3,053	11		457	42	9		20	0.006	5	0.11		0	
IanSouthwest	2,461	1,690	11		312	27	9		22	0.009	30	0.63	23	5	1.43
CaveCreek	10,743	9,300	10		1,960	196	10		36	0.003	69	0.28	346	20	8.95

Watershed	Primary hydrologic indicator Watershed Area harvested				Primary biological indicator: Riparian Fish Forest Harvested				Secondary hydrologic indicators: Road / Stream Crossings				Secondary hydrologic indicators: Potential sediment sources – unstable terrain		
	Total Area	Forest Area	% Watershed Logged	Potential Risk level based on % watershed logged	Area	Logged	% logged	Potential Risk level based on % RFF Logged	Road Length (km)	Road Density km/ha (forest area)	# of Road Stream Crossings	# of Crossings per km of stream	Area of Unstable (4/5) Terrain harvested	% of Unstable (4/5) Terrain harvested	Road Length on Unstable (4/5) Terrain (km)
LigniteCreek	14,720	12,662	10		2,025	209	10		74	0.005	31	0.16	229	21	7.98
KumdisIsland	3,603	2,984	9		447	40	9		5	0.001	1	0.04		0	
KuperInlet	9,217	3,742	8		1,418	298	21		8	0.001	28	0.11	136	3	0.04
GregoryCreek	3,390	3,142	8		716	70	10		18	0.005	34	0.32	54	5	1.25
KumdisCreek	6,152	5,451	8		517	26	5		30	0.005	9	0.2		0	
IanNortheast	5,979	4,901	8		837	27	3		29	0.005	9	0.1		0	
HangoverCreek	1,979	1,766	7		303	35	11		7	0.004	11	0.2	22	3	0.00
BillBrownCreek	2,871	2,705	7		421	31	7		16	0.006	22	0.3	38	3	1.37
TaraCreek	4,547	3,512	6		688	20	3		21	0.005	9	0.13	2	1	
DawsonHarbour	5,463	3,840	5		632	60	9		11	0.002	20	0.12	105	4	2.70
BurnabyIsland	7,410	7,028	5		647	37	6			0.000		0		0	
ChaatlIsland	3,709	3,178	4		329	35	11		1	0.000		0	20	1	
SkonunRiver	15,773	8,286	4		3,079	161	5		29	0.002	15	0.06		0	
LogCreek	4,929	4,489	4		494	4	1		28	0.006	19	0.35		0	
FairfaxInlet	4,282	3,200	4		796	3	0		11	0.003		0	3	0	0.02
FeatherCreek	4,567	3,933	4		574	2	0		17	0.004	5	0.09	2	5	0.26
KitgoroInlet	8,879	7,341	3		1,136	62	5		3	0.000	8	0.04	43	1	
KanoInlet	11,598	9,454	3		1,983	77	4		9	0.001	16	0.04	90	1	0.88
LowerTlellRiver	10,398	9,344	3		1,839	47	3		33	0.003	2	0.02		0	
YakounLake	8,372	5,582	3		1,522	45	3		8	0.001	5	0.02	4	0.00	0.06
HainesCreek	11,676	10,705	3		2,037	35	2		13	0.001	6	0.02	67	2	2.68
DawsonInlet	4,145	2,113	2		710	49	7		1	0.000	1	0.01	19	1	
GudalBay	9,394	5,708	2		1,671	60	4		6	0.001	28	0.09	65	1	0.70
HibbenIsland	3,392	2,917	2		490	19	4			0.000		0	14	1	
HustonInlet	9,350	8,148	2		904	24	3		12	0.001	8	0.06		0	

Watershed	Primary hydrologic indicator Watershed Area harvested				Primary biological indicator: Riparian Fish Forest Harvested				Secondary hydrologic indicators: Road / Stream Crossings				Secondary hydrologic indicators: Potential sediment sources – unstable terrain		
	Total Area	Forest Area	% Watershed Logged	Potential Risk level based on % watershed logged	Area	Logged	% logged	Potential Risk level based on % RFF Logged	Road Length (km)	Road Density km/ha (forest area)	# of Road Stream Crossings	# of Crossings per km of stream	Area of Unstable (4/5) Terrain harvested	% of Unstable (4/5) Terrain harvested	Road Length on Unstable (4/5) Terrain (km)
KlunkwoiBay	5,114	2,990	2		870	22	3			0.000		0		0	
MayerLake	12,661	10,194	2		1,638	51	3		30	0.002	11	0.09		0	
GeikeCreek	3,232	2,913	2		225	4	2		10	0.003	5	0.24		0	
KittHawnCreek	9,791	6,223	2		1,459	22	2		1	0.000		0		0	
CreaseCreek	2,337	1,741	2		227	1	0		3	0.001	2	0.05	4	3	0.25
MarshallInlet	8,208	6,404	1		1,298	16	1			0.000		0		0	
CraftBay	5,365	4,990	1		828	1	0		3	0.001	1	0.01		0	
GovernmentCreek	1,932	1,657	1		328	0	0			0.000		0	2	0	
KootenayInlet	12,625	8,216	1		2,077	6	0		15	0.001	12	0.03	9	0	0.65
LellaCreek	7,000	6,553	1		866	2	0		6	0.001		0	3	50	0.04
RoseSpit	6,126	3,871	1		875	2	0		14	0.002	1	0.02		0	
BottleInlet	7,334	4,071	0		1,091	7	1			0.000		0	0	0	
SecurityInlet	7,911	5,069	0		1,363	10	1		4	0.001	9	0.04	0	0	
AthlowBay	5,216	3,387	0		826	0	0			0.000		0		0	
BeresfordCreek	13,421	12,015	0		3,001	0	0			0.000		0		0	
CapeBallCreek	19,710	16,303	0		2,946	0	0		7	0.000	9	0.04		0	
ChristieRiver	10,907	8,154	0		2,522	0	0			0.000		0		0	
CoatesCreek	8,546	5,578	0		1,557	0	0			0.000		0		0	
FortierHill	3,246	2,537	0		465	0	0			0.000		0		0	
GowgaiaBay	16,330	10,290	0		2,393	0	0			0.000		0		0	
HanaKootCreek	6,277	5,832	0		1,275	0	0			0.000		0		0	
HancockRiver	19,975	14,727	0		3,659	6	0		4	0.000	3	0.01		0	
HiellenRIver	14,662	9,303	0		2,457	5	0		15	0.001	5	0.03		0	
HippaIsland	6,409	4,371	0		922	0	0			0.000		0		0	
HosuCove	2,141	1,416	0		200	0	0			0.000		0		0	

Watershed	Primary hydrologic indicator Watershed Area harvested				Primary biological indicator: Riparian Fish Forest Harvested				Secondary hydrologic indicators: Road / Stream Crossings				Secondary hydrologic indicators: Potential sediment sources – unstable terrain		
	Total Area	Forest Area	% Watershed Logged	Potential Risk level based on % watershed logged	Area	Logged	% logged	Potential Risk level based on % RFF Logged	Road Length (km)	Road Density km/ha (forest area)	# of Road Stream Crossings	# of Crossings per km of stream	Area of Unstable (4/5) Terrain harvested	% of Unstable (4/5) Terrain harvested	Road Length on Unstable (4/5) Terrain (km)
HoyaPassage	2,574	1,869	0		410	0	0			0.000		0		0	
InskipChannel	3,003	1,480	0		396	0	0			0.000		0		0	
JalunRiver	18,738	14,679	0		3,974	0	0		0	0.000		0	3	0	
KlashwunPoint	4,257	3,441	0		1,012	0	0			0.000		0		0	
Kung	8,621	7,071	0		1,486	4	0		1	0.000	1	0.01		0	
KunghitIsland	12,905	8,884	0		1,116	0	0			0.000		0		0	
LangaraIsland	3,188	2,431	0		530	0	0		7	0.002	6	0.12		0	
LepasBay	6,551	5,907	0		1,140	0	0			0.000		0		0	
LouscooneInlet	6,285	5,327	0		687	0	0			0.000		0		0	
MercerLake	4,036	2,715	0		782	0	0			0.000		0		0	
OeandaRiver	16,640	11,786	0		3,077	0	0		2	0.000	9	0.04		0	
OtardCreek	9,036	6,447	0		1,981	0	0			0.000		0		0	
OtunRiver	14,597	10,773	0		2,942	0	0			0.000		0		0	
PortChanal	4,545	2,704	0		874	0	0			0.000		0		0	
PuffinCover	9,685	5,952	0		1,727	0	0			0.000		0		0	
RoseInlet	10,938	8,886	0		928	0	0			0.000		0		0	
SealInlet	10,229	7,432	0		1,619	0	0		1	0.000		0		0	
SialunCreek	8,439	7,648	0		1,643	0	0		37	0.004	94	0.4	547	15	6.75
SkaatHarbour	6,043	4,980	0		645	0	0			0.000		0		0	
SkittagetanLagoon	11,925	6,824	0		1,736	3	0			0.000		0		0	
StakiBay	6,469	3,960	0		824	0	0			0.000		0		0	
SundayInlet	8,617	4,024	0		1,630	0	0			0.000		0		0	
TianHead	4,987	3,699	0		841	0	0			0.000		0		0	
WiaPoint	6,720	4,624	0		1,180	0	0			0.000		0			

RESULTS B: DETAILED WATERSHED CONDITION ASSESSMENT

To provide insight into specific effects on water resources that have occurred on the Islands, the condition of two example watersheds is described in detail, based on field assessments. The Awun River and Deena Creek watersheds have been chosen for more detailed discussion. Selection was based on the availability of current field-based information from Coastal Watershed Assessment Procedures (CWAP), hydrological assessments and other field experience (M. Milne pers. comm.). Both are identified as HLUV watersheds (See Chapter 4.4 for full list of HLUV watersheds).

EXAMPLE 1: AWUN RIVER

The Awun River is a 7,200 ha watershed draining into the west end of Masset Inlet. A large lake (Awun Lake) is present on the lower system. A CWAP was completed on the Awun River in December 2002. Five main tributary basins (East Awun, Southeast Awun, South Awun, Upper Awun, and Talking Bear Creek) range in size from 220 to 2,200 ha flow directly into the lake. Sockeye and other species of pacific salmon utilise the Awun system, and resident fish are present. Sockeye salmon from the Awun are used by the Haida for food and ceremonial purposes.

Forest development has been the primary land-use activity in the Awun watershed. To date approximately 20% of the watershed and 20% of the Riparian Fish Forest (RFF) has been harvested (Table 4), and these levels of development result in a moderate potential risk ranking (Table 4).

The road density is 0.015 km/ha (1.5 km/km^2), there are 148 stream crossings, 6.8 km of road on potentially unstable terrain (i.e. class IV or V areas), and 7.0% of the potentially unstable terrain in the watershed has been logged.

STREAMS, STREAMFLOW AND HYDRORIPARIAN FUNCTION

The percent of the watershed and RFF area logged, and the road density suggests a moderate potential risk for negative effects on streamflow magnitude, stream stability and hydroriparian function. Field results confirm significant site-specific effects on stream stability and hydrologic function resulting from past forest development activity, particularly harvesting from the 1930's and 1940's.

From fieldwork, road related effects on runoff were determined to be minor based on high construction standards, adequate drainage, and good locations for roads. Negative effects on streamflow were determined to be unlikely on the lower Awun channel based on the presence and hydrologic effect of Awun Lake, but may have occurred to some degree in one or more of the smaller sub-basins.

Logging began around the mouth of the Awun River in the early 1900's using A-frame methods. In the 1930's to 1940's, tote roads were built into Awun Lake where a barge was used to move equipment to the mouths of three of the five main tributary systems (South Awun, Upper Awun, and Talking Bear). Most of the mature timber was removed from hydroriparian or RFF areas along these channels to a maximum distance of 1.5 km from the mouth. The channels were likely used as skid trails at this time. Approximately 2.0% of the watershed and RFF area were harvested during this period, but the effects on hydroriparian function and fish habitat were significant and long lasting. Channel bed and bank stability, and the long-term source of large woody debris for channels were all reduced by this activity. Forest regeneration in hydroriparian areas has been ongoing since the completion of 1940's development and the condition of all channels has improved with regard to bank stability. Hydrologic functions associated with the hydroriparian zone are also improving. However, despite some recovery in these areas, hydroriparian processes related to large woody debris recruitment, instream complexity, and the provision of high quality fish habitat remain lower than likely conditions present prior to logging.

No additional forest development occurred in the Awun watershed until the mid-1980's. Then, over an approximate 15-year period, 10% of the watershed was logged along the south side of Awun Lake. All large and small streams were harvested to both banks during this period of development. Disturbance to the lower channel and hydroriparian area on one of the remaining un-logged tributary basins (East Awun) also occurred during this period. Channel stability and hydroriparian function was reduced by this activity and remains so with young deciduous regeneration in logged hydroriparian areas. Stability and sensitivity related effects on smaller channels were less, as these streams were less dependent upon hydroriparian timber for stability reasons. Deciduous regeneration is occurring in all hydroriparian areas logged during this period. Hydroriparian functions related to bank stability, shade and leaf litter are improving. However, the broader biological functions related to the hydroriparian ecosystem are less than those present under pre-logging conditions.

Since 1995 and the onset of the Forest Practices Code (FPC) an additional 9% of the Awun watershed has been logged. Development since 1995 focussed on the Southeast Awun, Upper Awun and Talking Bear sub-basins. Field review findings revealed that few channels in excess of 1.5 m bankfull width had been harvested to both banks since 1995, and riparian buffers as outlined by the FPC were maintained on fish-bearing streams. Development since 1995 has been located in areas upstream of fish barriers on most channels and where fish were present near to cutblocks, reserves of various widths were left according to FPC standards. Some windthrow in riparian reserve and management zones has occurred since 1995, particularly along streams where narrow reserves were left as a blanket treatment, regardless of stream size and/or hydroriparian dependency. Stream stability and water quality related disturbance would perhaps have been less if buffers were applied more judiciously depending on stream type (i.e. maintain wider buffers in some areas and less, or no buffer on other streams).

In response to increases in stream sensitivity resulting mainly from 1930's and 1940's logging in hydroriparian areas, rate of cut constraints were applied to forest development planning in all affected sub-basins based on operable and productive timber areas. Two basins received a "conventional development not recommended" rating based on current condition and trends with regard to recovery. The purpose of the constraints is to limit the rate of forest development in all areas upstream of disturbed hydroriparian sites so that recovery can continue without additional stress placed on the system by potential increases in streamflow magnitude or sediment input associated with road construction and harvesting. Constraints are similar to those outlined by Church and Eaton (2001), but were refined to account for differences in runoff generation processes with elevation and are based on operable and productive forest area, rather than total watershed area.

In summary, the effects of past forest development on streams, streamflow and hydroriparian areas in the Awun River watershed are site-specific in nature and largely dependent upon the era within which the activity was conducted, proportion of each sub-basin that has been logged to date, and regeneration situation on old cutblocks and along stream channels. Early development employing ground-based methods focused on highly sensitive and easily accessed hydroriparian areas. These areas were significantly affected and complete recovery from both a biological and hydrological perspective has not occurred. More recent development has been conducted in less sensitive areas of the watershed, using better practices which have less of an effect on watershed condition and hydroriparian function.

Indicators such as forest area logged, road density, and percent RFF logged suggested that some impacts had occurred and this was confirmed in the field. However, the details around the site-specific severity and extent of disturbance are not captured by the indicators, nor was the aspect of recovery with regeneration in harvested areas.

Sediment Sources

In terms of sediment source indicators the extent of road construction and number of stream crossings outlined in Table 4 both suggest some potential for sediment input to streams. The proportion of potentially unstable terrain logged and length of road constructed on potentially unstable terrain are both considered low, indicating no immediate concern with regard to landslides.

Field review results found the Awun watershed to be in good to excellent condition with regard to unnatural sediment sources. Of the 108 km of road (95 km from landscape level analysis) that have been built in the watershed, three chronic road-related sediment source sites were noted in the field, all of which involved downhill road approaches to stream crossings. The methods used to locate and construct roads in the Awun watershed are largely responsible for the good to excellent rating with regard to road related sediment sources in particular. Many of the roads in the watershed have also been deactivated according to operational requirements under the FPC; in total, 60 km of road was found to be "active" in the Awun watershed. The remainder (48-km) had been deactivated to some level.

Landslides have not been a major factor in the condition of the Awun watershed to date. Natural landslide activity is limited by bedrock type, and only two of fourteen slides visible in the watershed are attributable to past forest development activity. It is possible that the low frequency of development related slides is a function of the limited amount of development on potentially unstable terrain, but more likely it is the result of better management practices in and around steep terrain since the advent of the FPC.

In summary, sediment source indicators presented in Section A suggest a potential for increased erosion and sediment input to streams. While some sediment input to streams is expected during road construction and active use, only three sites were determined to be chronic sediment input locations that required attention on the part of the forest licensee.

EXAMPLE 2: DEENA CREEK

Deena Creek is a 7,000 ha watershed draining into the Moresby Island side of Skidegate Inlet. There are no lakes on the Deena System. Several CWAP's have been completed on the Deena, the most recent in March 2001, and hydrologic assessments have also been conducted on parts of the watershed as recently as January 2005. There are six tributary basins in the Deena (Weeping Willie, Coho, Shomar, Porter, and Upper Deena Creeks) ranging in size from 340 to 2,700 ha. All species of pacific salmon utilise the Deena system for spawning and rearing, and resident fish are present.

Forest development has been the primary land-use activity in the Deena watershed. According to Table 4, approximately 57% of the Deena watershed (61% of the forested area) and 64% of the riparian zone has been logged. The road density is 0.023 km/ha (2.3 km/km^2), there are 200 stream crossings, 30 km of road on potentially unstable terrain (i.e. class IV or V areas), and 1400ha (42%) of the potentially unstable terrain in the watershed has been logged.

STREAMS, STREAMFLOW AND HYDRORIPARIAN FUNCTION

Indicators around watershed area harvested, RFF logged, and road density in the Deena suggests high potential risk for widespread negative effects on watershed condition. Results of the various field assessments completed in the watershed confirm high levels of channel bed and bank erosion combined with an overall "straightening" of the channel as a result of past forest harvesting in hydroriparian areas plus increases in sediment load through the system. Problems in the channels were additionally likely exacerbated by increases in streamflow magnitude related to harvesting in several sub-basins and on the Deena mainstem.

Some early logging was conducted around the mouth of the Deena between 1900 and 1940. Intensive development began in the late 1960's and continued until the mid-1990's, with approximately 50% of the watershed logged between 1965 and 1995. Most of the Deena mainstem channel and lower reaches of all tributaries were logged to both banks during this period. The Deena mainstem and lower tributary channels were destabilised by this activity, resulting in widespread bed and bank erosion, increase in sediment load and channel width, and reduced complexity. Fish access into many tributaries was restricted by sediment accumulation related to localised channel destabilisation and landslide impacts.

In addition to hydrologic effects, the removal of natural riparian forest was considerable during this time, removing habitat attributes throughout riparian ecosystems and likely restricting habitat values for many species. The recovery of these attributes has started to occur, but large sized structural features remain absent through many of these areas.

Early road construction methods were characterised by poor water management practices generally, with most roads having low cross-drain (culvert) frequencies resulting in interception, diversion, and concentration of surface and sub-surface runoff. These characteristics likely contributed to increases in streamflow magnitude on tributaries and the Deena mainstem, particularly in the late 1980’s.

The effects on streams, streamflow and hydroriparian areas peaked in the late 1980’s when rates of cut were at their highest level. Since this time, regeneration in logged hydroriparian areas has helped to restore channels to an intermediate stage of recovery with respect to stability and hydroriparian function. Despite some recovery, large woody debris volumes and associated fish habitat value remain depressed in most channels subject to past harvesting in hydroriparian areas.

Today, regeneration on cutblocks logged between the late 1960’s and early 1990’s is improving stream flows throughout the watershed. Regeneration on 1960’s cutblocks is in excess of 10 m in height, trending to 3 – 5 m in early 1990’s openings.

Development since 1995 has focussed on the Upper Deena, Coho and Porter sub-basins, covering approximately 5.0 % of the watershed area. Most of the development has been undertaken in areas upstream of fish-bearing waters, and as a result very few small fish streams have been affected. Rates of cut have been reduced through the application of FPC standards, and constraints applied to several areas through the CWAP and more recent hydrologic assessments. Windthrow in hydroriparian reserves is a key management issue in the watershed today.

A comprehensive road deactivation and slope stabilisation effort was also undertaken in the late 1990’s using Forest Renewal BC funds. Essentially all of the branch and spur roads not required for future development were deactivated at this time, resulting in measurable improvements with regard to water management on roads and likely effects on runoff and streamflow.

In summary, landscape level indicators of potential effects on streams, streamflow and hydroriparian function (Table 4) provided a good overview of watershed condition - moderate to high levels of disturbance from past forest development was found in these areas. However, indicators did not capture the positive effect of regeneration with respect to recovery in harvested hydroriparian areas and on old cutblocks, or deactivation on old roads.

SEDIMENT SOURCES

In terms of sediment source indicators the extent of road construction, number of stream crossings and amount of harvesting and road construction on potentially unstable terrain suggests that there may be sediment-related problems in the Deena watershed.

Results of the CWAP and more recent hydrologic assessment exercises reveal significant detrimental effect on water resources and watershed condition resulting from road related sediment input to streams and landslide impacts on channels. An inventory of landslides completed in the 2001 CWAP found 182 slides in the watershed, 68% of which were related to past forest development. While landslide frequency is considered moderate to high naturally as a result of easily weathered bedrock types in the Deena Creek area, past forest development, particularly on areas now designated as Class IV or V has had a significant effect. Most (75%) of the natural and development related slides in the Deena watershed impacted tributary or mainstem channels.

Old roads, particularly within Class IV and V areas were chronic sources of erosion and stream sedimentation, and regular points for landslide initiation prior to being deactivated in the late 1990’s. Approximately 120 km of road (from a total of 170 reported in the CWAP) were deactivated to some degree in the Deena watershed between 1996 and 1999, and the number of active stream crossings was reduced by this activity. Deactivation included temporary, semi-permanent and permanent measures to control erosion and stabilise slopes. Monitoring of deactivation work, undertaken in 2002, revealed success with regard to improved water management, reduced erosion and stream sedimentation, and reduced landslide frequency. Roads that remain active in the Deena watershed have been upgraded to FPC standards, reducing erosion and generally improving water management. Very little new road construction has occurred in Deena Creek since 1995.

In summary, landscape level sediment source indicators (Table 4) suggested a strong potential for road and landslide related sediment input to streams, and field review findings confirm this assumption. However, there have also been improvements in watershed condition resulting from road deactivation, slope stabilisation, and improved road construction and water management practices since FPC implementation in 1995.

CHAPTER SUMMARY

In this chapter, watershed condition is considered from two separate but inter-related perspectives. One is from a 'biological' perspective and focuses on the biological functions of hydroriparian ecosystems. The second is primarily hydrological and considers watershed condition in relation to water resources. In this context, biological function is seen as an emergent property of water resources, in that hydroriparian ecosystems exist as a result of the extent, distribution, and condition of water resources on the landscape.

A broad analysis of indicators relating to these two water-related resource values was undertaken for all 145 watersheds on the Islands. Using the primary biological indicator of watershed condition (i.e. area of hydroriparian zones harvested), 46 of 145 watersheds were classified as being at potentially high risk (>30% of riparian area harvested), with 25 at moderate risk (>10% RFF harvested) and 74 at low risk (<10% harvested). Using the primary hydrologic indicator, 43 of 145 watersheds are at potentially high risk, with 17 at moderate potential risk and 85 at low potential risk. The top 40 – 45 watersheds receive a high potential risk rating, irrespective of which indicator is used.

A more detailed analysis of two example watersheds suggests that these broad indicators do represent real risk to some degree, but more detailed review is required to provide watershed or site-specific recommendations for land-use planning and implementation. Detailed watershed assessments are currently carried out as part of forest development planning for selected watersheds that have been identified as sensitive for fisheries or water quality reasons. This includes approximately 52 of the 145 watershed units on the islands.

To better understand watershed trends and conditions, as well as to ensure LUP objectives for watershed integrity and restoration are achieved, the development of a comprehensive strategy for watershed assessment and monitoring is recommended. Priority watersheds for continued and additional watershed assessment and monitoring should be identified based on the following considerations:

- Watersheds identified as high risk in Table 4
- Watersheds identified as "of concern" based on previous hydrologic and watershed assessments
- Watersheds identified in the Haida Land use Vision as culturally important and of concern (e.g. HLUV watersheds – see Chapter 4.5 for a list of relevant watersheds and their potential risk levels),
- Watersheds with high aquatic resource values, such commercially, culturally or ecologically significant fish stocks and community watersheds
- Watersheds identified as priorities for restoration
- Watersheds with available monitoring information, and
- Undisturbed watersheds that could provide important 'control' areas for monitoring and adaptive management trials.

The identification and mapping of sensitive water-related features is an important planning step that is also needed to minimize the likelihood of future water-related disturbance in all watersheds (i.e. not just those on the priority lists). Sensitive sites can include alluvial fans, floodplains, fisheries sensitive areas, glacio-fluvial terraces and gentle-over-steep topographic situations, steep coupled slopes, and potential windthrow hazard areas. Good land-use practices within and around sensitive sites can minimize or avoid cumulative effects on water resources.

The objectives of more detailed analysis and planning should be:

- Protection or improvement of watershed condition as defined by both hydrologic and biological values,
- Promotion of recovery on disturbed systems with respect to water resources and hydroriparian function, and
- Identification of opportunities to restore or recover old growth Riparian Fish Forest habitats and values.
- To provide baseline information from watersheds with low levels of disturbance, in order to inform monitoring and adaptive management trials, and in order to assess the effectiveness of LUP recommendations in relation to watershed management.

Recognising the complex nature of water resource and hydroriparian systems (e.g. Karr 1998), an interdisciplinary approach that allows for the integration of hydrological, ecological, traditional, and operational forestry knowledge and considerations should be an integral part of management that strives to improve and not degrade watershed condition over the short and long-term.

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2.5. NORTHERN GOSHAWK (ACCIPITER GENTILIS LAINGI)

PRIMARY CONTRIBUTORS

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Rachel F. Holt, Veridian Ecological Consulting Ltd.

INDICATOR RELEVANCE

The Northern Goshawk *laingi* subspecies present on HG/ QCI is provincially red-listed (BC CDC; Endangered/ Threatened), and identified as Threatened by COSEWIC. The subspecies is 'listed' primarily because it exists in small populations mostly on islands and is therefore sensitive to habitat change, fragmentation and disturbance.

Goshawks inhabit primarily coniferous forested ecosystems, nesting and usually foraging within mature and old forest types. It is a relatively sensitive species due to long lifespan, low reproductive rate and specific habitat requirements.

On HG/ QCI the diversity and abundance of prey species available is considerably lower than for mainland populations of Goshawks because typical forage species such as hares and spruce grouse are absent from the Islands. However, the non-native red squirrel has become a significant prey species since its introduction to the Islands.

BACKGROUND INFORMATION

This forest hawk is a small subspecies of the Northern Goshawk and occurs on HG/ QCI, Vancouver Island, S.E. Alaska and possibly the northern mainland coast. Goshawks are a resident species on HG/ QCI, both breeding and over-wintering on the islands.

Northern Goshawks nest in old or mature coniferous forest, typically requiring a relatively closed canopy / gappy forest (50-60% canopy closure) with open understory. Goshawks are territorial, and breeding territories are comprised of three components; a nest area which often has multiple nest sites, a post-fledging area, and a foraging area (Fig 1). The three areas within the territory overlap but may not be centred on the nest area.

Nests are generally located in old growth forests; nest trees tend to be large and have to be able to support the large nest (>1m) that is located below the canopy. These general requirements have been confirmed by the nest sites located on HG / QCI. Goshawks have also been found to nest in second growth stands (on Vancouver Island and elsewhere), usually in the largest second growth trees available, or remnant old growth within the stand. No nests in second growth have been found on HG/ QCI, though second growth stands will likely become useful for foraging, as they become 40 – 50 years old (on productive sites). Nests are typically used over many generations and pairs often have high fidelity to an established nest site.

The total average territory size for birds on HG / QCI is 9000 – 10,000 ha, with spacing between nests averaging 11.3km (range 9.5 – 15km). This is similar to the sizes observed in S.E. Alaska, where spacing between nests averaged 10.5km (range 7 – 15.2km; Iverson et al. 1996).

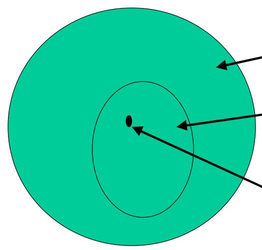

Figure 1. Representation of Goshawk territory components.

On the Islands, prey consists primarily of mid-sized mammals and birds including red squirrels, forest passerines (thrushes, jays, woodpeckers) and blue grouse. Availability of prey in winter is thought to be a key factor to maintenance of a resident population, influencing both reproductive success and individual survival. The use of open areas rather than forests for foraging, as found in Europe and mainland North America, is not commonly seen on HG/ QCI likely because the prey species usually found in those locations (hares, rabbits, additional grouse species, pigeons etc) are generally absent from HG/ QCI. On HG/ QCI there is a unique prey base compared to other areas in which Goshawks live and the suite of potential prey species is reduced compared to the mainland. Historic prey species (Marbled Murrelet and grouse) have likely declined over the last 100 years, however red squirrel was introduced in 1947 and has become a significant portion of the diet of HG/ QCI Goshawks.

Recent work (currently under review) suggests there may be a complex interaction occurring with blue grouse (a likely primary winter food supply of Goshawks) and deer. A field study on HG/ QCI shows blue grouse populations are at low densities, approximately seven times lower than those found in similar habitat types on Vancouver Island and S.E. Alaska (Doyle 2004) and historical evidence suggests that grouse populations have been much higher than seen currently. It has been hypothesised that grouse populations may be declining due to competition from introduced deer that compete for forage plants and also perhaps from increased nest predation from introduced small mammals (red squirrels/ raccoon). Although under review, this work suggests complex factors underlie Goshawk population dynamics on the Islands.

The complicated issues around prey base for this species remain under study. Additional complications around prey include the fact that the major prey species is currently a non-native one (the red squirrel) which itself may reduce the natural prey base. The work outlined above which has started to address questions of prey base interactions is on-going and will require further testing. Additional research is underway on HG/ QCI to link forage quality to attributes of particular forest stands. Patterns between site series (and forest cover data) and prey abundance have been found (Doyle 2004 unpublished information). This more detailed data will allow a fine-tuning of habitat forage quality within territories and may guide future management strategies, but is not included in this analysis.

Goshawks on HG/ QCI are found at lower densities than in other study areas. A summary of the literature from study areas outside of HG/ QCI shows that Goshawk territory size is thought to be determined primarily by prey abundance combined with accessibility (prey availability) at the landscape scale. In relatively homogeneous forest types Goshawks therefore tend to be evenly distributed.

Model Approach and Assumptions

In summary, a model for assessing Northern Goshawk trends has been produced using the following steps:

> Task 1: Goshawk nests have been located on HG / QCI over a number of years. Ten nests have been found and are on average 11.3km apart from each other.
>
> Task 2: Based on these ‘known nests’, other potentially suitable areas for Goshawks have been allocated a ‘potential territory’, depicted by a circle. Sixty-one potential territories were located and assumed to be circles located 11.3km distance apart. Map 19a.
>
> Task 3: Thresholds to determine potential territory occupancy were determined by analysing the amount of mature and old forest present within known Goshawk territories. The minimum amount of mature and old forest in all nests was 41%; the minimum amount from active nests was 61%.
>
> Task 4: Potential territories were overlaid with historic, current and predicted future maps of forest cover for the Islands. The number of potentially active territories at each time period was determined by applying the two thresholds (41% and 61%), and comparing the results from both thresholds and through time.
>
> Results in: a trend in the number of potentially active territories through time, assuming current management.

Additional details can found in Chapter 4.6.

The model uses habitat selection information collected from field studies undertaken on HG / QCI to predict the number of Goshawk territories that could *potentially* be located on the Islands under different land use scenarios. Estimated territory dispersal (average 11.3km between nest sites) is overlaid on potentially suitable habitat types to produce an estimation of the potential number of territories. Known nest sites (10) are used as a starting point for placing potential territories. The output is a map that shows 61 potential territories as non-overlapping circles. This approach is a theoretical interpretation of the data – it is not expected that territories would exactly follow this pattern, or that future nest sites would lie directly in the centre of each circle. It is simply an approach for generally estimating number and distribution of territories over time.

The ten known nest sites on HG/ QCI have been found on the Skidegate Plateau, or on the boundary / transition areas with the Queen Charlotte Ranges and Queen Charlotte Lowlands. No nests have been found in these adjacent ecosections (though relatively little sampling has occurred there). Nests are expected in the QCM as apparently suitable habitat can be found there, however, the West Coast of the Islands is generally considered too wet to provide potential habitat. The QCL typically lacks Goshawk habitat, having open low productivity forest types which lack nest sites and probably lack suitable prey availability. A small number of potential territories have been located in the lowlands and west coast region where potential habitat seems to be present (F. Doyle pers. comm.).

For coastal Goshawks, a significant reduction in reoccupancy of territories that have been fragmented by harvesting has been observed. This is thought to be linked to food supply in these areas where prey availability is not increased by harvest. This is contrary to some mainland populations, and is likely due to the lack of prey species in open areas, compared with interior BC clearcuts. In western Washington which has relatively comparable prey species to HG /QCI, low prey density was correlated with decreased adult winter survival, larger home range sizes and lower nest reoccupancy and overall lower reproductive success. In HG/ QCI, data from known nest sites is used to provide a preliminary habitat use threshold. The amount of old and mature forest present in known territories ranged from 41 - 76%, with an average of 61% (Section 4.6). It is also known that areas with a high percentage of clearcuts (low percent mature / old remaining) do not appear to support active Goshawk territories. As a result, we use a minimum value of 41% as a threshold for ‘turning on’ Goshawk territories. In addition, we also use a sensitivity analysis of 61% to determine how sensitive the analysis is to the choice of threshold (see Table 1; Figure 2). In a study by Iverson in Tongass National Forest

(1996) landscapes with less than 23 or 28% old forest (for adult males and females respectively) were not used. The average proportion of old forest within a territory was 43% (standard deviation = 15%).

Note that this threshold of habitat availability considers only the abundance of potentially suitable habitat. It does not consider the size of the patches of habitat or their distribution within the territory. In addition, some known territories with >41% mature and old forest are currently thought to be unoccupied after field sampling (F. Doyle pers. comm.). As a result there are obviously additional mechanisms that determine whether a particular territory is occupied or not that are not incorporated in this threshold. As a result these thresholds should be considered preliminary and useful for comparative purposes only. The use of two thresholds based on available data allows a sensitivity analysis – i.e. an assessment of how the results may vary if different assumptions are made about the data. In this case, the results are quite sensitive to the threshold used, and care should be taken in interpreting the results.

RESULTS:

ECOLOGICAL BASELINE

The map of 61 potential territories was overlaid with the backcast of forest cover to assess how many potential territories could have been active based on 1800 forest cover. Map 19a identifies potential territory circles, and shows which potential territories are considered active.

It is estimated that historically, 58 of 61 (using 41% threshold) or 53 of 61 (using 61%) potential territories could have been active based on forest cover information from 1800.

CURRENT CONDITION

The map of potential territories is overlain with forest cover data (2000) to estimate the potential number of territories which could be active during this period (Map 19b).

Currently (year 2000), it is estimated that 43 of 61 (using 41%) and 24 of 61 (using 61%) potential territories could be viable based on current forest cover. The amount of mature and old forest present within each territory is shown in Table 1.

A map of the location of potential territories active in 2000 is shown – Map 19b.

PREDICTED FUTURE CONDITION

The map of potential territories is overlain with predicted forest cover at time periods into the future (as output from timber supply modeling – see Section 4.1). The number of potentially active territories changes over time, as forest is harvested and regrows (Table 2; Map 19c – year 2250). The amount of mature and old forest present within each territory is shown in Table 1.

At the end of the projected timeframe, in year 2250, it is predicted that 37 of 61 or 18 of 61 territories could be active, depending on the threshold used.

TREND SUMMARY

As shown in Figure 2, the number of potentially active territories is predicted to have been between 58 and 53 in 1800 depending on the threshold used to define 'potentially active', and has continued to decline over the time period, reaching the lowest number of predicted territories in year 2050 (between 11 and 32 potentially active territories depending on the threshold). After this time period the number of potentially active territories cycles around 17 (61%) and 38 (41%) active territories. This leveling out in the number of territories results from the fact that all the old growth that is to be harvested occurs in the next 40 years across the landscape, and then the amount of mature and old forest in the landscape stays fairly constant, but its location changes through time – resulting in some territories being 'turned on' and others 'turned off' through time.

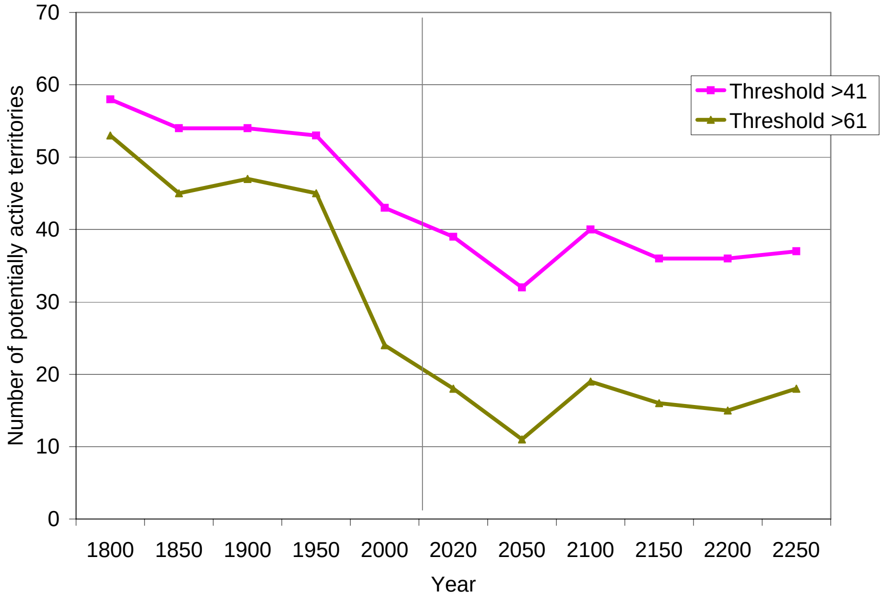

Figure 2. Number of potentially active territories predicted over time, using two thresholds for defining 'active', as described above.

In Table 1, for each territory the amount of mature and old forest cover available in each potential territory is summarised, in addition to the percent that occurs within a federally or provincially legislated protected area, plus the percent that occurs within a Riparian Management Area buffer.

Of the 61 potential territories, only 6 have a significant area (>50%) protected within a Protected Area. For the remaining territories, an average of 17% (minimum 9%, maximum 44%) of the mature + old forest is found within a Riparian Management Area buffer. At the present time, in unharvested areas, these 'buffers' are connected to surrounding old forest, but as the remaining old forest is harvest this can be inferred as meaning that in the future an average of 17% of the remaining old and mature forest will be located in riparian buffers surrounded by a matrix of younger forest stands.

LIMITATIONS

This model reflects only certain aspects of Northern Goshawk biology. For example, the threshold being used is simple and does not consider whether goshawks require a certain size of forest patch in order to forage efficiently. As increased harvesting occurs the amount of landscape fragmentation will also increase and may increasingly reduce the quality of habitat available for goshawks. As outlined above, on average, 17% of the forest within the NoGo territories is identified as excluded from harvest as a riparian buffer. It is possible this could significantly alter the quality of these stands for food production.

In addition, the model considers all forests between the age of 80 – 140 (mature) to provide the same habitat value as forests 140 years plus. This is unlikely to be true, as considerable changes in forest structures and complexity occurs across this range of ages of forest. The contribution of mature forest to each territory increases through time in this model, but if it does not provide equal value habitat then the numbers of potentially active territories estimated by this model will be reduced.

Table 1. Forest cover summary for each potential Goshawk territory in years 1800, 2000, 2250.

#	Area of mature + old forest in each territory (hectares) 1800	2000	2250	Percent in PA*	Percent in RMA**
1	7438	6254	2892	0	13
2	8880	6670	3589	0	16
3	8554	7201	5954	0	16
4	8348	5957	3314	0	12
5	8797	5829	5621	0	19
6	7269	6813	4477	0	31
7	6753	5854	4155	0	17
8	9376	8549	4645	0	13
9	6819	4395	7071	73	-
10	7483	6892	6274	0	19
11	8871	7106	6332	0	13
12	7695	7543	6853	0	27
13	7484	3987	2042	0	25
14	7624	6067	3216	0	23
15	8237	5750	6154	0	21
16	5439	5226	4452	12	16
17	7350	7357	7369	86	-
18	6551	2686	2182	0	12
19	9000	5245	5777	0	19
20	8310	3215	2208	0	14
21	5005	4482	2741	0	15
22	6480	5342	5178	15	13
23	5255	5163	5214	55	-
24	7958	6905	5633	3	17
25	9518	3804	3144	0	18
26	6870	6777	5383	10	9
27	9209	4777	2240	0	16
28	8948	6266	6529	0	17
29	8176	7941	6409	0	10
30	8565	8854	8854	100	-
31	7466	3572	2004	0	10
32	8638	3137	2096	0	13
33	7309	7337	6371	0	38
34	8866	8196	6942	0	11
35	7843	3964	4266	0	11
36	6545	6309	6173	0	22
37	7391	5274	5607	0	12
38	6872	5867	5446	0	13
39	6277	5537	4963	0	14
40	8197	2821	4406	0	14
41	8802	2541	1872	0	22
42	8632	1084	788	0	21
43	7452	1593	1768	0	12
44	9126	3606	2617	0	13
45	8982	936	2003	0	15
46	3577	2259	2515	0	9
47	7692	3793	2568	0	13
48	5715	3869	3238	0	12
49	7892	4115	3555	0	13
50	6805	5236	3862	0	14
51	8034	4707	4258	2	14
52	6774	7261	6851	0	15
53	8856	4965	4585	0	14
54	8011	8164	8164	81	-
55	6620	6669	6669	100	-
56	5079	4689	4847	11	44
57	8994	9127	8256	0	19
59	9014	8951	7540	0	23
60	8494	8523	7319	0	27
61	3617	3136	3470	0	17

* = Percent of the territory that is included in a Protected Area (as designated by provincial and federal legislation.

** = Percent of the territory that falls within a Riparian Management Area (RMA). This area may exist as linear corridors of old forest within a second growth matrix, especially in the future as remaining old growth areas are harvested.

In addition, the threshold does not consider additional factors that alter the quality of the habitat. For example, different site series (ecosystems) within the mature and old forest categories are known to provide different levels of forage for goshawks. Plus a significant and uncertain variable also not incorporated into this model is the impact of introduced species. Extensive browsing by deer of the understory can result in removal of much of the understory layers, which may impact abundance of key goshawk prey species such as blue grouse.

POPULATION VIABILITY (STEVENTON, FROM DOYLE 2003).

Assuming HG is an isolated population, using data from HG/QCI on reproductive success, and using survivorship data from other populations (Sweden, S.E. Alaska, and Arizona), a population trend (increasing / decreasing) can be estimated using optimistic and pessimistic interpretations of the data. In both cases, the population is thought to be declining: **Optimistic estimate : 3% decline; Pessimistic estimate : 21% decline.**

Using this range of estimates, the likely Goshawk persistence for HG/QCI can be estimated using a diffusion persistence model. Although simple, this model is designed to include environmental influences on survival and breeding success. Under the influence of moderate fluctuations in these variables, the probability of extinction with the optimistic population trend is shown to change with both the optimistic and pessimistic population trends, and the minimum number of territories (Table 3).

The table shows that as the number of territories increases, the probability of population persistence also increases IF the optimistic population trend is assumed. If the pessimistic population trend is assumed, then the probability of long-term persistence is zero, irrespective of territory number, and it is predicted that the mean time to extinction is within 9 – 15 years.

Table 3. Diffusion persistence approximations for Goshawk population on HG/QCI.

	Optimistic population trend (3% decline)		Pessimistic population trend (21% decline)	
Minimum # of territories	Mean time to extinction	Probability that the population will persist	Mean time to extinction	Probability that the population will persist
10	50	14%	9	0%
20	72	25%	12	0%
30	85	31%	14	0%
40	94	35%	15	0%

The results provided from the model of potentially active goshawk territories estimate that at a minimum, there is the capability for between 11 and 33 potentially active territories. The population model summarised in Table 3 suggests that pessimistically, based on the available data, the probability that the population will be maintained is as low as 14%. Using the more optimistic population size of 33 active territories the probability of population persistence is higher at around 31%.

If the pessimistic population trend is assumed (21% decline, Table 3) then there is an estimated zero probability that the population will persist through time.

An outstanding question remains about the extent of immigration and emigration from the Islands to the mainland for this species. Currently no data are available that demonstrates movement of birds to and from the mainland. Irrespective, if the goal is to maintain an island population of birds management for mature and old forest, combined with management for introduced species will be required.

SUMMARY

Trends in the number of potentially active goshawk territories are presented over time. The number of potentially active territories has declined substantially since 1800, and continues to decline in the future to a minimum level in year 2050. Two different 'thresholds' are used to 'switch on' goshawk territories, because of the uncertainty surrounding how to define a potentially active territory. The general trends using both thresholds are similar, but the resulting number of territories that are potentially switched on is quite sensitive to the value used.

Mature and old forest is used as the key variable in the model and is known to be important for providing goshawk nesting habitat and foraging habitat. However, work is on-going to fine-tune the definitions of foraging habitat for this species, which is known to be more complex than simply defining forests of a particular age.

The goshawk model presented here should be viewed as a an overview of the potential of the forested landscape of the Islands to provide habitat for goshawks, but the reality will depend on additional factors such as management of invasive species, and ensuring that the size and distribution of the forest remaining on the landscape is suitable for goshawks.

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2.6. MARBLED MURRELET (BRACHYRAMPHUS MARMORATUS)

PRIMARY CONTRIBUTORS

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Rachel F. Holt, Veridian Ecological Consulting Ltd.

INDICATOR RELEVANCE

The Marbled Murrelet is a provincially red-listed (endangered) species, as well as COSEWIC (Threatened) listed.

Marbled Murrelets are associated with old growth forest for breeding, and the conservation status for BC is derived from concern regarding loss of nesting habitat over the entire coastal range. It is a relatively vulnerable species, being quite long-lived and with low reproductive rate.

BACKGROUND INFORMATION

Marbled Murrelet is an unusual member of the Alcid[1] family which forages and winters at sea but nests inland in canopy nests on old growth trees; all other alcid species nest in burrows or cliff ledges (see Section 2.7). The first nest ever found was in California in 1974, and the first in Canada was not found until 1990. To date more than 200 additional nests have been found in BC. Marbled Murrelet occurs from California to Alaska and no genetic differentiation across this range is known.

Most of the nests that have been found have been on wide limbs of old growth trees. A very small number of nests have been found in locations other than in old growth trees - a couple on ledges / ground sites and 1 in a deciduous tree (see SFU website[2] for pictures and descriptions of all nests found). Stand characteristics of forests used for nesting include large trees (must have limbs 15 – 75cm wide), epiphyte mats on branches, an uneven canopy and canopy gaps. In Desolation Sound stands with nests had larger mean basal area of trees and greater vertical canopy complexity compared with other random polygons. Predation is thought to be the primary cause of nest failure, with corvids, small mammals (particularly red squirrels), owls and forest hawks all depredating nests. Murrelets typically lay a single egg, and don't commence breeding until between 3-5 years old. Population recovery potential for this species is therefore relatively low.

Most Murrelet nests found have been at lower elevations (84% <1000m), with an apparent preference for lower elevation sites (though not in all studies). Many nests have also been found on steep slopes and nest success increased with slope in Desolation sound, though in this study area the remaining old growth is primarily at higher elevation, due to historic harvesting in the valley bottom. It is hypothesised that the poor maneuverability of Murrelets in flight results in a preference for accessible forest stands; for example broken canopy stands, or those on steeper slopes where birds can access below the canopy relatively easily. It is also hypothesised that steeper slopes may have negative consequences associated with flying further distances and requiring additional energetic

[1] Alcids are seabirds including auklets, puffins, guillemots, murrelets, murres and razorbills.

[2] Website: http://www.sfu.ca/biology/wildberg/species/mamu.html

output to reach the nest (D. Lank SFU pers. comm.). Incidental information suggests that birds tend to use lower elevation passes, and avoid crossing high mountain ridges where possible.

At the landscape level occupied areas tend to have higher proportions of old-growth forest, larger stands and higher stand complexity. Birds tend to avoid the coastal fringe, but otherwise distance to ocean does not generally affect occupancy. On Haida Gwaii, a small study using radio telemetry of birds round that areas with nests tended to be less than 600m in elevation (75%), and all were below 900m. Evidence for the effects of nesting near forest/ human made 'edges' is contradictory; some studies have shown negative impacts of nesting near edges, while others have not. Avoidance of predators is often quoted as a driving factor behind habitat selection by Murrelets. Density of some predators on HG/ QCI (particularly corvids – ravens and jays) is low on HG/ QCI compared to other areas of the coast where predation studies have taken place (F. Doyle pers. comm.), though red squirrels are are quite abundant on the Islands. Local predation effects for the Islands remain unquantified.

There are a number of HG/ QCI studies that do provide local information (quoted from Burger 2000). One study focused around Lagins and Phantom Creek (Graham Island) and showed that the highest numbers of Murrelets were associated with low elevation Sitka spruce / hemlock stands, and that Murrelets were largely absent from the coastal fringe where epiphytes are rare. An additional study (Duschesne and Smith 1997, analysed again by Burger 1999) over 2 years on Graham Island showed few significant habitat associations, with detections being similar on lower slopes and valley bottoms but lower on upper ridges and slopes (though sample size was low). Manley et al. (2000) used radio telemetry to track birds on HG/ QCI and found the nest areas for 7 pairs though individual trees were not identified. Mean elevation of nests was 219 m; 6 of 7 nests were found in forest stands greater than 140 years old (age class 8 and 9), three nests were in trees 19.5 – 28m (class 3), 2 in trees 28.5 – 37.4 (4) and 1 in tree 37.5 – 46.4m (5). Data collected on HG / QCI in the field have been used to test attributes in a Habitat Suitability model outlined in McLennan et al. (2000); see Section 4.7. In addition, detailed habitat suitability analysis using air-photo interpretation (A. Donaldson in prep.) is on-going for the Islands and has been used to calibrate the model used in this work (see below and section 4.7).

The suitability of habitat for Murrelets varies depending on a number of factors and habitat of 'higher suitability' tends to provide habitat for a higher density of birds. Low suitability habitat may provide some nesting sites, but at considerably lower densities. Marbled Murrelet densities are not yet available for HG / QCI (though work is on-going). Densities of birds found in other areas varies from 0.3 – 0.7 birds per hectare in areas of the Sunshine Coast, 0.66 birds per hectare in Clayoquot Sound, and 0.6 nests/ ha in valley-bottom habitat of the Carmanah.

Foraging tends to occur in shallow marine sites with main prey items being macrozooplankton and fish. The impacts of hazards at sea (variety of fishing nets, oil spills, aquaculture etc) are largely unknown. Ocean temperatures likely affect food sources, and therefore Murrelet densities; birds appear to have been negatively impacted by recent warmer temperatures off southern Vancouver Island. Similarly, ocean conditions in Alaska may have reduced forage and impacted populations in that area.

POPULATION PARAMETERS

Birds breed for the first time between 2 – 5 years of age, with average of fledglings per female of 0.17 – 0.22, and adult survival of 0.83 – 0.92 per year. Population models suggest population growth to vary between 0.93 (declining) to 1.02 (increasing) coastwide (Burger 2000).

The extent to which populations of birds are isolated from others will affect the likelihood of local populations being extirpated. However, there is only limited information to determine the extent to which sub-populations of birds interact, although it appears that birds do move considerable distances at sea and birds travel long distances to forage at productive sites during breeding. Radio-telemetry in

Clayoquot Sound has also shown some limited movement of birds between watersheds across years.

Surveys in Laskeek Bay (HG/ QCI) from 1990 – 1998 showed no significant population trends. Although radar counts have been used on HG/ QCI sampling remains insufficient to determine likely population or subpopulation sizes (Manley 2003), though this work is on going and will provide additional data in future.

The current population coast-wide in BC is estimated at 55,000-78,000 birds. The available data are weak for assessing trends though there is some evidence that populations are declining at least in some regions (notably southern and east coast Vancouver Island). Confounding factors include large intra and inter annual variability, lack of consistent census techniques over broad areas, and the likelihood that any trend will be relatively small and hard to detect over large, difficult to sample areas.

Population estimates for HG/ QCI have been made, suggesting a population size ranging from 9500 - 8500 birds (Steventon et al. 2003).

MODEL APPROACH AND ASSUMPTIONS

Population viability can be determined using models that combine life-history parameters into estimates of viability under different scenarios. Such a model has been generated for the Islands, using best available information (see below).

An alternative approach to quantifying the effect of different land use patterns is to compare the amount of the Islands covered by habitat of different quality for Murrelets through time. Indices of changes in available habitat may reflect the percent change in population size for the islands (e.g. Burger 2002; Marbled Murrelet Recovery Team (MMRT)), though it is unclear since the factors limiting population density are so poorly understood. The model described in Section 4.7 and results presented in this chapter summarise the amount of habitat of differing qualities the HG / QCI landscape will supply for Murrelets at different points in time. We assume there is a relationship between amount of habitat and population size of Murrelets.

Overall, a PTT habitat suitability model and results were developed using the following steps:

Task 1: Use preliminary model developed by McLennan et al. (2000) based on field data from HG / QCI as the basis for this work.

Task 2: Review model in light of literature review of attributes relevant to HG/ QCI. Combine relevant attributes into a PTT habitat suitability model (see Section 4.7 for details).

Task 3: Calibrate habitat suitability model by comparing outputs to the results of a detailed air-photo interpretation study done in the Eden Landscape Unit.

Results in: Map of habitat suitability for the Islands that shows 4 classes of habitat (high, moderate, low and unsuitable).

Task 4: Run habitat suitability model on time series for the Islands, to output amount of habitat available through time.

Results in: Distribution and abundance of habitat for Marbled Murrelet of different qualities (high, medium, low, and unsuitable) through time.

Additional details for each step is provided in Section 4.7.

A number of different habitat suitability models have been developed for Marbled Murrelets in BC, and a number of these have been applied on HG/ QCI. Models tend to focus on forest structure which influences canopy accessibility and potential nest site attributes. Accessibility is an important attribute because Murrelets are relatively weak flyers, and it is considered that steep slopes / broken canopies may increase accessibility of potential nest sites. Landscape attributes included in models often include distance to ocean, elevation, slope and factors affecting predation risk (e.g. edge densities). For HG, distance to ocean is not included because of the large number of steep inlets and fjords on the Islands. Slope gradient is not included because data are contradictory on how slope affects habitat quality, and edge variables are not included because a) data are relatively weak, and b) predation risk may be relatively low on the Islands due to low densities of corvid predators.

The PTT model used identifies **habitat suitability**, which is a relative term and suggests that there would be higher densities of birds more often in the higher quality habitat types. It does not say that no Murrelets ever nest in the lower quality habitat types but that this habitat is less often used by the birds.

In addition, the multi-stakeholder Marbled Murrelet Recovery Team (MMRT) has set objectives for population objectives that can be assessed against. MMRT objectives are to ensure that:

- Murrelet populations do not decline by more than 30% from current population over next 30 years. Assuming a habitat surrogate for population size (i.e. no loss of habitat >30%)[3].
- Must be a low risk of loss of viability at end of this 30 years
- Present range should be maintained (in each conservation region and within each region)
- Bird should remain relatively common
- Conservation goals should not be minimal standards.

The analysis presented here can be compared against these objectives over a long time frame, including losses to date from 1800, and predicted declines into the future.

RESULTS

TRENDS

Population persistence is the true measure of the success of a conservation strategy, and maintaining a species across its range (i.e. not losing sub-populations) is considered almost as important as maintaining the entire species. In order to assess the amounts of habitat change, and inferred population changes, at different geographic scales the results are presented at three different geographic scales:

a) Overall Marbled Murrelet trends for the Islands.

b) Overall Marbled Murrelet trends within different Ecosections

c) Marbled Murrelet trends within the 24 Landscape Units

A) HABITAT TRENDS FOR THE ISLANDS

Trends in the amount of Marbled Murrelet habitat in three classes is shown in Figures 1 and 2, plus Table 1. The location of Marbled Murrelet habitat in three different time periods is shown in Maps 20a, b and c.

The overall amount of suitable habitat (high, moderate and low suitability) has declined 42% between 1800 and 2000 (Fig 1; Table 1), and is predicted to decline a further 15% from the amount available in 2000 over the next 250 years. The total decline in suitable habitat is estimated at 50% decline from 1800 – 2250, based on current management. The amount of suitable habitat then levels off at approximately 200,000ha, and remains stable over the remainder of the timeframe. This leveling-off

[3] This objective is considered by the Marbled Murrelet Recovery Team sufficient to maintain the population over the longer term **provided no additional declines occur** after 30 years. It also assumes that a lower level of loss will be required in the more southern populations which are already significantly at risk, with the implication therefore that a higher rate of decline will be accepted in the 'more stable' northern populations.

in the trend curve corresponds to the end of the harvest of old forest on the Islands, and this minimum level represents murrelet habitat retained in protected areas, in areas presumed to be outside the timber harvesting landbase and in reserves maintained in the timber harvesting landbase.

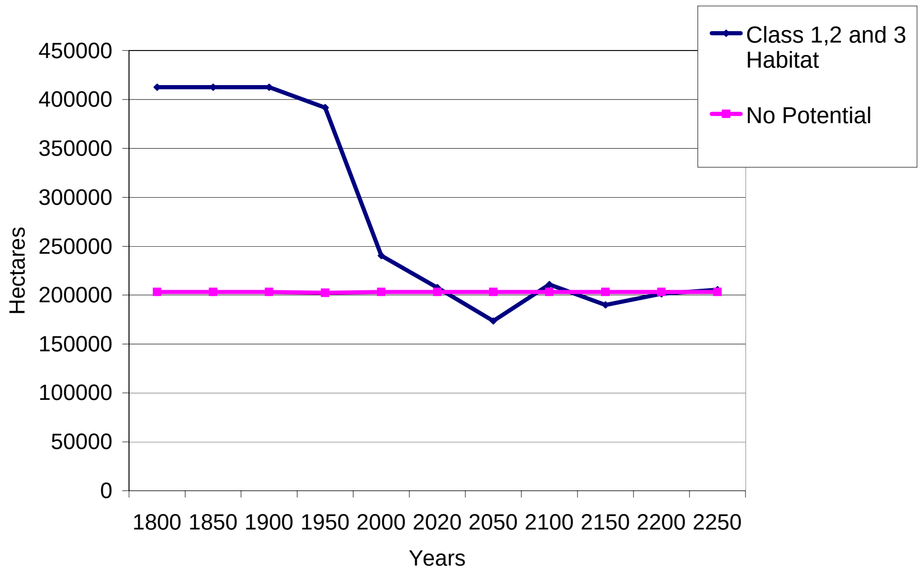

Figure 1. Trends in Marbled Murrelet habitat (Suitable Classes 1,2 and 3) and Areas with No Potential, between 1800 and 2250.

The area of habitat in suitability classes 1 and 2 (high and moderate suitability) provides the vast majority of the habitat for murrelets in the landscape (Fig. 2). Class 3 (low suitability) habitat has always been and remains relatively rare in the landscape. The area of 'unsuitable' habitat includes two types of habitat: a) forest types that have the potential to provide habitat but do not do so in that time period, such as recently harvested areas and b) areas that are never capable of providing habitat such as low structured forest types, bogs, rock areas, alpine etc. This second category explains the high level of originally unsuitable habitat on the Islands in 1800, and which is shown in Figure 1 as habitat that has 'no potential' for Marbled Murrelets.

The total decline comes primarily from a reduction in the highest quality habitat (Class 1) which has already declined by 47% between 1800 – 2000 (Figure 2). To 2000, the moderate and lower quality habitat types have declined less, by 29% and 21% respectively. The amount of unsuitable habitat has increased correspondingly as previously suitable habitat is harvested.

Many of the areas previously harvested but currently in Protected Areas grow back into murrelet habitat through time as indicated by the increase in habitat availability in some areas after year 2050 (Table 1 and Table 3). Areas within the timber harvesting landbase continue to be harvested on a rotation short enough that no additional murrelet habitat is created through time in these areas.

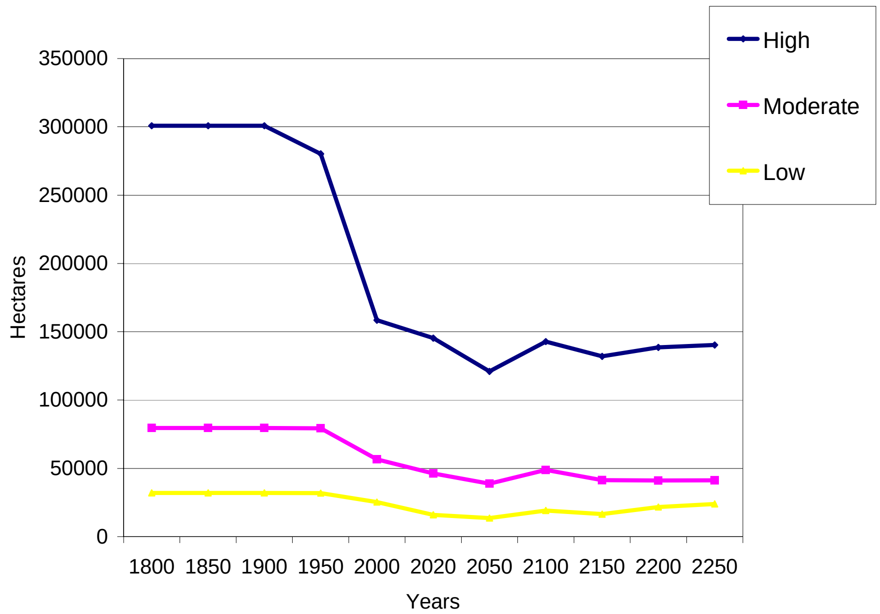

Figure 2. Trends in three classes of Marbled Murrelet habitat (High, Moderate and Low Suitability Habitat).

The area of habitat in each suitability class is shown for years 1800, 2000 and 2250 in Table 1. The area and percent change is also shown for each of three time periods (1800 – 2000, 2000-2250 and 1800 – 2250).

Table 1. Amount of habitat in each Marbled Murrelet suitability class, in 1800, 2000 and 2250. Absolute and percent change between 1800 – 2000, 2000-2250, and 1800 – 2250 are shown.

Murrelet Habitat Suitability				Change* 1800 – 2000		Change* 2000-2250		Change* 1800 – 2250	
	1800	2000	2250	Area	Percent	Area	Percent	Area	Percent
High (1)	300,829	158,494	140,274	142,335	47	18,220	11	160,555	53
Moderate (2)	79,665	56,602	41,272	23,063	29	15,330	27	38,393	48
Low (3)	31,998	25,307	23,995	6,691	21	1,312	5	8,003	25
Unsuitable	591,422	763,512	798,374	+172,090	+29	+34,862	+5	+206,951	+35
All Suitable	412,493	240,403	205,541	172,090	42	34,862	15	206,951	50

Class 1 = highly suitable; Class 2 = moderately suitable; Class 3 = low suitability; Unsuitable includes forest types considered unsuitable, plus other non-forested areas which do not provide habitat.

* All Change is a reduction in habitat, unless indicated by a + sign which indicates an increase in habitat.

PATCH SIZE OF REMAINING HABITAT

The quality of habitat for marbled murrelets is thought to vary with the patch sizes of forest, particularly in landscapes fragmented by forest harvesting, when predation of nests has been seen to be higher in some fragmented landscapes. We did not include patch size in this analysis because there is insufficient information known about exactly how patch size influences habitat quality for this species. However, we did include an assessment of how much of the Marbled Murrelet habitat remaining on the landscape in 2250 is included within Riparian Management Areas (RMAs; Table 2).

Table 2. Area and percent of habitat found within Riparian Management Areas in 2250 for three different habitat quality classes.

Habitat Quality	Area IN RMA	Total Area	Percent
High	14,207	140,274	10%
Medium	2,090	41,272	5%
Low	4,678	23,995	19%

An average of 10% of the remaining suitable habitat (Classes 1, 2 and 3) is located within a Riparian Management Area by 2250, and in fact this situation will likely occur by 2050, which is when the harvest changes from old forest to second growth. We do not know the extent to which RMAs are adjacent to other remaining old forest at the end of the time period (e.g. Protected Areas, or inoperable areas etc), however it is likely that most RMAs (since they are within the timber harvesting landbase) will consist of linear strips of old forest surrounded by a matrix of younger second growth. We estimate that approximately 10% of the remaining murrelet habitat may be of lower quality than predicted by our model as a result. Additionally, the harvesting model assumes that old growth will be retained as 'wildlife tree patches' and Old Growth Management Areas retained. Our model assumes that these areas, irrespective of their size and configuration, will provide similar quality habitat as larger patches.

B) Habitat trends for three ecosections

The distribution of habitat through time in each of the three ecosections is shown in Figure 3.

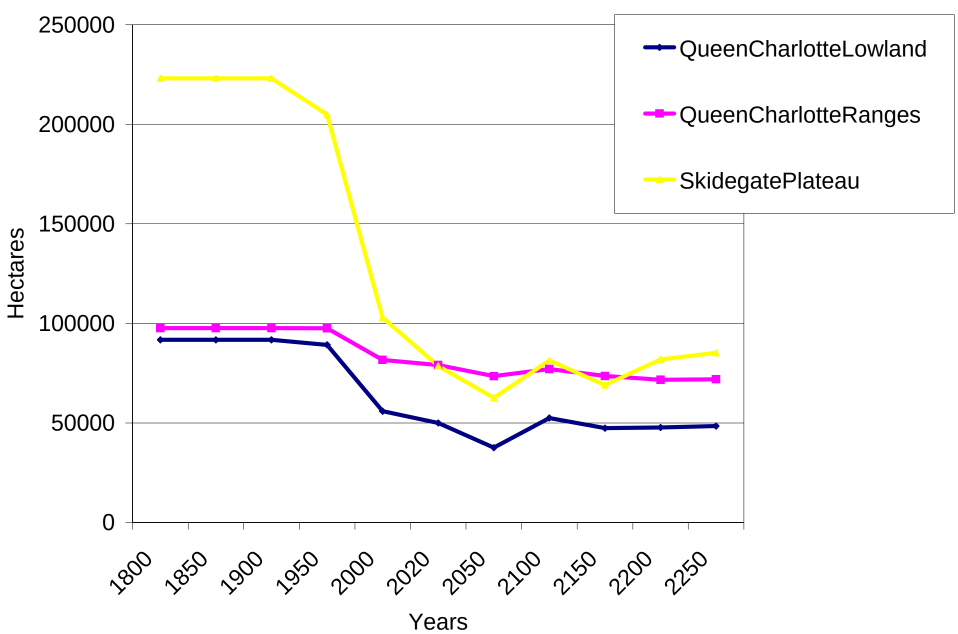

Figure 3. Suitable habitat (Class 1, 2 and 3) trends for three ecosections through time.

Figure 3 shows that more than half of the original suitable habitat was located in the Skidegate Plateau ecosection. To date, this area has also seen the highest decline, and suitable habitat has declined by more than 50% in the plateau since the 1950's. The area of suitable habitat also declines in the two other ecosections, with higher rate of decline in the QC Lowland than in the QC Ranges.

c) HABITAT TRENDS FOR 24 LANDSCAPE UNITS

The original, current and predicted future contribution of different landscapes to suitable murrelet habitat differs. Table 3 summarises the area of habitat in 1800, 2000 and 2250, plus the area and percent change over these time periods.

Table 3. Area of suitable habitat (Classes 1, 2 and 3) in 1800, 2000 and 2250. Area and percent change over three time periods (1800-2000, 2000-2250, 1800-2250). Minimum size change counted 200ha.

Landscape Unit	Area of Suitable Habitat (1+2+3)			Change* 1800 – 2000		Change* 2000-2250		Change* 1800 – 2250	
	1,800	2,000	2,250	Area	Percent	Area	Percent	Area	Percent
AthlowBay	12,333	11,573	8,786	760	6	2,787	24	3,547	29
Beresford	22,487	20,944	14,301	1,543	7	6,644	32	8,187	36
Bigsby	3,476	3,371	3,390	105	3	+19	+1	86	2
EdenLake	23,616	11,980	6,942	11,636	49	5,038	42	16,674	71
Gowgaia	5,338	5,339	5,339	+1	0	0	0	+1	0
Gudal	5,712	4,911	5,115	802	14	+204	+4	598	10
Hibben	13,170	11,409	11,566	1,761	13	+157	+1	1,604	12
Honna	19,509	8,455	6,648	11,055	57	1,807	21	12,861	66
Ian	17,432	12,001	4,014	5,432	31	7,987	67	13,419	77
Jalun	6,855	6,791	3,390	65	1	3,401	50	3,465	51
KunghitIsland	3,269	3,269	3,269	0	0	0	0	0	0
LouiseIsland	18,353	7,739	5,957	10,615	58	1,782	23	12,397	68
LowerYakoun	18,761	8,014	6,691	10,746	57	1,324	17	12,070	64
LyellIslandGroup	19,379	11,666	17,662	7,714	40	+5,996	+51	1,718	9
MassetInlet	42,071	18,246	12,301	23,825	57	5,945	33	29,770	71
Naikoon	20,125	13,674	22,406	6,451	32	+8,733	+64	+2,282	+11
Otun	10,073	8,505	3,488	1,568	16	5,017	59	6,585	65
Rennell	16,965	12,103	12,177	4,862	29	+73	+1	4,789	28
Sewell	26,814	12,124	9,011	14,690	55	3,113	26	17,803	66
SkidegateLake	43,415	9,424	7,958	33,991	78	1,466	16	35,457	82
Skincuttle	13,800	13,246	13,620	554	4	+374	+3	180	1
Tasu	12,133	5,769	4,648	6,364	52	1,122	19	7,485	62
Tlell	18,540	10,686	9,163	7,854	42	1,523	14	9,377	51
YakounLake	18,863	9,166	7,701	9,697	51	1,465	16	11,162	59

* All Change is a reduction in habitat, unless indicated by a + sign which indicates an increase in habitat.

As of 2000, 13 of 24 Landscape Units showed a decline in total marbled murrelet habitat of greater than 30% from historic levels, and 8 have shown a decline of greater than 50%. Following the Marbled Murrelet Recovery Team assumption that population density is linked to suitable habitat abundance, this suggests that murrelet populations may be significantly reduced over more than 50% of the landscape of the Islands.

Although we have not attempted to assign density ratings to habitat of differing qualities (in order to estimate a population size and change), the habitat that has been lost has tended to be Class 1 to date. For example, originally (in 1800), Skidegate Lake, Masset Inlet, Sewell, Eden Lake, Beresford and Naikoon Landscape units had the most marbled murrelet habitat available on the Islands (each landscape unit contributed more than 20,000ha), most of which was Class 1 (high quality habitat). Skidegate Lake, Masset Inlet, Sewell, Eden Lake and Naikoon Landscape Units have all seen declines to date of more than 30% of this Class 1 habitat, with only Beresford remaining with a significant percent of the original suitable high quality habitat. This suggests that in fact the reduction in density of birds may be greater than the overall loss of habitat suggests, since primarily the high quality habitat has seen most reduction to date.

WHERE IS THE HABITAT REMAINING TODAY?

All the results above demonstrate where habitat has been reduced for Marbled Murrelets. Table 4 below identifies those landscape units where significant amounts of habitat remain. High quality and moderate quality habitat is added together and shown for each Landscape Unit (sorted highest remaining to lowest). Low quality (Class 3) habitat is shown separately. This summary does not take into account the original amounts of habitat available in any landscape unit, for example Bigsby currently does not contain much suitable habitat but this simply reflects the low potential of the LU.

Table 4. Hectares of high and moderate suitability, and low suitability marbled murrelet habitat in each landscape unit. LU's are ranked from highest to lowest amount of habitat remaining.

Landscape unit	High and Moderate Suitability (1+2)	Low Quality (3)
MassetInlet	17,696	550
Beresford	14,160	6784
Skincuttle	13,238	7
Ian	11,964	37
LyellIslandGroup	11,662	3
Sewell	11,601	522
Naikoon	11,324	2349
Hibben	11,136	273
Rennell	11,069	1034
AthlowBay	10,421	1152
EdenLake	10,249	1731
Tlell	9,505	1181
SkidegateLake	9,360	64
YakounLake	8,839	327
Honna	7,787	667
LowerYakoun	7,562	452
LouiseIsland	7,294	445
Gowgaia	5,326	13
Tasu	5,064	705
Otun	4,766	3739
Gudal	4,312	598
Jalun	4,130	2661
Bigsby	3,366	4
KunghitIsland	3,268	0

CURRENT POPULATION VIABILITY

A detailed population viability analysis has been undertaken for Marbled Murrelets on the entire coast of BC. The analysis used a range of life-history parameters produced from the many studies coast-wide, and used expert opinion to estimate likely ranges for unknown parameters (Steventon et al. 2003). It contained separate demography, nesting habitat and ocean effects models, combined into a

Bayesian Belief Network model. Within this analysis HG/ QCI was analysed separately as a Conservation Region for Murrelets. Modeling also used sensitivity analysis to test the effects of different assumptions on the outcome of the model.

Initial population size was estimated for HG/ QCI (Burger 2002): **Most likely population size = 9500 individuals; Pessimistic population size = 8500 individuals**

Note that these estimates were considered some of the least reliable of the different conservation units for murrelets across the entire coast. Most of the HG/ QCI counts come from 'at sea' surveys which tend to underestimate the total number of birds when compared with radar counts. In addition, density of birds per watershed seems to be highly variable on North and Central Coasts and HG/ QCI, which again makes it difficult to estimate likely population size.

Using these ranges for population size, a population viability analysis estimated expected probability of population persistence over time (Steventon et al. 2003; Table 5).

Table 5. Expected probability of population persistence for HG/ QCI using current population estimates, and after 50%, and 65% declines in current population size (from Steventon et al. 2003). Range within table cells ranges from using the two estimates of current population size, and the strength of environmental correlations among regions.

Scenario	Expected probability of population persistence using current population sizes, and under each scenario
Current population size	83–84 % probability of persistence
Assuming a 30% decline in population size as allowed by recovery team**	77–79 %
Assuming a 50% decline in population size	70–71 %
Assuming a 65% decline in population size	62–64 %

**30% decline over 30 years is suggested by MMRT as sufficient to allow delisting of the bird in the future.

This model shows that the probability of persistence of the murrelet population on HG/ QCI is currently quite high, using either estimate of population size (83 – 84% probability of persistence). Decreasing the population size however results in a quite significant decrease in the probability of persistence over time (down to 62%).

Note, however that this analysis does not analyse the extent to which the larger the conservation goal of maintaining healthy populations of birds throughout their range (i.e. in all Landscape Units). As outlined above, based on habitat availability, more than 50% of LU's may already have seen a significant reduction in population size since 1800.

SUMMARY

This analysis summarises the trends in three classes of marbled murrelet habitat (high, medium and low suitability), through time. Data are summarised at three spatial scales; for the Islands as a whole, for the three ecosections and for 24 landscape units. The model results are dependent on the extent to which the timber harvest forecast reflects the reality of future harvesting.

The amount of suitable (Classes 1,2 and 3) habitat for murrelets has declined since 1800 to 42% of its original level, and is predicted to decline to 50% of its original suitable level by 2050, and to remain at about that level into the future.

The analysis presented assumes that Marbled Murrelet habitat is retained across the landscape within Protected Areas, as exclusions within the timber harvesting landbase and in areas considered not harvestable due to economic constraints. As outlined in Section 2.1 summary (Old Forest) these different areas provide habitat values at different levels of certainty. At the end of the time period (2250) only 33% of the remaining Marbled Murrelet habitat is retained within Protected Areas, the remainder consists of a) areas retained within the Timber Harvest Landbase (e.g. wildlife tree patches, riparian areas, etc), and b) areas assumed to be retained to due their current low economic value. Considering a) in 2250, 10% of remaining suitable murrelet habitat is predicted to be captured in riparian management areas (RMAs), which may have lower habitat qualities that predicted in our model due to high probability of windthrow and the lack of interior habitat conditions which may reduce predation. Additionally,the analysis does not include a more detailed patch size analysis, and we do not know the extent to which patch size distribution of the remaining habitat may reduce our predicted habitat values. Considering b), some habitat is likely retained in areas currently considered uneconomic to harvest but which have no protected status should economic values change. As a result, the amounts of habitat retained in the future may a) have lower values than predicted by the model, or b) may not be retained at all if economic situation changes.

To date, the largest declines have been observed in the Skidegate Plateau ecosection. More than half the landscape units on the Islands have seen a larger than 30% decline between 1800 and 2000, most of which are found within the Skidegate Plateau ecosection. The largest reduction currently has been in the Class 1 habitat (high quality), which suggests that the population reduction associated with the loss of habitat may be of larger magnitude than is suggested simply by the extent of habitat loss.

The Marbled Murrelet Recovery Team suggested that a decline of 30% from current levels would be an adequate conservation goal for Murrelets coast-wide. However, they did not inform this target with an assessment of the extent of reduction in habitat and population sizes that has already occurred. In this chapter, the analysis shows that Marbled Murrelet habitat, and therefore likely associated population sizes, has already declined by an average of 42% on the Islands, with considerably higher levels of reduction in individual Landscape Units.

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2.7. SEABIRD COLONIES

PRIMARY CONTRIBUTORS

Harfenist, A. 2003. Seabird colonies background report for the Haida Gwaii / Queen Charlotte Islands Land Use Plan. Prepared for MWALP.

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INDICATOR RELEVANCE

The HG/ QCI supports approximately 1.5 million breeding seabirds of 12 different species which nest on more than 200 islets, islands and rocks in the HG/ QCI archipelago. This very large diversity and abundance has additional global significance since it also represents more than half the global breeding population of Ancient Murrelets, and one fifth of the breeding population of Cassin's Auklets.

In addition to providing critical foraging habitat for breeding birds, the ocean areas surrounding HG/ QCI are also used by millions of seabirds when they are not breeding. This includes providing habitat for maturing juveniles, for over-wintering and as a stop-over area on annual migrations.

BACKGROUND INFORMATION

There are twelve species of seabirds nesting in the HG / QCI archipelago. Two species of Storm-petrel – Fork-tailed and Leach's Storm-petrel; the Pelagic Cormorant and the Glaucous-winged Gull. Plus eight alcid species - Common Murre, Pigeon Guillemot, Marbled Murrelet, Ancient Murrelet, Cassin's Auklet, Rhinoceros Auklet, Horned Puffin, and Tufted Puffin.

Currently, the vast majority of seabirds nest on the Islands off the northwest coast of Graham Island, and the northwest, south and east coasts of Moresby Island. In addition, islands within Masset and Skidegate inlets also have nesting colonies of gulls and pigeon guillemots. Map 21a shows the locations and approximate sizes of known nesting colonies. The numbers and distribution of individuals differs greatly across species. Some species are extremely abundant and widespread, representing a high percentage of the total birds in existence while others are locally very rare and localised in distribution.

Seabirds typically spend most of their life cycle on the ocean and come to land only for breeding. The exception in the above list being the glaucous-winged gull which spends more time in inshore areas. The primary areas of relevance to land use planning are therefore breeding colony Islands within the archipelago.

Detailed species information is provided in Harfenist 2003, and is summarised from that report for each species in brief below.

STORM-PETRELS

There are approximately 156,000 pairs of Storm-petrels nesting on the Islands, with roughly 53,000 pairs of Fork-tailed and 103,000 pairs of Leach's Storm-petrels, which represents about 21% of the BC population of storm petrels. These birds tend to nest on small forested islands, laying a single egg in a burrow in June (for Fork-tailed) and in August (Leach's Storm-petrel). Chicks are fed on invertebrates and larval fish and fledge from the nest approximately 60 days after hatching. Adults return to the colony only at night.

There are 70 known colonies with one or both petrel species, and an additional 18 that are known to have been abandoned. Many of these local extirpations have unknown causes; though a number of islands have lost colonies as a result of introduced rats.

Map 21b shows the location and size of colonies for this species. Estimated marine density usage is also indicated[1].

PELAGIC CORMORANT

Cormorants nest in colonies on cliff ledges and in caves on offshore islands as well as on Graham and Moresby Islands. Pelagic cormorants are found primarily in shallow in-shore waters since they feed on bottom fish. Exact numbers of cormorants are unknown: the latest survey estimated 280 pairs in 1986 however since 430 birds were observed flying from 16 previously unidentified cave locations in 2000 this is likely an under-estimate. The number of colonies / breeding sites is estimated at 42. More accurate population estimates are hard to determine since numbers of birds nesting in caves is difficult to estimate. Pelagic cormorants are red-listed in BC due to recorded declines in populations and colony sites, however population numbers may reflect poor sampling effort and movements in colonies. Population trends for HG / QCI are uncertain but probably declining.

Map 21c shows the location and size of colonies for this species. Estimated marine density usage is also indicated[1].

GLAUCOUS-WINGED GULL

Glaucous-winged gulls nest on rocky headlands or other open areas of islands and nest both colonially or solitarily. They are found in-shore and off-shore. Between 1 and 3 eggs are laid in open nests on rocks. Primary food sources include invertebrates and fish taken from the ocean surface and birds also forage through the intertidal and in garbage from humans. On HG/ QCI approximately 2800 pairs of birds nest at 110 known breeding sites with only a single extirpation known. This number represents 11% of the BC population and in coastal BC the population of gulls has increased 350% from 1940 – 1990. It is thought that the HG / QCI population is also increasing.

COMMON MURRE

Murres nest on cliff ledges in colonies, laying a single egg on the rocky edge. Chicks are fed during the day by fish caught by adults foraging underwater. There is only a single known colony on HG / QCI located in the Kerouard Islands and between 0 – 400 birds have been observed in this location. Other locations are possible, but overall numbers of birds are low in the archipelago. The species is red-listed in BC because the concentration and low number of birds results in a high vulnerability for extirpation.

PIGEON GUILLEMOT

Pigeon guillemots are one of the most commonly sighted seabirds in the archipelago being abundant and located in many inshore locations. They nest primarily in burrows or on cliff ledges, laying 1 or 2 eggs and foraging for invertebrates and fish underwater. Approximately 5100 guillemots have been counted on the waters around 157 probable breeding islands though estimates of the numbers of breeding birds are unknown. However, it is estimated that the Islands provide breeding habitat for approximately 50% of the BC population and 6% of the global population of birds. Overall population trend data are unavailable for the Islands, but it is likely that local populations on Islands have been extirpated by introduced rats and raccoons.

Map 21d shows the location and size of colonies for this species. Estimated marine density usage is also indicated[1].

MARBLED MURRELET

See Section 2.6 for more detailed assessment of this species.

ANCIENT MURRELET

Ancient Murrelets nest in colonies and in burrows, usually on forested islands. Pairs lay 2 eggs and adults return to the colony only at night. Chicks leave the burrow within a few days of hatching and

[1] Density was evaluated using a decaying function with a radius of estimated normal marine useage of nesting birds. Results were squareroot transformed.

are fed on the ocean on fish and large zooplankton. This species is primarily found off-shore though they congregate around the colony in the afternoon and through the night. Approximately 256,000 pairs of birds nest in 33 colonies in the archipelago. About half of these nest off the West Coast of Graham Island on Langara, Hippa and Frederick Islands. HG/ QCI is the only site in Canada where Ancient Murrelets breed and this number represents about 50% of the global population. Overall, the population is thought to have declined by about 50% since last century; at least 9 colonies have been abandoned and declines have been seen in another 6 colonies. These declines are thought to be due primarily to introduced predators. In another 5 Islands, where predators have not been found, the populations of birds has increased which may have resulted from movement of birds to safer nesting sites. Abandonment of another 10 islands is unexplained, though may be related to predators. Introduced predators have been removed from 4 groups of Islands.

The Ancient Murrelet is blue-listed (vulnerable) as a result of the concentrations of birds and the vulnerability to introduced predators, in addition to threats from human disturbance, gillnets and oil spills.

Map 21e shows the location and size of colonies for this species. Estimated marine density usage is also indicated[1].

CASSIN'S AUKLET

Cassin's Auklets nest in burrows under grassy hummocks or in the forest. Pairs lay a single egg, and the chick is fed zooplankton and larval fish. This species is the most numerous on the Islands, with an estimated 297,000 pairs in 45 colonies. The Islands represent about 18% of the global population, with BC representing about 80% of the global population. Overall population trends are unknown but numbers have declined at some colonies and at least 7 former nesting sites have been abandoned. The species is blue-listed (vulnerable) because of the relative concentration of birds and colonies.

Map 21f shows the location and size of colonies for this species. Estimated marine density usage is also indicated[1].

RHINOCEROS AUKLET

Rhinoceros Auklets nest in burrows under grassy hummocks or moss. Pairs lay a single egg and chicks are fed small fish caught by adults foraging underwater. Adults return to the colony at night only. Approximately 24,000 pairs nest on the Islands in 19 colonies found around the south and northwest coasts of Moresby Island, with extirpation from 6 known colonies. This number represents 7% and 4% of the BC and global population respectively. Rigorous trends are unavailable but numbers are thought to have declined over the last 50 years due to introduced predators causing abandonment and declines of some colonies.

Map 21g shows the location and size of colonies for this species. Estimated marine density usage is also indicated[1].

PUFFINS

Two species of puffin nest on the Islands

Horned puffins nest in burrows on grassy slopes or in small crevices along cliff ledges. Pairs lay a single egg and chicks are fed on fish, invertebrates and squid. Breeding of this species on the archipelago is unconfirmed, though is suspected on a number of sites around the south east of Moresby Island due to presence and behaviour of birds during appropriate time periods.

Tufted puffins nest colonially in burrows on grassy slopes. Pairs lay a single egg and chicks are fed small fish and invertebrates, which are caught underwater. The number of pairs is roughly estimated at about 560 pairs nesting at 12 known colonies. The islands represent less than 1% of the global population. Regional population trends are unknown but local declines and abandonments have been documented. Rat predation is probably the cause at some sites. Tufted puffins are blue-listed (vulnerable) in BC due to the concentrated breeding locations.

Map 21h shows the location and size of colonies for this species. Estimated marine density usage is also indicated[1].

LAND USE CONCERNS

Exact estimates of population trends for many species are unknown. However, it is known that a significant number of colonies for many of the species have been extirpated or undergone significant declines relatively recently. The global and local significance of the seabird colonies, and their vulnerability to a number of different pressures make this of particular concern. In addition, although this work focuses on terrestrial concerns, it should be remembered that a significant portion of the life-history of most of these species is spent on the ocean which also provides year-round food supplies. Complex factors affecting sea temperature, conditions and forage supplies could significantly impact the status of populations on the Islands.

INTRODUCED SPECIES

The majority of seabird colonies were historically on islands with no mammalian predator species. The introduction of non-native species particularly rats and raccoons has had dramatic impacts and caused the extirpation / abandonment of a significant number of colonies. Rats and raccoons both eat eggs, chicks and adults in burrows and will also kill adults on the surface when possible. Together, these predators have resulted in extirpation of a large number of colonies and have significantly reduced some species on other islands. For example, Ancient Murrelets on Langara Island were reduced from 200,000 pairs to 14,600 in 1993. Rats have been removed from this island since 1993, but the colony has not shown signs of recovery since this time. A detailed list of colonies impacted by introduced species is listed in Harfenist 2003.

HABITAT LOSS AND DEGRADATION

Habitat loss of old growth forest is considered a primary concern for Marbled Murrelets and is dealt with in detail in Section 2.6. In addition, harvest and salvage around edges of Islands may be a concern on any seabird Islands, particularly Ancient Murrelets, Cassin's and Rhinoceros Auklets and Storm-petrels. Forestry activities that impact marine environments may also have negative impacts, for example run-off and sedimentation effects close to colonies or impacting fishing areas.

Other terrestrial developments may degrade habitat conditions for seabirds, including fishing lodges , recreation sites or marine aquaculture operations built on or close to current or historic colonies.

TOURISM AND RECREATION

Tourism activities may impact seabirds in a variety of ways and because nesting seabirds and tourists tend to use the same areas at similar times of year the potential for impacts is quite high. Impacts include direct degradation of habitats and disturbance of birds on nests and during foraging.

The approach of people too close to nesting areas can cause surface-nesting birds (gulls, cormorants, and murres) to leave nests rapidly, knocking chicks and eggs off rocky ledges. Absence of parents can also result in increased predation of eggs or chicks by gulls and ravens. People wandering in forests can also cause burrows to collapse.

Many seabirds are primarily nocturnal and for these species lights around the nests and islands (on-shore or off-shore) can cause disorientation and sometimes prevent birds from leaving or approaching their islands. Disoriented birds may crash into buildings, ropes or other obstructions causing death or injury. Potential light sources include lodges, commercial and pleasure boats close to islands, campfires, flashlights etc. These effects can be quite significant, for example Ancient Murrelets chicks leaving the nests may move towards the lights rather than to safe locations on the ocean.

At sea concerns include boats and kayakers disturbing foraging birds, especially in inshore waters. Oil contamination from boats may also be a problem.

OFF-SHORE OIL AND GAS DEVELOPMENT

Off-shore oil and gas development has the potential to impact seabirds in two broad ways. First, on-going impacts could be caused by collisions with infrastructure and potential repeated exposure to low level pollution sources such as from leaking pipes or from bilge pumping etc. The potential impacts would depend on specific locations of developments. Second, the potential for larger scale catastrophic effects of oil spills obviously has a large potential impact for seabirds throughout the archipelago and across the coast.

COMMERCIAL FISHING

Incidental catch (bycatch) of seabirds in gillnets and longlines, over-fishing of seabird prey and disorientation of nocturnal seabirds by boat lights are the main issues of concern related to commercial fishing. Bycatch of Ancient Murrelets and Cassin's Auklets in salmon gill nets near Langara Island during the breeding season has been recorded and likely contributed to population declines at that colony. It is estimated that as many as 25,000 seabirds may be killed annually in fishing gear in the province. Diving species are at greatest risk from salmon gill nets: Common Murres, Marbled Murrelets and Rhinoceros Auklets, as well as Ancient Murrelets and Cassin's Auklets mentioned above, have been recorded in B.C. gillnets. Herring gillnet fisheries and salmon troll fisheries are not considered to be as significant a problem. Surface feeding seabirds such as albatrosses and shearwaters are the main species at risk from longline fisheries.

Pacific herring (*Clupea pallasii*) and juvenile rockfish (*Sebastes* spp.) are important prey items for seabirds nesting in Haida Gwaii/Queen Charlotte Islands and depletion of stocks from commercial and recreational fishing are a concern. If the euphausiid (zooplankton) fishery expands to the waters around the archipelago, species that feed on plankton could be impacted.

Marine aquaculture operations may cause entanglement by seabirds in wires and nets and habitat degradation. The use of anti-foulant chemicals in marine aquaculture operations has also been identified as a risk for seabirds.

CLIMATE CHANGE

As discussed in Chapter 1, climate change scenarios are at best speculative for the archipelago. However, the reliance of seabirds on ocean currents to provide foraging opportunities is well known and changes in currents may have unpredictable effects on populations. It is known that ocean warming has changed the timing, abundance and distribution of seabird prey in different areas of the Pacific. For the Islands it has been suggested that reduced survival of adult Cassin's Auklets on Frederick Island and decreased reproductive success of Ancient Murrelets in Laskeek Bay are related to warm oceanic waters associated with El Niño events.

WINDFARM TURBINE TOWERS

Little information exists as to the potential impacts of land or marine-based turbine towers. Mortality rates for birds have been seen to differ with different types / speeds / sizes of turbine, and depending on location in relation to fly-ways for nocturnal or diurnal birds. The altitude at which different species habitually fly is a critical factor in determining impacts.

LAND STATUS ISSUES

Although many of the important seabird nesting areas are already protected, significant colonies such as Frederick, the largest colony in the archipelago and second largest in B.C. remain unprotected. Additionally, within 'protected' islands the status of protection differs; some islands are seasonally closed during the breeding season while others are completely closed to access while others are only closed to camping. Development of the intertidal and nearshore areas is additionally unrestricted on some 'protected' islands. The effectiveness of any protection depends on potential visitors understanding the different designations and complying with them. Enforcement of these regulations is difficult due to the large scale of the area involved.

In addition, there remain islands and islets that are not protected. These are highlighted in Map 21.

Key issues of concern include current and potential future tourism and / or lodge developments on seabird islands. Additional concerns relate to introduction or reintroduction of rats and other predatory species from boats, plus unregulated disturbance and impacts of lights on night flying seabirds.

PRIMARY INFORMATION SOURCES

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2.8. HAIDA GWAII BLACK BEAR (URSUS AMERICANUS CARLOTTAE SUBSPECIES)

PRIMARY CONTRIBUTORS

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INDICATOR RELEVANCE

There are three key reasons why the The Haida Gwaii black bear was selected as an indicator of environmental conditions:

- Haida Gwaii black bears are an endemic sub-species (*Ursus americanus carlottae*), unique to the Islands
- The isolated race is the largest native omnivore and is an 'umbrella' species with large area and highly diverse habitat requirements (by managing for effective habitat for black bears, the habitat requirements of other species may be addressed)
- Black bears are also considered a "keystone" species: their transport of salmon from spawning channels into adjacent forests is recognized as a critical component of nutrient transfer in some forest ecosystems.

BACKGROUND INFORMATION

The black bear is widely distributed throughout British Columbia, and is the most widely distributed bear found in North America. The subspecies found on HG /QCI is generally larger than its mainland counterparts with a huge skull and molars, and is only found as a black colour phase. These physical differences are thought to result from retaining characteristics after a long period of isolation during the last ice-age. Populations of black bears cannot sustain high kill rates by humans (greater than 6% per year). Roads (which bring people into black bear habitat) and conflicts over human food and garbage can create situations where bear mortality exceeds natural population growth. Black bears are considered to be secure in BC, and have been assessed but not listed by COSEWIC.

Black bears are a generalist species, classified as carnivores, but have a wide ranging diet that includes vegetation, making them "omnivorous". Bears feed on concentrated food sources to conserve energy. Consequently, they use a wide range of habitat types, often only avoiding high density human settlements. In spring and summer, post-hibernation, they eat primarily succulent vegetation (found in meadows, estuaries, grassy south-facing slopes and some clearcut areas) and in intertidal areas where they eat crabs, barnacles and amphipods (sand fleas). They also prey on newborn deer fawns. Throughout the summer and into fall they feed on insects and larvae, berries and carrion opportunistically as well as continuing to graze on succulent vegetation. Roadside margins are problematic: hydro-seeded areas can be very attractive forage sites but as a result may be associated with higher levels of human-caused mortality than other habitats. Closed canopy, second growth forests are typically avoided by bears because they lack productive understories, are little used by deer, and also lack adequate bedding habitat. Riparian (streamside) habitats are used across seasons for feeding and travel. High alpine grassy areas offer grazing opportunities that persist into the summer, as higher elevations green up later in the season. The importance of Pacific salmon to bears in Haida Gwaii has been well established (Reimchen 1998a, 1998b, 2000).

The lack of ability to digest coarse forage and the rigours of hibernation result in bears requiring high quality food sources to be accessible year round. The key unknown factor regarding forage on Haida Gwaii is the extent to which bears forage on Black-tailed deer. Work is underway to investigate the annual contribution deer make to the typical black bear diet on the Islands.

Black bears have relatively low reproductive rates. Females often don't breed until the age of 5 or 6, and males often don't mature until the age of 4 or 5. After delayed implantation, 1-3 cubs are born during hibernation in January or February, at which time they are hairless and helpless. They nurse until the mother leaves hibernation, and in that time gain 2.5 – 4.5 kg in weight. Hibernation usually lasts 3 – 5 months in southern coastal regions, and it is expected to be the same on Haida Gwaii. Cubs stay with their mothers for at least a full year, and often longer, only being chased from her home range when she is ready to breed again. Female cubs often remain in their natal home ranges, sharing the home range with their mothers and grandmothers.

Coastal black bears depend upon old-growth structures to provide winter denning sites (Davis 1996). Dens are usually found in large standing live or dead trees, or down dead trees, logs and stumps. Size of these features is usually greater than 1.4m diameter. Natal dens have been found up to 25m above ground level, and such sites may provide additional security from disturbance or predation from other bears. Den sites are most often found in large western red cedar (*Thuja plicata*) and yellow cedar (*Chamaecyparis nootkatensis*). Second growth forests may provide den sites in old growth stumps or logs for the short-term, but these structures are relatively rare, and will rot and will not be present in typical third growth stands.

Home ranges of bears are typically 2,500 to 15,000 ha for adult males and 500 to 2,500 ha for adult females. Individual bear behaviour is considerably influenced by interaction with other bears and proximity to human settlements (bear-human conflicts). Some bears are displaced from preferred habitat by vehicles and other machinery, but others will become habituated to such disturbances.

Factors which can increase bear mortality include: higher bear densities (from predatory interactions between individuals / usually males and cubs), higher road densities (hunting pressures + direct mortality), expansion of human settlements (interactions between bears and humans over human food and garbage usually result in bear mortality). Road density is included as a modifier in the model described below, as a reduction in habitat quality.

The BC population of black bears is estimated at between 120,000 - 160,000 animals, with higher densities found in areas with wetter climate and more lush vegetation than in dry regions. Coastal densities are also higher due to availability of high nutrient salmon stocks. Current density estimates for Haida Gwaii are between 1 bear per 100 ha to 1 bear per 500 ha for the Coastal Western Hemlock Zone.

For this process, a map of black bear residency on Haida Gwaii has been produced where "residency" is defined as year-round occupancy of adult female black bears. Occassional sightings of bears on small islands for short periods of time are insufficient evidence of year-round occupancy. Work is underway to determine the genetic diversity of Haida Gwaii Black bears. If sufficient diversity is present, it may be possible to conduct a population inventory using systematic hair collection from live animals, and DNA analysis of the hair samples.

MODEL APPROACH AND ASSUMPTIONS

Additional details are available in Chapter 4.9.

Watershed Model: This model uses Broad Ecosystem Inventory (BEI), an intermediate ecological land classification between Biogeoclimatic variants and Site Series. Broad Ecosystem Units (BEUs) subdivide variants into permanent areas of the landscape that support a distinct type of dominant vegetation cover, or distinct non-vegetated habitats such as lakes or outcrops. One of the advantages of using BEI is that each forested unit is defined as including potential (climax) vegetation and associated successional stages. The BEI for Haida Gwaii was subjectively ranked into 6 habitat suitability classes, according to estimated forage values. The habitat suitability ratings table of BEUs is provided in Chapter 4.9. Habitat suitability classes were weighted by BEU area and generalized to the level of watersheds.

The watershed model also uses estimates of salmon biomass, based on analysis of the escapement estimates for all species. Average escapements for 1992-2001 were linked to the 1:20,000 TRIM stream network for a spatial representation of the amount and distribution of salmon available to bears. The model creates an index of kilograms of salmon per hectare for each PTT watershed.

Current and future road mapping was used to explore the potential influence of roads on habitat suitability and mortality risk. Road mapping was analyzed using a specialized roving window approach that creates the equivalent of road contour mapping. The higher the road density, the more likely that bears will be displaced from preferred habitat by people and vehicles and the higher their mortality risk from being shot. As such, the road density mapping can be used to step-down *suitable* habitat to estimate the amount of *effective* habitat. Effective habitat is useable habitat that is rated not only for its underlying suitability, but also for the level of expected human influence on the area.

The model provides as output estimates of the availability of habitat of different qualities (Map 18).

Key limitations of the model include:

- Lack of understanding how deer may alter forage choice of bears, particularly in the spring and during the fall berry feeding periods (bears elsewhere in coastal BC are highly dependent on berries) – suitability ranks were based on expected vegetative forage value. Because these ranks are likely equivalent to deer habitat value, and deer may form a significant portion of black bear diets, model output may still be reliable.
- Scale of mapping: No Islands-wide ecological land classification was available other than Broad Ecosystem Inventory. Mapping of BEI is conducted at 1:250,000 scale. As such, small, important habitat units are not identified at this level of resolution.
- Lack of understanding of the population value of forage opportunities on shorelines
- Lack of understanding of the relative contribution among vegetative, shoreline, deer and salmon forage sources to both individual survivorship and population welfare

RESULTS: CURRENT CONDITION

Relative habitat value for black bear habitat for year 2000 is shown on Map 19 . Watersheds throughout the Islands differ in their current contribution to black bear habitat value, largely dependent on the availability of spawning salmon, the landscape dominance of closed canopy, coniferous second growth and road density.

The ten top salmon biomass producing streams in descending order are:

- Yakoun River
- Pallant Creek (although all of the enhanced escapement may not be available to foraging bears)
- Deena Creek
- Naden River
- Mathers Creek
- Davidson Creek
- Ain River
- Kaisun Creek
- Copper Creek
- Lagoon Creek
- Mamin River

Each of these streams produces and average of over 80,000 kg. annually. Other streams may have higher escapement, but these watersheds reflect Chum distribution, rather than the smaller body sized Pink or Sockeye salmon.

The Broad Ecosystem Inventory, when weighted for area and presented at the watershed scale, suggests only limited variation in habitat suitability across Haida Gwaii. This is likely to reflect reality because higher habitat values tend to be associated with small patches of only a few habitats. For example, higher habitat values occur on estuaries, and along some shorelines where inter-tidal areas can be productive feeding sites. As well, some wetland areas also have higher habitat values, especially rich "fen" wetlands rather than the more common poor nutrient bogs. Similarly, riparian habitats (forested and non-forested), are important cross-seasonal habitats and are frequently used as travel corridors (e.g. Alder or Spruce forests on floodplains), but typically occur in patches of limited size. As a result, when habitat suitability is generalized to a larger area, the lower value / high area habitats 'wash out' the contribution of the high value units. Variation on the interpreted Broad Ecosystem Map is due to variation in the distribution of low value closed canopy second growth forests (which has a negative influence on value) and higher habitat diversity in mountainous terrain (which has a positive influence on value).

SUMMARY

Although a wide variety of factors influence the abundance and distribution of black bears on Haida Gwaii, the availability of Pacific salmon is perhaps the best index of relative habitat value. Bears, especially males, may travel some distance to take advantage of the available high quality food source, particularly important to over-winter survival. Cub production and survival is likewise strongly influenced by salmon fishing.

The second major influence is the distribution of closed canopy second growth, which is typically neither suitable black bear nor deer habitat. The availability and spatial distribution of smaller scale seasonally important habitats like estuaries, rich non-forested wetlands, riparian areas, beaches and intertidal areas, alpine grasslands, and berry patches also strongly influence bear habitat value (although at a scale not apparent in this modeling).

Finally, although the exact influence of open road density on black bears on Haida Gwaii is unknown, high road densities likely displace some bears from preferred habitat and put all bears at higher mortality risk.

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2.9. SALMONIDS

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INDICATOR RELEVANCE

Pacific salmon are keystone species[1] contributing significant marine-derived nutrients to the flora and fauna of hydroriparian and terrestrial ecosystems. The migration of salmon back to their spawning ground acts as a “nutrient pump” that which provides vital food for everything from herbs to trees to insects to the next generation of salmon to bears and humans. Marine derived nutrients from salmon carcasses have been shown to have far-reaching influences on terrestrial ecosystems.

BACKGROUND INFORMATION

SALMONIDS AS KEYSTONE SPECIES

Salmonids represent a significant portion of the animal biomass of the Islands, and individual species and stocks have different life cycles, which influences their interaction with the surrounding ecosystem. Some species are ‘resident’ remaining in a stream reach for their entire life, while others are ‘anadramous’, moving between the ocean and streams. Anadramous species move significant amounts of nutrients between the marine, streams and surrounding terrestrial riparian areas and iIsotopic analysis of forest vegetation, soils, and invertebrates has demonstrated a significant contribution of nutrients from salmon to extent beyond the localised riparian zone (Reimchen et al. 2003). A dramatic example of the importance of spawning salmonids for healthy terrestrial ecosystems is in Flathead Lake, Montana, which once supported a large population of kokanee (landlocked sockeye salmon). Bald eagles and grizzly bears were highly dependent on nutrients from spawning kokanee and completely disappeared from carcass-deficient tributary drainage basins after the kokanee population collapsed (Spencer et al. 1989). While this is not an inland example, it demonstrates the influence of salmonids entire ecosystems and not just stream channels and immediate riparian zones.

ISLAND SALMONIDS

All five species of Pacific salmon and three other salmonid species inhabit the lakes and streams of HG / QCI (Table 1).

Table 1. Salmonids found in Haida Gwaii streams, rivers and lakes.

Common Name	Scientific Name	Life History Type[2]
Coastal Cutthroat trout	Oncorhynchus clarki clarki	Anadromous and Resident

[1] Keystone species have a disproportionately large influence on the surrouding ecosystem for their size. Impacting these species can have wide-ranging complex consequences that are difficult to predict.

[2] Freshwater fishes in BC exhibit two main life history types: (1) anadromous and (2) freshwater resident. Anadromous fish start their life in freshwater, go out to sea, then return to spawn in freshwater again. Freshwater resident fish spend their entire life cycle, from hatch to spawn, in freshwater.

Rainbow/Steelhead trout	O. mykiss	Anadromous and Resident
Pink salmon	O. gorbuscha	Anadromous
Chum salmon	O. keta	Anadromous
Coho salmon	O. kisutch	Anadromous
Sockeye salmon (Kokanee)	O. nerka	Anadromous (Resident)
Chinook salmon	O. tshawytscha	Anadromous
Dolly Varden char	Salvelinus malma	Anadromous and Resident

PACIFIC SALMON

All five species of pacific salmon are anadromous. Pacific salmon spawn in gravel beds of river and streams or along lakeshores, spend a varied amount of their early freshwater life (0 to 3 years) in streams or lakes before heading out to sea for 1 to 7 years. The length of time they spend in freshwater and in the sea before returning to their natal streams to spawn depends on the species and availability of food.

The physiological changes fish undergo when they adapt from living in a freshwater to a saltwater environment is called smolting. Upon returning to spawn as mature adults, each species of salmon has a preferred habitat type, time of year and general location in a watershed where it prefers to spawn. All Pacific salmon species exhibit strong sexual dimorphism during the spawning period and die after they spawn.

Anadromy and the strong homing tendency of Pacific salmon have resulted in the evolution of many reproductively isolated sub-populations (stocks). Pacific salmon swim up from stream mouths to spawning grounds further upstream and may be limited in their upstream migration by barriers to fish passage such as falls, cascades, beaver dams and perched culverts. The different species have varying abilities to navigate upstream; thus a barrier to one species may not necessarily be a barrier to another.

Data on the distribution and abundance of salmon on the Islands differs in quality for different areas and sizes of stocks. Small stocks tend to have been sampled at lower frequency so a large number of different stocks are relatively poorly known (see section on current condition for additional description of data issues. The following section describes the general distribution of salmon across the Islands (based on North Coast Background Report and Table 9, Northcote):

Coho salmon occur in a high percentage of streams throughout all ecosections. Strong swimmers and jumpers, they can be found throughout the anadromous range of salmon in a watershed, although they prefer to spawn in smaller tributary channels and will migrate upstream from lakes to spawn in lake tributaries. Abundant good quality overwinter rearing habitat is critical to coho freshwater survival; this habitat includes places where coho juveniles can hold during winter floods such as off-channel areas, deep pools, log jams, sidechannels, backeddies, lakes and wetlands. Floodplains and fans provide particularly important overwintering habitat for coho.

Sockeye salmon occur in limited distribution throughout all the ecosections. All known major sockeye stocks on the Islands are associated with lakes in the Skidegate Plateau: Yakoun, Skidegate, Awun, Ian, Eden and Mathers (with the exception of the Mercer River watershed). Minor sockeye stocks occur in Mayer Lake in the QC(HG) Lowlands, however, a thorough population survey has never been completed. At least three minor sockeye populations are known in the QC(HG) Ranges (Fairfax, Mercer and Gudal). The majority of spawning occurs in tributaries to the lakes with a minor component of spawning in the lake outlet stream. Lakeshore spawning is also known to occur along shorelines where appropriate spawning gravels and good upwelling of freshwater occurs. In some smaller systems, lakeshore spawning may be a significant contributor to sockeye production.

Riverine sockeye are thought to occur widely along the BC coast but population sizes are not large. On the Islands, sockeye have been noted in a few river systems including the Tlell, Deena, and Mamin Rivers. The Mamin River population has been recognized (Reimchen 1992), the Deena sockeye are unlikely to be self-sustaining (P. Katinic, pers. comm.) and status of the Tlell sockeye population is unknown. The occurrence of riverine sockeye on the Islands is likely more widespread than currently documented though whether these populations are self-sustaining or strays from larger systems is debatable.

Kokanee are self-sustaining resident sockeye populations that rear in lakes and spawn in tributaries to the lake or along areas of lakeshore with appropriate spawning gravels and good upwelling. Local information reports kokanee in Mosquito Lake and in a small QC(HG) Lowlands lake along the east coast of Graham Island. In the Yakoun and Copper (Skidegate Lake) systems, a residual form of sockeye has been reported. Residuals are very small sockeye that have never migrated to the ocean and mature and spawn in lakes. It is thought that residuals can be precursors of kokanee populations in a lake.

Chinook Salmon: The only endemic and sizable population of Chinook occurs in the Yakoun, the largest watershed on the Islands. Chinook stock from the Quimsam River on Vancouver Island was introduced to Pallant Creek in the mid-1980s and the population still persists today. Local knowledge indicates the presence of Chinook in the Naden, Mamin and Deena watersheds, although population sizes are likely small and it is unknown if these populations are self-sustaining or strays from the Yakoun or other watersheds.

Chum salmon: are relatively large and are strong swimmers however they dislike jumping and are restricted by relatively small obstructions. They use the lower reaches of a river system to spawn and prefer to spawn in mainstem and main tributary stream channels. It is thought that small self-sustaining populations can occur in very small coastal watersheds and that in years of great abundance, straying from larger systems may populate adjacent smaller systems (B. Spilsted, pers. comm.). Chum are very commonly found throughout streams of the QC(HG) Ranges, with decreasing occurrence through the Skidegate Plateau into the QC(HG) Lowlands. There is a large biomass of returning fish so nutrients provided by chum salmon spawners are particularly critical to the hydroriparian health of small coastal watersheds where their nutrient inputs are key to the wildlife, invertebrate and forest communities of hydroriparian ecosystems.

Pink Salmon: In northern BC, pink salmon abundance occurs in two-year cycles such that in most stream systems, even years have very large runs and odd years have very small runs to no fish returning at all. The exception on Haida Gwaii is the Tlell River watershed where the even and odd year runs of pink salmon are almost equal. Pink spawners tend to arrive at the stream to spawn within a short time period such that they will push further upstream to spawning grounds if there are abundant spawners returning. For example, when close to 2 million pinks arrived in the Yakoun River watershed one year, pink salmon were noted spawning in tributaries upstream of Yakoun Lake.

Like chum, pink salmon generally occur more commonly in the QC(HG) Ranges, followed by the Skidegate Plateau, then the QC(HG) Lowlands. Unlike chum, they have been noted in East Coast Graham Island streams, although not in the large numbers found in the Ranges. For example, the Tlell River, a large Island watershed, has about 5,000 pinks spawners each even year, whereas a much smaller watershed like the Salmon River in South Moresby might have tens of thousands returning. Like chum salmon, pink salmon are particularly critical to hydroriparian health in the small watersheds of the QC(HG) Ranges owing to their great returning biomass.

OTHER SALMONIDS

Coastal Cutthroat trout, rainbow/steelhead trout and Dolly Varden char all exhibit both anadromous and resident life histories. These salmonids fundamentally differ from the Pacific salmon in that they do not necessarily die after they spawn and in fact, are known to spawn several times throughout their adult life. Anadromous forms of cutthroat trout and Dolly Varden char tend to spend the first few years of life rearing in freshwater, then rear in nearshore marine and estuarine waters, moving in and out of freshwater depending on prey availability. They exhibit a wide range of life history variability in terms of how long and when they rear in fresh and salt water throughout their life.

The resident forms of all three species spend their entire lives in freshwater, with maximum lengths partially dictated by the freshwater habitat in which they live e.g. resident salmonids in lakes tend to reach a larger size than those that reside only in streams, and those that live in small headwater streams tend to be smaller than those that are found in larger streams. Self-sustaining populations of resident salmonids are commonly found upstream of barriers to anadromous fish. In unlogged watersheds, they have been noted in first order streams with gradients up to 27% gradient.

Rainbow/Steelhead trout are referred to as rainbow trout when they are juveniles and when they have a freshwater resident life history. Anadromous rainbow trout are referred to as steelhead trout. On the Islands, rainbow trout are common throughout streams of the QC(HG) Ranges, fairly common in the Skidegate Plateau, and less common in the QC(HG) Lowlands. In the Lowlands, the anadromous form is most common, whereas in the QC(HG) Ranges, resident and anadromous forms are both fairly common. In the Lowlands, it also appears that rainbow have only been reported in larger, generally less-acidic waters. Rainbow trout are not well studied and little is known about the Islands' populations and ecological interactions.

Coastal Cutthroat trout are widespread in the QC(HG) Lowlands, moderately common in the Skidegate Plateau and largely absent in the QC(HG) Ranges. Both anadromous and resident forms occur, with resident forms common in the steep headwater creeks of watersheds where they are present. For example, in the Tlell River watershed, a resident population exists from the Tlell falls (anadromous fish barrier) upstream to the headwaters; in some step-pool headwater streams, they occurred up to 25% average gradient, with only 1 or 2 small mature cutthroat present in any single pool, dependent on the size of the pool[3]. Reimchen (1992) conducted long-term studies of predator-prey interactions at selected lakes in the QC(HG) Lowlands, including ecological work on cutthroat trout. Otherwise, there is a paucity of information on cutthroat trout populations and ecological interactions on the Islands.

In watersheds where the distribution of rainbow/steelhead and coastal cutthroat overlap, it is thought that there may be a limited amount of cross-breeding between the species to form a juvenile with characteristics of both rainbow and cutthroat trouts[4]. Although there are many streams with both cutthroat and rainbow trout in reaches downstream of barriers to anadromous fish, resident cutthroat trout and resident rainbow trout have not been noted in the same stream reaches upstream of these barriers; however each species of trout has been separately noted with resident Dolly Varden.

Dolly Varden char, like coho salmon, are widely distributed throughout all ecosections of the Islands. Both anadromous and resident forms are common. Resident Dolly Varden char are common throughout all fish-bearing headwater streams and in one case, were found to reside in a stream with almost 30% average gradient.

FACTORS AFFECTING POPULATIONS OF SALMONIDS

Salmonid production is affected by their survival rates in freshwater and, for anadromous species, in the ocean.

[3] Personal communications with Lynn Lee, contract biologist. Observed during field work for the Reconnaissance Fish and Fish Habitat Inventory for the Timber Supply Area portion of the Tlell River watershed.

[4] Local knowledge passed on to Lynn Lee, Consulting Biologist, personal communication.

In freshwater, salmonids depend on good quality adult holding, spawning and rearing habitat. Resident salmonids who spend their entire lives in freshwater require good freshwater habitat for all their life stages. Anadromous salmonids require good freshwater habitat for spawning, hatching and varying periods of rearing ranging from weeks to years, depending on the salmonid species. Salmonid spawners/adults, eggs, alevins and juveniles depend on cold, clean, oxygen-rich water, clean gravel and sufficient habitat quality and quantity for the different life stages.

Critical habitats most relevant to Land Use Planning (i.e. riparian habitat) for salmonids have been negatively impacted by a number of different factors, including forestry operations, road building, mining and natural disturbances (landslides etc). Commercial and sport fishing impacts are also discussed below because they can significantly impact populations but aren't directly under consideration here.

TERRESTRIAL IMPACTS

Impacts to aquatic systems arise from harvesting activities such as large-scale forest removal, riparian zone and stream channel disturbance, and road building.

Large-scale forest removal and watershed disturbance can influence the hydrological and nutrient regime of aquatic ecosystems. This is evident in watersheds that have had a large proportion of the forested landscape removed and converted to extensive clear-cut and young second growth stands. Large harvested areas have reduced water retention capacity which can result in increased overland flow, changing hydrological regimes and resulting in extremes (high and low) in water flow. Many salmonid populations are limited by extreme environmental conditions and an increase in extreme stream flows can reduce populations.

In addition to changes in hydrological regime, the vigorous growth of second growth trees and shrubs creates a high nutrient demand from surrounding soils and water. As a result the regenerating forest acts as a nutrient sink and fewer nutrients are available for aquatic ecosystems. This reduced nutrient availability can impact salmonids by limiting their growth and survival, which in turn can reduce the carrying capacity [5]of salmonids within streams.

Logging and mining activities over the past century have also resulted in the direct disturbance of riparian zones and channels. Removal of riparian zone forests and large wood structure in stream channels has contributed to the degradation of fish habitat which can still be seen today in poor quality habitat. This is especially true in small – medium streams on the Islands that have a stream morphology that is highly dependent on large woody debris. Loss of instream large woody debris and riparian forests often results in stream destabilization and degradation of fish habitat through stream channel overwidening, shallowing, and creation of multiple unstable stream channels. These effects can be long lasting when the riparian forest has been removed from both stream banks and the long-term recruitment of large woody debris, essential for channel structure and fish habitat, is unavailable for potentially hundreds of years. Ironically, the practice of removing large wood from stream channels to aid in salmon migration upstream also negatively impacted stream channels by removing the structures that created and maintained good fish habitat quality. Watershed restoration work in specific watersheds over the past 8 years has attempted to improve the fish habitat in some of these areas by replacing large wood structures in the stream channel.

Road building and existing logging roads can produce some of the most dramatic negative impacts on salmonid populations. Impacts range from acute impacts such as destruction of habitat or the creation of barriers to migration or triggering landslides, to chronic impacts such as changes to hydrological regime to sedimentation sources. In extreme cases, roads have influenced the flow of water on hillslopes and resulted in landslides. These slides are especially destructive for fish and fish habitat as large volumes of sediment and debris are introduced to the stream. These effects are usually long-term as slide paths typically continue to unravel and act as a sediment source for many years before

[5] Maximum number of salmon able to live in a stream

the slope stabilizes and revegetates. Many roads cross over streams using inappropriate stream crossing structures (culverts) which has resulted in the degradation of fish habitat adjacent to the structures as well as blocking adult and juvenile salmon migration. In many cases roads were built along floodplains which blocked fish access to key off-channel and tributary habitat which can be essential overwinter habitat for salmonids.

In some cases small salmon populations were extirpated, such as in the numerous small streams that cross the Island Highway primarily on the east coast of Graham Island. In many cases culverts blocked salmon migration upstream to spawning grounds for many years before any rehabilitative work was done, and have led to population decline and extirpation of some unquantified number of small salmon populations. Over the past 20 years, small-scale salmonid enhancement work has restored some of these salmon populations with salmon from geographically neighbouring stocks, however, the effects on genetic diversity will remain unknown. Rehabilitative work on logging road and highway stream crossings continues today in efforts to maintain or improve salmonid access to impacted streams.

The chronic effects of roads on salmonids are less tangible and difficult to measure. High densities of roads can influence the hydrological regime of watersheds by increasing overland flow. Where roads cross slopes, water that would normally percolate through the ground becomes trapped in the upslope ditch and then flows overland through the ditch system. This combined with the area of impermeable road surface can increase overland flow and sedimentation to aquatic ecosystems. These effects have been correlated with increasing road density and would likely be more dramatic in steep watersheds associated with the Queen Charlotte Ranges.

Terrestrial activities can also affect marine survival by influencing the quantity and quality of nearshore rearing habitat especially in important salmonid habitats such as estuaries and eelgrass beds. Overall, there has been a relatively low level of foreshore development on HG/ QCI in recent years and therefore the contemporary impacts on nearshore salmonid habitats is generally low, although there may be specific streams that have been greatly impacted. Past logging practices of A-frame logging from the foreshore and numerous log dumping and storage sites have had an unquantified effect on nearshore salmonid habitat over the past century.

MARINE IMPACTS

Marine survival for anadromous species is affected by natural elements such as ocean/climate conditions, predation and food availability. Commercial, recreational and food fishing affects all Pacific salmon species, decreasing the number of adult fish returning to spawn in their natal streams. The specific impacts of fishing on Haida Gwaii salmonid stocks and populations is largely unquantified except for a relatively good estimate of Haida food fishing for sockeye on major sockeye runs: Copper River sockeye for the past 20 years, Yakoun River sockeye for the past 10 years and Awun and Ian sockeye for the past 5 years (P. Katinic, pers. comm.). Terminal net commercial fisheries targeting Haida Gwaii pink and chum salmon, but having a notable effect on Islands' coho salmon stocks, have occurred off the east and west coasts of the Islands. North Coast troll fisheries targeting Chinook, sockeye and pink salmon, mostly mixed-stock fisheries, occur mostly off the west and north coasts of the Islands and catch an undetermined percentage of salmon destined to return to Haida Gwaii streams. The timing of the North Coast troll fishery tends to preclude effects on the major Haida Gwaii sockeye runs which return very early to their natal streams: It may, however, have greater impacts on the Islands' coho and pink salmon stocks.

Similar to the North Coast troll fishery, recreational and ocean-based food fishing are also mixed-stock fisheries. Although a creel survey program to estimate the ocean-based recreational catch has been implemented by the Haida Fisheries Program over the past decade, the proportion of salmon caught that would return to Haida Gwaii streams remains unknown. The recreational fishery also produces an unknown amount of mortality associated with catch and release practices: Under controlled net pen conditions, the mortality rates for Chinook and coho salmon average about 15 and 30% respectively. An unknown quantity of Haida Gwaii pink, chum and coho salmon is also caught by recreational anglers fishing in stream mouths, estuaries and off the beaches. At present, this recreational effort is concentrated at the mouths of the Copper, Deena, Pallant, Tlell, Yakoun, Datlamen and Mamin Rivers, and in Skidegate Inlet in general.

Steelhead/Rainbow trout are affected by commercial fishing to a minimal degree (very few seem to be caught in the commercial fisheries), and are mostly affected by recreational fishing in freshwater through the late fall and winter. This recreational steelhead fishery is primarily a catch and release fishery with relatively high survival rates, although impacts on reproductive success are unknown. An unknown number of steelhead are also impacted by the Haida food fishery for sockeye since spawned-out steelhead kelts are migrating out of the river at the same time as the sockeye gillnet food fishery.

Anadromous Cutthroat trout and Dolly Varden char are caught in land-based recreational fisheries on stream and lakes. Again, the impacts of this fishery on those fish populations are unquantified.

Directed fisheries on resident trout and char are limited to recreational lake-based fishing and again, the impacts of this fishery are unknown. The small resident fish living in streams are not of interest to recreational or food fishing.

MODEL APPROACH AND ASSUMPTIONS

In this chapter, we provide an overview of available trends in fish stocks based on escapement data from the Department of Fisheries and Oceans. A review of the robustness of these data and methodologies is given in Section 4.10.

In the Watershed Condition chapter (2.3) we provide an overview of the biological condition of hydroriparian ecosystems on the Islands. Although we could not link this work with salmon trends, due to lack of time in this process, that chapter provides an overview of the trends for potential salmon habitat on the Islands.

ECOLOGICAL BASELINE

Determining ‘historic levels’ for fish species is difficult. Many stocks have been extirpated or reduced over time and have not had systematic counting efforts in place. This is particularly problematic for smaller runs for which there are little or no reliable data. It is likely that various human activities including construction of the Island highway, logging activities and fishing activities have had a significant impact but undocumented impact on an untold number of small streams throughout Haida Gwaii, and particularly on small populations of coho, chum and pink salmon.

Additionally, intensive commercial fisheries for salmon began over a century ago before records were kept. Assessing available data therefore fails to take into account earlier fishing impacts. For example, Gresh et al. used historical cannery records dating to the late 1800s, current escapement and fishing records to estimate historical salmon escapement biomass in the Pacific and estimated that current salmon biomass is currently at about 50% of the salmon biomass of pre-industrial fishing levels.

As a result, determining an ecological baseline for the different salmon species and stocks specific to Haida Gwaii is extremely difficult. The lack of historic data on numbers of each species and extent of harvest, in addition to more recent salmon enhancement activities, plus significant but unquantified effects of industrial human activities further complicates the task.

Consequently, no ecological baseline is used in this analysis: Instead, a discussion of data limitation for trend analyses and trends for different stocks where available and reasonably reliable is presented.

SHORT-TERM POPULATION TRENDS

Several recent papers have examined population trends for the different salmonids on HG / QCI (see reference list). All are broad analyses covering large geographic areas, providing very general trends in abundance based on the larger salmon runs. All have assessed trends in abundance of Pacific salmon stocks using the Salmon Escapement Database (SED) compiled and maintained by Fisheries and Oceans Canada, based on field data collected by charter patrol stream walking surveys.

As outlined above obtaining reliable information on population trends for all salmonids on the Islands, over a reasonable timeframe (e.g. 1800 – current) is not possible. As a result, we present some short-term trends based on available data, for a limited number of streams. Interpreting these data is difficult and a number of key data limitations are listed below. These items are discussed in more detail in Section 4.10.

TREND SUMMARY

Keeping the data limitations in mind, some general summaries have been made with relative confidence for some species. For other species, trend summaries from the SED will be meaningless and other means are necessary for determining trends in salmon stock status over time. Overall numbers for salmon species are shown in Table 2 below. In addition, commentary on individual species trends for the Islands is given below.

Table 2. Overall figures for salmon condition from available SED data. (L. Lee pers. comm.). Methodology shown in Section 4.10.

Salmon species	4-Year Period	Estimated Abundance
Sockeye	2000-03	35,000
	1978-81	35,000
	1968-71	70,000
	1950-53	30,000
Pink Even Year	2000-02	1,500,000
	1996-98	3,000,000
	1980-82	700,000
	1950-53	1,400,000
Chum	2000-03	240,000
	1950-53	965,000
Chinook[2]	2000-03	4,000
	1978-81	500
	1964-67	8,000
	1950-53	1,500
Coho[3]	2000-03	80,000
	1994-97	40,000
	1963-66	245,000
	1950-53	165,000
All Species	2000-03	1,859,000
	1950-53	2,561,500

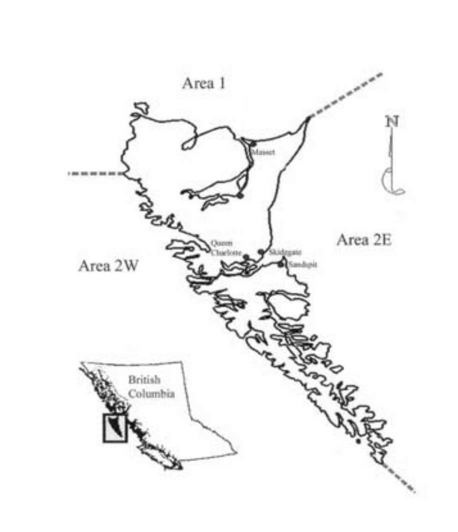
[1]Estimates of abundance are based on the Fisheries and Oceans Canada Salmon Escapement Database that spans the period

1950 to present. Note that although the early 1950s are considered 'past' abundance, 50 years is not very long in the grand scheme of salmon. Additional sockeye abundance information was provided by Pete Katinic of the Haida Fisheries Program.

[2]Chinook estimates are based on the only significant population on the Islands (Yakoun). Yakoun chinook have been enhanced since the 1980s, likely resulting in the increasing trend observed in recent decades.

[3]Coho estimates likely underestimate the number of coho by a significant amount. There has been neither time nor money available to accurately assess coho populations for Haida Gwaii and the BC Coast in general.

Chum salmon: Brian Spilsted's (2004) paper represents the best existing summary of the status of chum salmon on Haida Gwaii/QCI (see Map 1 for areas). In this analysis, the trend of annual chum salmon escapement and how it compares to the escapement target or goals is assessed on chum stocks that are pooled together within their management areas. Target escapement refers the number of spawning salmon required to completely utilize the estimated spawning and rearing habitat for each stock. The summary conclusions from his analysis of the SED from 1952 to present are:



1. For Area 1 chum stocks • The average annual escapement is below escapement goals. Escapements have also been variable over time (1952 – Present) and without trend;
2. For Area 2E chum stocks • The average annual escapement is below escapement goal. Escpapemnets have also been variable over time (1952 – Present) with slight downward trend;
3. For Area 2W chum stocks • The average annual escapement is below escapement goals. Escapements have also been variable over time (1952 – Present) and without trend.

Pink salmon: Although the pink salmon escapement data is comparable in reliability to the chum data, there are no recently published results analyzing trends in pink salmon escapement. Riddell (2004) alludes to a reduction in the abundance of odd-year pink salmon on Haida Gwaii attributed mostly to a decline in the Copper River run. No trends are noted in this report for the much stronger even-year pink salmon run which is dominated by the Yakoun River run averaging 100,000 to 1,000,000 spawners in a year.

Sockeye salmon: While noting the unreliability of using the SED data for sockeye population trend analysis, Hyatt and Rankin (1996) concluded that up to 1996, all major Haida Gwaii sockeye stocks were in decline, with the caveat that "Given the range of uncertainty in both catch and escapement estimates of QCI sockeye stocks, it is impossible to draw sound conclusions about whether apparently low stock sizes exhibited by all Charlotte Sockeye stocks in the current decade represent major declines, artifacts of field and "analytical" procedures or combinations of the two."

Looking only at escapement and in absence of statistical analyses, Riddell (2004) concluded that of the 9 major sockeye stocks on Haida Gwaii, 1 was increasing, 3 were stable, 3 were decreasing, 2 were depressed (i.e.: lower than previous levels, but no longer decreasing) and 2 were unknown. Considering the limitations of the data, the absence of catch accounting and the limited data analysis accompanying the report, these conclusions should be considered preliminary at best and treated with caution.

Overall, it appears that sockeye populations on Haida Gwaii are generally in decline compared to recorded levels in the 1950s. In more recent years, some populations such as the Copper appear to have stabilized but at a lower level than seen in past decades.

Coho salmon: It is largely recognized that escapement estimates for coho salmon based on visual stream surveys are inaccurate for the many reasons previously discussed. For the North Coast, Fisheries and Oceans Canada uses indicator sites to determine escapement trends based on a combination of visual estimates and fence counts available since 1988 and 1992 (Sawada et al. 2003). Four indicator sites are used and all are on the mainland with relatively few returning coho salmon. At present, no indicator sites are located on Haida Gwaii and the sites on the mainland are not necessarily indicative of coho salmon stocks on the Islands.

The Haida Fisheries Program has been working to establish an indicator system for coho abundance based on Area Under the Curve (AUC) adult escapement estimates and smolt production estimates on the Deena River since 1994. The Haida Fisheries Program, DFO and Streamkeepers groups have also been working to expand the indicator systems by conducting AUC counts on other potential indicator stocks but have faced funding challenges in the recent years.

Taken at face value, Sawada et al. analyzed the visual escapement data for Haida Gwaii coho stocks and concluded the following:

1. For Area 1 coho stocks • An insufficient number of streams were counted for coho and a lack of escapement data from this area in recent years prevent analysis of trends in escapement Escapement levels are below escapement goals and historical numbers show wide fluctuations with no apparent trend;
2. For Area 2E coho stocks • Analysis of escapement trends shows a noticeable, although not always statistically significant increase since 1997. Escapement levels are below escapement goals and lower than historical numbers.
3. For Area 2W coho stocks • Analysis of escapement trends shows a significant increase in escapements over the period 1990-1997. Escapement levels are below escapement goals and lower than historical numbers;

Overall, the reliability of the SED for coho salmon is questionable. For those reasons, the conclusions above should be viewed as a very rough indicator that requires refinement through continued and consistent monitoring of indicator coho systems that represent the wide range of coho watersheds on Haida Gwaii.

Chinook salmon: As indicated earlier, only one significant endemic population of chinook salmon exists on Haida Gwaii. This Chinook stock was severely depressed in the 1970s, with significant impacts from a recreational fishery in Massett Inlet, and has been enhanced by the Old Massett Village Council since 1979, releasing a maximum of 400,000 smolts in 2000. Assessment of the population is a combination of fence and visual counts during even years, and visual counts only during odd-years. The Yakoun Chinook population appears to have stabilized in recent years.

In the 1980s, DFO introduced Chinook salmon into Pallant Creek for hatchery enhancement from Vancouver Island stock. Although the Chinook enhancement plans were quickly discontinued, Chinook continue to spawn naturally in Pallant Creek and a small population persists.

Other very sporadic observations of Chinook have been noted in the SED in the Ain and the Naden Rivers. It is not known whether these Chinook are self-sustaining populations or simply strays from the Yakoun or another system.

Steelhead trout: A reliable time series of data for steelhead populations on the Islands does not currently exist and at present, there do not appear to be plans to establish a reliable methodology for documenting steelhead abundance and trends in abundance over time. The only measures of steelhead trout populations available for Haida Gwaii stem from voluntary recreational license holder surveys sent out by mail, and some limited work completed by the Provincial Ministry of Environment in the 1980's. Despite the limited available data, steelhead populations on the Islands have been identified by the Province as stable.

Resident Rainbow trout: No current or historic population estimates for resident rainbow trout exist for the Islands.

Coastal Cutthroat trout: No current or historic population estimates for anadromous or resident forms of cutthroat trout exist for the Islands. Anecdotal information from former Steelhead Society members have indicated a perceived decline in anadromous cutthroat trout over the past decade for some streams, including the Tlell and the Copper Rivers. There is no verifiable evidence to substantiate this information.

Dolly Varden char: No current or historic population estimates for anadromous or resident forms of cutthroat trout exist for the Islands.

DATA LIMITATIONS

The SED database is the best province-wide information available for salmon escapement over time; however, it has limitations that restrict the confidence and reliability of resulting trend analyses. Major caveats are identified below and discussed in more detail in Section 4.10.

Limitations in terms of interpreting the database include:

- Variable consistency of data collection (annually and across years)
- Variable consistency of data collection for different species (e.g. targeted sampling for large sockeye runs)
- Variable consistency of data collection in geographic areas of the Islands
- Variable methodologies making comparisons across runs difficult
- Extraneous factors changing results (e.g. weather effects etc.)
- Confounding effects of native individuals returning, combined with hatchery releases etc.
- Changing environmental conditions over time (climatic effects, watershed disturbances, fisheries variability all causing population fluctuations).

POPULATION VIABILITY

Genetic population determination has been conducted by Fisheries and Oceans over the past few years for coho salmon. Preliminary work demonstrated a closer genetic relationship between coho stocks that are geographically closer together than between those that are geographically further apart. Some preliminary genetic stock analysis is being conducted for chum and pink salmon on Haida Gwaii, however, additional samples continue to be collected from different stream systems to develop a more comprehensive dataset.

Appendix A of the Living Blueprint for BC Salmon Habitat lists salmon stocks at 'high risk of extinction' defined as those stocks having "mean populations in the current decade that are at less than 20% of the long-term mean level and less than 200 fish". Although this document lists 2 stocks of chinook, 2 stocks of sockeye, 32 stocks of coho, 31 stocks of pink and 21 stocks of chum, this information should be viewed with caution. The chinook and sockeye salmon listings are likely based on sporadic observations and some of the pink, chum and coho salmon listings are based on the fact that they are small runs of less than 200 fish. Others, however, are listed because of observed declines in abundance relative to the 1950s. In addition to these considerations, there are likely many more streams with small salmon populations (particularly for coho, chum, pink and possibly riverine sockeye) that have not been documented in Fisheries and Oceans escapement records.

Some analyses (e.g. CIT Ecosystem Spatial Analysis) attributed higher ecological value to areas with large fish runs. Although there is some justification in this approach because of the cascading ecosystem influences from the large volume of biomass, it is also troublesome because small stocks are genetically distinct and should carry as much conservation value as larger stocks.

FURTHER TREND ANALYSES RELEVANT TO THE LAND USE PLAN

Analyses of escapement information relevant to the land use plan should look at watershed-level analyses examining salmon trends in combination with riparian disturbance data, beginning with watersheds that appear to have consistent estimates of pink and/or chum salmon over time. Relevant trends in pink and/or chum abundance may coincide with habitat condition, dependent on the general logging practices at the time and expected time period of habitat degradation following the logging activity.

For coho and sockeye salmon for which historical escapement estimates may not be so reliable, examining the proportion of potential spawning and rearing habitat impacted by logging activities may shed some light on general effects on these species.

In conjunction with this analysis, fisheries catch information should be incorporated where possible for terminal fisheries to provide some indication of catch targeting salmon from a particular geographic area such as Cumshewa Inlet (Pallant Creek) or Skincuttle Inlet. This may provide further substance to apparent trends in salmon abundance specific geographic locations.

SUMMARY

Trends for salmonid populations for the Islands are based on largely unreliable, and unsystematic data. However, it appears there have been a number of specific impacts to salmon on the Islands including:

- Extirpation of an unknown number of stocks, particularly through isolation from the Island Highway over a number of years.
- Local declines in fish abundance for a number of major creeks. Declines appear to be associated with degradation of fish habitat from a variety of terrestrial causes including extreme impacts on riparian channels from inappropriate management practices, changing nutrient regimes adjacent to creeks, road impacts etc.
- Fish harvesting has also impacted fish numbers, but these issues are outside the scope of the LUP and are not further discussed.
- Small streams and salmon stocks are more susceptible to land use impacts when compared to larger streams. Once impacted, these small streams have a longer recovery time.
- Ian Lake sockeye populations are severly depressed. Historically Ian Lake was an important sockeye food fishery for Haida people. At present the populations are at low levels and do not support a fishery. This stock has not been exploited for over a decade and still does not appear to be rebuilding. The specific cause for the depressed populations is unkown.

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2.10. Non-native / Introduced Species

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J-L Martin supplied unpublished work from Research Group on Introduced Species (RGIS). 2004. Lessons from the Islands. In Preparation.

Indicator relevance

Non-native species have been introduced to HG / QCI since the mid 1800s and introductions continue to the present day. For HG / QCI a very large number of species are known to have been introduced including rusts, slugs and snails, earthworms, a wide variety of insects, amphibians, birds, mammals, and a large number of plant species. The ecological implications differ by species; with some having relatively small ecological impacts, while others have very severe ecological impacts. In composite, these introduced species have significantly altered abundance and distribution of native species, native habitat distribution and functioning and ecosystem functions and processes.

One species in particular, black-tailed deer, also has important social value on the Islands, being an abundant food source for many Island residents.

HG / QCI is more vulnerable than mainland sites to introduced species because the native species composition is relatively impoverished compared with mainland areas, making it relatively easy for introduced species to become established.

Background Information

Non-native or 'introduced' species have impacted the ecosystems of many areas across the globe. However, the greatest impacts have been on Island ecosystems. Islands are particularly vulnerable to the impacts of invasive species because they often have relatively few native species (e.g. few large predators or ungulates), so making easy for other species to invade, and because they often have unusual species or combinations of species, making the overall impacts from invaders of more ecological concern.

More than 23 animal and 140 plant species are non-native to the Islands. These species have been listed in detail in Engelstoft Part 2 (2002) and are not all summarised here. However, a preliminary set of key species is discussed below.

Approximately 20% of the flora of the Islands are thought to be non-native (approximately 143 of 657 vascular plants, Golumbia 2000). Not all these species are 'invasive', i.e. they don't all have the propensity to spread widely and so some are of lower concern than others. "Invasive" species tend to be those that do well in disturbed habitat types, are often highly competitive species outgrowing the competition under open growing conditions. Fortunately, the natural vegetation of the Islands (old age forested ecosystems) tends not to allow colonisation by this type of species, since there are relatively few naturally disturbed sites in these ecosystems and most typical 'invasive' plants do not tolerate the shade of the forest understory. Most introduced / invasive plant species are therefore confined to roadways (and some are intentionally seeded there as a management strategy), and have colonised associated shorelines, beaches and open forest types, particularly around Tlell. Fortunately, to date there have been no introductions of freshwater fish.

Non-native animals include ten mainland mammals, two amphibians, three birds and five domestic animals introduced since European settlement either by accident or through active introductions (Table 1).

Table 1. Introduced animal species on HG/QCI (from RGIS 2002), in order of first

introduction date. Species marked with ** are no longer present on the islands.

Common Name	Latin Name	Earliest Known Date of Introduction
Feral dogs	Canis familiaris	No Date
Feral cats	Felis catus	No Date
Sitka black tailed deer	Odocileus hemionus sitkensis	1878
Feral rabbits	Oryctolagus cuniculius	1884
Feral cattle	Bos taurus	1893
House sparrow	Passer domesticus	1900?
House mouse	Mus musculus domesticus	1901
Ring necked pheasant	Phasianus colchicus	1913
European red deer**	Cervus elaphus elaphus	1919
Black rat	Rattus rattus	1919
Norway rat	Rattus norvegicus	1922
Muskrat	Ondatra zibethica osoyoosensis	1924
Rocky Mountain elk	Cervus elaphus nelsoni	1929
Beaver	Castor canadensis leucodontus	1936
Raccoon	Procyon lotor vancouverensis	1940's
Red squirrel	Tamiasciurus hudsonicus anuginosus	1947
Pacific tree frog	Hyla relilla	1964
Feral goats**	Capra hircus	1976
European starling	Sturnus vulgaris	1980
Red-legged frog	Rana aurora	2002

In addition, a large number of invertebrates (snails, earthworms, earwigs, aphids, weevils, beetles, and butterflies) have been identified as introduced. The real impacts of this diverse array of species are largely unknown.

INTRODUCED SPECIES IMPACTS

Introduced species have a wide range of impacts on the native ecological of the Islands. The diversity and extent of impacts recognised as a result of a local research program (RGIS – Research Group on Introduced Species) has recently been summarised in Martin et al. 2004.

In addition, some specific impacts caused by deer on plant species are outlined in Section 2.2 (this document).

In general, the primary impacts include

a) vegetation impacts caused by excessive browse, (e.g. from deer)

b) predation impacts caused by mammalian predators (e.g. raccoons, rats impacting seabirds, shrub nesting songbirds etc.)

c) direct competition for specific habitat elements (e.g. cavity nesting holes) or food supplies,

d) complex interactions of an additional prey base combined with increased competition and / or predation, (e.g. squirrels which provide a food source for some species such as northern goshawk, but prey on other parts of the food source for the same species, e.g. songbird /

woodpecker nests).

The cascading effects through the ecosystem of each of these impact types are largely unknown, though recent research has increased knowledge on some specific impacts. For example, research has shown that deer browse has significant ‘knock-on' effects on insect abundance and diversity, with areas showing long histories of deer browse having significantly reduced insect communities compared with areas with more recent histories of browse. Similarly, deer and red squirrel impact nesting success of songbirds by removing understory nesting habitat, insect abundance (food supplies) and elevating nest predation probabilities.

MANAGEMENT ISSUES RELATING TO LUP

Introduced species are an unusual aspect of concern for a Land Use Plan. However, for HG / QCI is it recognised that failing to address introduced species' issues will have cascading impacts and potentially undermine other decisions. For example, attempting to maintain representative old forest ecosystems into the future (through a Protected Areas, or reserve strategy) requires both a consideration of future harvesting and a consideration of future browse levels from deer. Failing to address both issues together will result in a lower quality set of representative old forest ecosystems.

A great deal of work has already occurred on the Islands, in relation to introduced species management. Some examples of this work include:

- Annual monitoring of seabird colonies in relation to raccoon numbers, and organisation of raccoon control along shorelines close to seabird colonies, or on seabird colonies when they are encountered (multi-agency partnership),
- Haida Resource Restoration Project (HRRP) or Daamaan Xil ("taking care of our plants") has the guiding principle that all life is intertwined and the cycle of life is broken if any part is ruined. Project was initiated by the Council of the Haida Nation around 2000, and guided by many community members and elders in Skidegate and Old Massett knowledgeable in cultural plant use and historical land use, with the goal to repair degraded ecosystems using EBM principles. One long-term goal was to control impact of deer on culturally significant plant communities through participating in a deer management plan. A short-term goal within this is to protect selected sites from deer browse and other animal interference. As a result plant enclosures in various sites were set up to monitor understory recovery of these important plants. In addition, project goals include capacity-building with the Haida Nation and cultural restoration.
- Rat monitoring on Islands, plus eradication program on Langara Island, which has been apparently successful (CWS and partners),
- Rat eradication programs on St James and Bishofs Islands (Parks Canada),
- Deer control / culls on Reef and Skungwaii Islands, as part of research study on vegetation responses (RGIS),
- Change in hunting regulations to increase pressure on deer through increasing the bag limit and lowering hunting tag price,
- Studies of deer browse impacts on regenerating cedar and study of potential control methods (MoF),
- Establishment of a network of deer exclosures on Graham, Moresby and several other islands, to monitor, and serve as demonstration sites. Work on raccoon predation on seabirds, including monitoring long term impacts and control (Laskeek Bay Conservation Society the RGIS partners),
- Work on impact of beaver on cedar, and crabapple trees (Streamkeepers Port Clements).

PRIORITY SPECIES AND PRIORITY LOCATIONS

A conceptual framework for determining key species of management concern is presented in Engelstoft 2002. It includes assessing species for their biological and cultural impacts, the feasibility of restoration or elimination of the species, and the current and potential future distribution of the species. This model has not yet been applied for the Islands. In the interim, the LUP Process Technical Team used existing information to provide a starting place for prioritising key species of immediate concern based on their relevance to land use planning (Table 2).

Table 2. Key introduced species identified as primarily relevant to land use planning.

Species	Primary Impacts
Beaver	• Potential impacts on wetland / bog ecosystems potentially huge. Significant change in drainage patterns in QC lowland as a result of beaver activity. • Potential interaction with harvest activity.
Rats	• Primarily a concern due to impacts on seabird colonies. Management strategies underway on some Islands. Not present on all Islands. Species primarily transported to new sites by people / lodges / boats etc.
Raccoon	• Broad impact on a wide variety of species (e.g. nesting sandhill cranes, grouse, songbirds, shoreline fauna etc), plus seabird colonies. Capable of movement to new Islands by swimming – does not rely on humans for dispersal / recolonisation to new areas.
Sitka black-tailed deer	• Vegetation alteration due to extensive browse. Impacts include extensive loss of understory vegetation (abundance of vegetation) and long-term implications to species diversity. High impacts in long-lived woody species, and cedar – possible extirpation of these species in the longer term. Impacts on rare ecosystems/ plant communities. Impacts on endemic plant species. • Loss or significant reduction of specific Haida food plants, and culturally significant species and medicinal plants. • Cascading impacts on animal communities (e.g. insect communities shown to be reduced as a result of deer browse; similarly songbird populations affected by deer browse and increased predation) • Potential cascading impacts through animal / plant communities into ecosystem processes (water, nutrient cycling etc.). • Success of deer is related to high flexibility in habitat use and forage plants, relatively benign winter conditions, lack of diversity of native predators, lack of chemical defence compounds in local plants. High dispersal ability to offshore islands. • Population dynamics, spatial distribution and trends are not well understood.
Japanese knotweed (Polygonum cuspidatum)	• Primarily around hwy 16, however, potential for dispersal into surrounding harvested areas and along logging roads considered high (Identified by Pojar 2003). Spread by earth moving equipment along roads.
Scotch Broom (Cytisus scoparius)	• Likely has had the highest impact on the Islands to date. Invaded stabilised dune areas, and open spruce forest types in the Tlell area. (ID by Pojar 2003).
Gorse (Ulex europaeus)	• Can become established throughout the forest / forest edges (as on Vancouver Island). (ID by Pojar 2003)
Canada thistle (Cirsium arvense)	• Potential for invasive in wetland / riparian settings. (ID by Pojar 2003). • Expanding along beaches dunes and shorelines, into old Haida village sites on whole east coast.
Marsh thistle (C. palustre)	• Potential for choking out wetlands / riparian vegetation. Extremely invasive once established in forested settings. (ID by Pojar 2003).

Species	Primary Impacts
Wall lettuce (*Lactuca muralis)* English Ivy *(Hedera helix)*	• Specifically noted for potential future concern because both are shade-tolerant species that have the potential to become established in the shady forest understory where native species have been heavily reduced by deer browse (Pojar 2003).

In addition to different species having different impacts, the local severity arising from an individual species can differ across the Islands:

- Beavers have a significant ecological impact in the lowland region in the northeast because they can significantly alter water flow direction in this area with low topography.
- Deer browsing also varies across the Islands, with severity of browse related to a number of factors including distance to ocean (shorelines provide year-round food supplies, resulting in consistently higher populations of deer), density of black bear (which prey at least on young deer and possibly also on adults), hunting pressure (areas close to settlements and accessible by road tend to have higher hunting pressure), snowpack (areas of higher snowpack have lower consistent browse), area of Islands (small islands can be browsed severely by a small number of deer) etc. These factors together result in high variability in the amount of deer browse observed at any given place, and although the populations of deer likely move around the landscape in response to food availability, identifying areas with currently high quality understory may be an important short-term strategy.
- Rats and raccoons are widely distributed across the Islands, though not found on all Islands. Rats have their most severe impacts in areas with high density of nesting birds, particularly seabird colonies. Raccoons in particular may pose a threat to nesting of birds throughout the forest / wetland/ intertidal zones, though local impacts will be less severe than for colonially nesting birds. Management and monitoring strategies differ because rats are transported primarily by people (through boats / lodges etc), while raccoons can swim to islands.
- The plant species listed in Table 2 are primarily focused around the road system, settled areas, agricultural land, and particularly around the community of Tlell. Note that two species are identified as potentially larger threats because they have the potential to spread into forested ecosystems. Spread of non-native species into recent clearcuts is also of large concern.

Managing introduced species is a highly complex ecological and social task. Some species (particularly deer) are an important food supply for the people of the Islands, and even if it were thought ecologically feasible, eradication of species such as deer would likely not be a socially acceptable option (RGIS 2002). In addition, there are complex ecological responses that are likely to occur in any attempt to manage the deer population, even in local areas. For example, any recovery of forage caused by local reduction in deer may then serve to boost the recovering population or deer, resulting in increased pressure required to maintain the population at a constant lower level. Understanding and managing within the scope of these complex issues with be key to mitigation of introduced species impacts on the Islands.

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Chapter 3. ADDITIONAL SPECIES OF LAND USE CONCERN

The species listed in Chapter 3 are additional species considered to have potential relevance to land use decisions on the Islands. For each species, primary information sources, background information, and potential land use concerns are outlined in brief. Detailed discussion and modeling for these species is not presented either because the information is unavailable or because the species is more appropriate for single-species management strategies which are beyond the scope of this work. The species tend to be endemic subspecies, for which HG / QCI holds a large global responsibility. Species also tend to be vertebrates, which reflects a state of knowledge for biodiversity rather than any assumptions that these have higher ecological value than other biological groups.

3.1. NORTHERN SAW-WHET OWL (AEGOLIUS ACADICUS BROOKSI)

PRIMARY INFORMATION SOURCES

Carmen Holschuh. 2004. Review and Report on the Current State of Knowledge about the Haida Gwaii Saw-whet Owl *Aegolius acadicus brooksi.* Prepared for Ministry of Water, Land and Air Protection, Queen Charlotte City, BC.

Gill, M. and Cannings, R.J. 1997. Habitat selection of Northern Saw-whet Owls (Aegolius acadicus brooksi) on the Queen Charlotte Islands, British Columbia. In: Duncan, J.R., D.H. Johnson and T.H. Nicholls. Biology and the Conservation of Owls of the Northern Hemisphere. USFS General Technical Report NC-190: p 197-294.

BACKGROUND INFORMATION

The Northern Saw-whet owl is an endemic sub-species breeding on HG/ QCI and it is the only breeding owl found on the Islands. It is blue-listed provincially, and listed in Version 2 of the provincial Identified Wildlife Management Strategy[1]. The sub-species is also a high priority candidate for listing by COSEWIC.

The Saw-whet owl has been found across the Islands particularly on Graham and Moresby Islands, but are thought to inhabit any Islands with suitable habitat types. Typically habitat includes mixed forest types, shrubs to coniferous forests in mid to low elevation forests. Structural complexity such as found in mature/ old forest is required for high quality breeding habitat. There may also be a preference for riparian associated habitat areas, as found for the mainland subspecies.

The Saw-whet owl is a secondary cavity nester, i.e. it does not excavate its own breeding cavity but depends on Northern Flickers (*Colaptes auratus*) and Hairy Woodpeckers (*Picoides villosus*) to excavate cavities which it then occupies. The most common tree species used for nests on HG / QCI are Western Hemlock (*Tsuga heterophylla*), Sitka Spruce (*Picea sitchensis*) and less often in Western redcedar (*Thuja plicata*).

Availability of suitable cavities throughout the forests of the Islands is unknown, though a primary excavator, the Pileated Woodpecker, which excavates many cavities used extensively on the Mainland, is not present on the Islands. Hairy Woodpeckers also occur at low densities which may suggest that cavities are relatively scarce and that availability of suitable owl cavities may be influenced by the long-term conservation of the Hairy Woodpecker on the islands.

During the breeding season, foraging occurs along forest edges, openings and along riparian edges, and males may move more than 1km from core breeding area to forage. In general, their diet is not

[1] The IWMS outlines a series of Best Management Practices for Identified species. However, these are not automatically applied. A process is required in each case to propose a Wildlife Habitat Area (WHA). The number of WHA's provincially is limited by a timber supply impact cap not to exceed 1%.

well known but includes small mammals (rodents and shrews), a wide range of invertebrates and birds (perching birds and Ancient Murrelet chicks (*Synthliboramphus antiquus*)). Rodents are thought to become increasingly important food source during the breeding season. Outside the breeding season, owls appear to disperse from breeding territories. Diet analysis of road-killed birds indicates an increased level of marine invertebrates are taken in fall and winter so the birds appear to expand into coastal areas during these times.

Predation pressure on adult owls is likely low, however Northern Goshawks (*Accipiter gentilis*) take Saw-whet Owls on occasion (Frank Doyle, pers. comm.), and other predators likely include Common Raven, Bald Eagle, Red-tailed hawk (*Buteo jamaicensis*), Sharp-shinned hawk (*Accipiter striatus*) and Peregrine Falcon (*Falco peregrinnus*).

It is thought that the population is less than 1000 individuals on the Islands. No actual trends in population are available, but it is considered likely to be declining due to loss of mature and old forest habitat. Habitat values for this species are to some degree assessed by the coarse filter analysis (Old Forest Section 2.1) which assess the amount, representation and distribution of old forest across the landscape.

LAND USE CONCERNS

The Northern Saw-whet owl appears quite flexible in its foraging capability, utilising a wide array of prey species. The impacts of introduced species are generally unknown, though predicted to be negative: red squirrels and raccoons may prey on nests. Rodents may enhance food supplies, but loss of understory vegetation may reduce the availability of other forage species.

The Saw-whet owl requires mature / old forest for nesting, preferably close to riparian areas. The additional requirement for suitably sized nest cavities likely results in lower habitat availability for nesting. The species does not appear to be very flexible in breeding habitat preference so is likely negatively impacted by harvest techniques that do not maintain mature forest with a wide variety of structural attributes.

3.2. GREAT BLUE HERON (ARDEA HERODIAS FANNINI)

PRIMARY INFORMATION SOURCES

Gebauer, M.B., and I.E. Moul. 2001. Status of the Great Blue Heron in British Columbia. B.C. Minist. Environ., Lands and Parks, Wildl. Branch. Working rep. WR-102. 66pp.

Butler, R.W., and P.D. Baudin. 2000. Status and Conservation Stewardship of the Pacific Great Blue Heron in Canada. Pp. 247-250 *in* L.M. Darling, ed. 2000. Proc. Conf. on the Biology and Manage. Species and Habitats at Risk, Kamloops, B.C., 15-19 Feb., 1999. Vol. 1; B.C. Minist. Environ., Lands and Parks, Victoria, BC, and Univ. College of the Cariboo, Kamloops, BC.

BACKGROUND INFORMATION

Great blue herons are found widely across British Columbia. The subspecies *fannini* is limited to coastal BC, but is not endemic to HG/ QCI. There are approximately 5000 birds worldwide, of which 2000 are resident in BC. The coastal subspecies is blue-listed provincially (vulnerable), and a COSEWIC Species of Special Concern. It is also part of the 'Identified Wildlife Management Strategy of BC', which outlines Best Management Practices which may be applied for some nests[1].

Great blue herons forage primarily in rich shallow water ecosystems and typically stalk prey. They catch a wide variety of prey from small fish, frogs, aquatic insects and crustaceans. However, they are also opportunistic foragers and will also catch small mammals and birds on land when the opportunity arises.

On HG/ QCI herons are relatively scarce compared to other coastal areas; the Islands have a relatively low density of estuaries or other good quality foraging areas (e.g. eelgrass beds or tidal mudflats), which likely results in the relatively low density, and their distribution throughout the Islands. Typically the Great Blue Heron is a colonial nesting species, but on HG / QCI it tends to nest as single pairs in individual trees, with no known colonies larger than 20 pairs. Nests occur at relatively low density and are often located close to wetland and/or coastal feeding areas. Birds will often re-use nest sites over a number of years.

Significant mortality sources of chicks include bald eagle and raven depredation of chicks in the nest, and it has been suggested that human disturbance may increase the possibility of a successful nest predation attempt by these predators. Adult herons are also vulnerable to bald eagles, and may also suffer from winter starvation in areas where food sources are sparse.

Coast-wide the subspecies' population is considered to be declining; evidence based on the Canadian Wildlife Service's Breeding Bird Surveys (BBS) suggests that Herons on the coast of British Columbia (including Queen Charlotte Islands and Vancouver Island) are declining at a rate of 9.4 per cent per year. However, the decline is not statistically significant, is based primarily on data from the Georgia Strait and should be viewed with caution particularly in relation to more northerly regions. There are few breeding records for HG/QCI, including 12 known nests, but which apparently unoccupied in 2004. The total population and local population trends for HG / QCI is unknown.

LAND USE CONCERNS

Nesting herons are extremely sensitive to human disturbance especially during nest selection and building. Nest abandonment has been recorded throughout the coast region due to human disturbance such as road-building, off-road vehicle use, urban construction and tree-felling. More remote nest sites appear to be more sensitive to human disturbance as local birds can sometimes habituate to local disturbances.

Forest harvesting may remove single nests or small colonies, particularly in areas such as HG / QCI where most nests are isolated from others and so difficult to locate. Best Management Practices are available for herons from the Identified Wildlife Management Strategy, but require that a Wildlife Habitat Area be applied to a known nest site or colony.

Foraging birds are also particularly sensitive to disturbance from shoreline pedestrians, dogs, boaters, etc. Loss or reductions in habitat quality in key foraging areas such as estuaries and tidal mud flats resulting from development or pollution may be a concern in some areas.

3.3. BALD EAGLE (HALIAEETUS LEUCOCEPHALUS)

PRIMARY INFORMATION SOURCES

Campbell, R.W., N.K. Dawe, I.McT. Cowan, J.M. Cooper, G. Kaiser, and M.C.E. McNall. 1990. The Birds of British Columbia, Vol. 2, Non-passerines: Diurnal Birds of Prey through Woodpeckers. Royal B.C. Mus. in association with Environ. Can., Can. Wildl. Serv. 636pp.

Environment Canada. Bald Eagle Population Trends. Available on the www at: http://www.ecoinfo.ec.gc.ca/env_ind/region/baldeagle/eagle_e.cfm

BACKGROUND INFORMATION

The bald eagle is widely distributed along the West Coast of North America and throughout the western provinces and States. The centre of the BC population is along the coast primarily on the Gulf Islands, Vancouver Island and HG/ QCI. British Columbia and Alaska account for approximately 70% of the total North American population of bald eagles. The species is not listed in British Columbia, though it has been substantially reduced in much of its former range across North America. British Columbia therefore has a high global responsibility for maintaining the species.

Bald eagles breed primarily in coniferous forests near seashores, rivers, marshes and other riparian areas. Large trees and especially veteran trees and snags (often Sitka spruce) that protrude through the canopy are high value for nest sites. Most coastal nests are within 100m of the shoreline.

Bald eagles forage on a wide variety of prey species that changes with the season. Many subpopulations undergo both seasonal and annual migrations, though in some locations individuals are resident year-round. During the breeding season eagles prey on whatever is locally available; often primarily fish, aquatic birds, mammals and crustaceans and other species found along the shoreline. Eagles also often steal food from other species such as ravens and will also scavenge on roadkill or discarded fish pieces etc. Generally, the adults are more likely to hunt and kill, whereas the younger birds rely more on scavenging and piracy.

Bald eagles often move away from nesting territories in summer to feed on herring or other high-density prey. Fall movements to estuaries and rivers correlate with salmon spawning. Winter food shortages may limit population sizes locally. On HG / QCI the local population often increases in winter as birds nesting further north move south to the more hospitable and rich feeding areas of the Islands.

Population trends for the Islands are unavailable, however, the numbers of bald eagles breeding and wintering in BC has increased by approximately 7% annually since the 1960s resulting in a large increase in the population of eagles over this time period. Low population numbers in the 1960s were thought to reflect both the significant declines salmon stocks which were highly impacted by forest harvesting and hydroelectric dam building in western north America up through the 1960s, combined with direct mortality of adult birds caused by pesticide poisoning and hunting. The population recovery since the 1970s reflects some recovery of food supplies and reduction in adult mortality combined with redistribution of birds from impacted areas to less impacted areas.

LAND USE CONCERNS

Negative impacts on salmon streams would impact local food supply for eagles. Maintaining old-growth coniferous forest along salmon streams protects salmon food source and provide wintering roost habitat for eagles. Roost habitat is critical and structurally large conifers are a preferred resource.

Maintaining nest trees is required (a map layer of known nests for Gwaii Haanas and north along Moresby Island is available).

Roosting and nesting birds are sensitive to human disturbance (fishing, boating etc.), but difficult to regulate.

3.4. STELLARS JAY (CYANOCITTA STELLERI CARLOTTAE)

PRIMARY INFORMATION SOURCES

Fraser, D.F., W.L. Harper, S.G. Cannings, and J.M. Cooper. 1999. Rare birds of British Columbia. Wildl. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 244pp.

BACKGROUND INFORMATION

The stellars jay is a subspecies endemic to HG/ QCI and Dall Island Alaska. It is provincially blue-listed (vulnerable).

Very little is known about the biology of this subspecies but it is assumed to be similar to the mainland subspecies. On the Islands, the stellars jay appears to prefer low elevation coniferous and mixed coniferous / deciduous forest. They will nest in undisturbed and disturbed second-growth forest and near human habitation. Nests tend to be located near the trunk of conifers.

On the Islands, the population is small and local with total size unknown though density appears to be lower than in similar areas on the mainland. Island population trends are also unknown, though it been suggested that populations may be threatened by harvesting, which removes understory habitat.

Silvicultural treatments of second growth stands can substantially reduce natural succession of shrubs in these stands, removing potential nesting and foraging sites.

LAND USE CONCERNS

Long term impacts of forest harvesting on this species are unknown. Regenerating forest may be suitable for some aspects of life history, but may lack structures over the long term to maintain populations.

The species tends to nest relatively low to the ground in low shrubs and saplings. It may therefore be negatively impacted by increased nest predation as a result of introduced mammals in particular.

3.5. HAIRY WOODPECKER (PICOIDES VILLOSUS PICOIDEUS)

PRIMARY INFORMATION SOURCES

Fraser, D.F., W.L. Harper, S.G. Cannings, and J.M. Cooper. 1999. Rare birds of British Columbia. Wildl. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 244pp.

BACKGROUND INFORMATION

One of 6 provincial subspecies of the Hairy Woodpecker, *picoideus* is an endemic subspecies breeding on the Islands. It is blue-listed provincially (vulnerable).

It is a primary cavity nester (i.e. it excavates its own cavity) nesting in a wide range of habitat types, including coniferous, mixed and broadleaf forests and is often associated with riparian areas. On the mainland, this species forages on a variety of insects and are usually resident in a particular locale.

Local population size and trends are unknown for the Islands though the local population is thought to be small.

LAND USE CONCERNS

Loss of structural attributes (wildlife trees / snags) in second growth stands likely results in loss of habitat for this species. Impacts on populations unknown.

Reliance on suitable trees in riparian habitat makes it locally vulnerable to loss of riparian forests and loss of larger dead structures in second growth stands. Longer term impacts of harvesting may be possible.

The low number of primary cavity nesting species on the Islands may increase the ecological importance of this species for maintaining other secondary cavity-nesters such as Saw-whet owl.

3.6. SANDHILL CRANE (GRUS CANADENSIS TABIDA)

PRIMARY INFORMATION SOURCES

Cooper, J.M. 1996. Status of the Sandhill Crane in British Columbia. B.C. Minist. Environ., Lands and Parks, Wildl. Branch., Bull. B-83. 40pp.

Forest Practices Code. 1997. Sandhill Crane *in* Species and Plant Community Accounts for Identified Wildlife: Vol. 1. B.C. Minist. For. and B.C. Environ. 184pp.

Fraser, D.F., W.L. Harper, S.G. Cannings, and J.M. Cooper. 1999. Rare birds of British Columbia. Wildl. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 244pp.

BACKGROUND INFORMATION

The Sandhill crane is blue-listed provincially due to its sparse population and is identified within the Identified Wildlife Management Strategy[1]. The crane breeds in marshes, swamps, meadows with emergent vegetation, and in close proximity to coniferous forests that provide escape routes for newly fledged young. It is a solitary nester with sites dispersed widely across the landscape in appropriate habitat.

There is a sizeable but unknown number of cranes breeding on HG/ QCI primarily located on Queen Charlotte Lowland and Skidegate Plateau. Some birds winter on HG / QCI though this is thought to be a considerably smaller number than the breeding population.

The species breeds over a large geographic area and are thought to be stable, but population trends are generally unknown. Population size and trends for the Islands are also unknown.

LAND USE CONCERNS

Agricultural and urban conversion of wetland habitat a problem across the range of Sandhill Cranes, but less likely to be a problem on HG / QCI. Changes in water flow patterns, caused primarily by introduced beaver may be an issue in the Queen Charlotte Lowlands.

Forest surrounding nesting habitat is used as escape for young and adults and as a buffer from disturbance. The potential impact of harvest of trees from areas important for nesting cover may cause local nest failure, or reduce reproductive success.

Disturbance along shorelines and in estuaries may also negatively impact foraging ability.

Populations are small and isolated, and therefore vulnerable to disturbance and habitat destruction.

3.7. PEREGRINE FALCON (FALCO PEREGRINUS PEALEI)

PRIMARY INFORMATION SOURCES

Fraser, D.F., W.L. Harper, S.G. Cannings, and J.M. Cooper. 1999. Rare birds of British Columbia. Wildl. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 244pp.

Kirk, D. A. and R. W. Nelson. 1999. Updated COSEWIC Status Report on the Peale's Peregrine Falcon, Falco peregrinus pealei. Committee on the Status of Endangered Wildlife in Canada. 15 pp

BACKGROUND INFORMATION

This subspecies of peregrine falcon is provincially blue-listed (vulnerable), and is a COSEWIC species of concern. It is locally distributed on Alaskan coast, north BC coast and QCI /HG.

It is typically a resident species once a pair has established and breeding has occurred. Nests are built primarily on inaccessible cliff ledges. The peregrine forages primarily on colonial seabirds, and has been associated with the historically extensive population of Ancient Murrelets on HG / QCI.

The global population is estimated at 700 pairs (1998), with 78 pairs on HG /QCI in 1995 and most of the remaining pairs found in Alaska. This subspecies did not suffer the extensive population declines seen in the inland subspecies that resulted from DDT impacts on eggs in the 1960s. However, local populations on HG / QCI may have been reduced to some degree by the large reduction in food supply caused by mammalian impacts on Ancient Murrelets, particularly on Langara Island. However, the population is thought to have remained relatively stable over the last 20 years (www.speciesatrisk.gc.ca).

Historically, removal of eggs and chicks for falconry was allowed; it was banned in 1987. There are some concerns that MWLAP may again allow removal of eggs from peregrine nests in the province to supply falconers, however it is unlikely that Peale's peregrine would be included.

LAND USE CONCERNS

This population appears to be vulnerable to changes in food supply. Maintaining food supplies primarily involves adequately managing and recovering seabird populations (especially Ancient Murrelet). Potential impacts of oil spills locally could be devastating to the population.

Disturbance caused by airplanes, and particularly helicopters, can also cause local nest failures. Access management issues can reduce these impacts where nests are known.

3.8. PINE GROSBEAK (PINICOLA ENUCLEATOR CARLOTTAE)

PRIMARY INFORMATION SOURCES

Fraser, D.F., W.L. Harper, S.G. Cannings, and J.M. Cooper. 1999. Rare birds of British Columbia. Wildl. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 244pp.

BACKGROUND INFORMATION

This coastal subspecies is endemic to HG/ QCI, Vancouver Island, and possibly the mainland coast.

Primary habitat is mid to high elevation coniferous forests of coastal mountain ranges (primarily spruce forests), where it nests low to the ground in coniferous trees. It is thought to use a range of forest seral stages, including early through to mature / old forest types. On HG/ QCI it has a widespread, but sparse distribution.

No information on population size or trends.

LAND USE CONCERNS

May be threatened due to harvest of high elevation forest breeding habitat, but effects largely unknown.

3.9. ERMINE (MUSTELA ERMINEA HAIDARUM)

PRIMARY INFORMATION SOURCES

Cannings, S.G., L.R. Ramsay, D.F. Fraser, and M.A. Fraker. 1999. Rare amphibians, reptiles, and mammals of British Columbia. Wildl. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 198pp.

Reid, D.G. *et al*. 1999. Status and Management of Ermine on the Queen Charlotte Islands, British Columbia. B.C. Minist. For., For. Res. Extension Note 1. 4pp.

Reid, D.G., L. Waterhouse, P.E.F. Buck, A.E. Derocher, R. Bettner, and C.D. French. 2000. Inventory of the Queen Charlotte Islands Ermine. Pp. 393-406 *in* L.M. Darling, ed. 2000. Proc. Conf. on the Biology and Manage. Species and Habitats at Risk, Kamloops, B.C., 15-19 Feb., 1999. Vol. 1; B.C. Minist. Environ., Lands and Parks, Victoria, BC, and Univ. College of the Cariboo, Kamloops, BC. 490pp.

BACKGROUND INFORMATION

The Haida ermine is one of the few mammals endemic to HG/ QCI. It is an endemic subspecies (1 of 5 provincial subspecies), and is apparently restricted to Graham and Moresby Islands though also possibly on Louise and Burnaby Islands. It is red-listed provincially and a COSEWIC Threatened species.

Ermine den in burrows or hollow logs and appear to have some association with riparian and foreshore habitats. They have been found primarily in coniferous forest in the CWHwh1 and close to water.

Ermine generally forage on mice and voles, but the lack of native microtines on the islands likely result in generally sparse populations under natural conditions. The introduction of rats and red squirrels likely now provide additional forage species, but likely also provide competition for other prey. Marten (*Martes americana*) appears to be increasing and may threaten ermine population viability.

Population size on HG/ QCI is unknown, but extensive live-trapping for ermine resulted in extremely low detection for the species. Population trend data are unknown, however historic information suggests that the species used to be considerably more common than it is today.

LAND USE CONCERNS

Effects of harvesting on habitat especially on coarse woody debris is a concern. Data from other populations shows the species to rely heavily on coarse woody debris for denning and foraging sites.

Introduced species (including feral / house cats) may have a significant negative impact, increasing predation for this small species.

Developing riparian silviculture prescriptions that enhance plants with heavy seed crops such as graminoids and alder may improve habitat quality.

3.10. KEEN'S LONG-EARED MYOTIS (MYOTIS KEENII)

PRIMARY INFORMATION SOURCES

Cannings, S.G., L.R. Ramsay, D.F. Fraser, and M.A. Fraker. 1999. Rare amphibians, reptiles, and mammals of British Columbia. Wildl. Branch and Resour. Inv. Branch, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 198pp.

Forest Practices Code. 1997. Keen's Long-Eared Myotis *in* Species and Plant Community Accounts for Identified Wildlife: Vol. 1. B.C. Minist. For. and B.C. Environ. 184pp.

M. J. Evelyn. 2004. Keen's Long-eared Myotis Inventory and Habitat Association Mapping on Haida Gwaii/Queen Charlotte Islands Interim Progress Report.

BACKGROUND INFORMATION

Keen's long-eared myotis bat is red-listed provincially, a COSEWIC species of concern, and an Identified Wildlife Management Species. It is endemic to coastal BC, though not restricted to HG/ QCI.

The species is resident on the Islands and likely hibernates close to breeding sites. It inhabits low elevation coastal forests, and likely uses mature and old forest types, though these are not known to be required. Low elevation coastal forests are thought to be required for forage production of moths and other insects.

Very little is known about specific habitat use. One known maternity colony is on Hotspring Island (HG/ QCI). Karst areas may be important for providing roost and particularly hibernation sites. Otherwise, the species probably uses tree roots, tree cavities, loose bark areas, rock crevices and caves for roosting. Protection of maternity colonies is likely crucial to population maintenance.

LAND USE CONCERNS

Protection of any known colonies required to prevent loss or disturbance. Location of new colonies however is difficult. The species is associated with tree cavities found in mature and old growth forest therefore habitat loss is likely associated with simplification of forests through clearcut harvesting. Maintaining larger sized snags and dead trees throughout the forest will likely maintain habitat quality.

Mineral interest in karst areas may become a concern in the future as these areas appear to be critical for hibernation.

3.11. MARINE MAMMALS

BACKGROUND INFORMATION

There are a large number of marine mammal species associated with HG / QCI, many of which are considered endangered or threatened provincially and globally. However, most of these species are not directly affected by land use decisions. One species, the sea otter, has been extirpated through over hunting from much of the coast of BC and currently only exists on the West Coast of

Vancouver Island and on a small area of the mid coast. The west coast of HG / QCI is thought to have high quality habitat value for this species however (www.speciesatrisk.gc.ca), even though currently a population has not recolonised the Islands its natural recolonisation is thought likely over time.

A small number of marine mammals – sealions and seals – currently use terrestrial areas for haul out and pupping. Historically, populations of Steller sealions were considerably larger than exist today; the decline in the populations related to direct killing to reduce impacts on fish stocks. Although this ceased in 1970 population sizes remain relatively low. Many of these areas are currently unprotected, or effectively unprotected since disturbance by humans is unregulated or unmonitored. Human disturbance, particularly during pupping can result in high mortality of young.

LAND USE CONCERNS

Identify sites that require protection, or enhance management within a Protected Area to reduce disturbance to haul-out and pupping colonies. Concerns will increase with increasing tourism and fishing operations close to sensitive areas.

Additional concerns include increased disturbance resulting from future tourism and fishing activities, which may possibly impact a wider variety of marine mammal species. In addition the potential catastrophic impacts of a large spill associated with oil and gas development could affect all species and the wider oceanic ecosystem.

3.12. GIANT BLACK STICKLEBACK (GASTEROSTEUS SP.)

PRIMARY INFORMATION SOURCES

Cannings, S.G., and J. Ptolemy. 1998. Rare Freshwater Fish of British Columbia. B.C. Minist. Environ., Lands and Parks, Victoria, BC. 214pp.

BACKGROUND INFORMATION

The giant black stickleback is red-listed provincially, and listed as vulnerable by COSEWIC.

Taxonomy still unclear, this species may be more closely related to Boulton Lake sticklebacks than to close marine species. On HG / QCI it is known from Drizzle and Mayer lakes on the east side of Graham Island, and from Misty Lake on northern Vancouver Island (Lavin and McPhail 1993).

It inhabits the limnetic zone of oligotrophic, peatland lakes, and does not appear to enter streams. Nesting males found in clumps over sand or gravel substrate where there is some shelter such as fontinalis moss or rocks. Eggs are laid in a nest constructed by the male.

Population sizes are unknown, but suggested to be stable, though highly localised.

LAND USE CONCERNS

Threats include non-game fish, and beavers altering water levels in relation to spawning.

3.13. HAIDA GWAII JUMPING-SLUG

PRIMARY INFORMATION SOURCES

Ovaska,K. and L. Sopuck. 2003. Distribution and status of rare forest slugs in Western Canada. Prepared for Endangered Species Recovery Fund.

BACKGROUND INFORMATION

Coastal forests contain a unique set of native gastropods (slugs and snails), including a number of species considered rare or at risk. On HG/ QCI sampling has detected 15 native species of terrestrial gastropods. The Haida Gwaii jumping slug was first found in 2002, and has been located in a number of different locations since that time. Currently it has been found in forested environments and moist subalpine meadows containing scattered, stunted trees. The species is sufficiently different from others previously known that it is likely to be named a new genus. It appears that this species is endemic to the Islands.

Broad habitat requirements, population sizes and distributions for the species are currently unknown.

LAND USE CONCERNS

Forest harvesting likely impacts local habitat use, however largely unknown impacts on populations for these species.

This species highlights the fact that there may be additional rare or endemic species on the Islands that are as yet unknown. In the interim, the coarse filter analysis Section 2.1 assess the extent to which these species may be maintained by a representative selection of old forest ecosystems across the Islands.

3.14. SUMMARY CHAPTER 3

The species included in Chapter 3 tend to be those that will require specific management strategies tailored to their individual needs. However, as a group they also identify a number of broader land use issues that are summarised below:

- Maintenance of old growth structural attributes throughout second growth forests
- Maintenance of natural understory throughout both second growth forests and in old growth forests
- Maintenance of key habitat features such as estuaries which provide critical foraging grounds for a large number of species
- Disturbance by people (in planes, helicopters, boats, along foreshores, and in development of sensitive habitat) has high potential to impact species
- Terrestrial riparian areas and associated salmon stocks are key to a broad range of terrestrial species
- Prey and forage changes resulting from introduced species remain a complex issue which means it is difficult to predict the outcomes of management strategies
- Potential impacts of larger scale oil spills / accidents near the coast could have wide-ranging devastating impacts.
- Precautionary management approaches may be required to maintain many species which are hard to locate in the landscape.

Chapter 4. APPENDICES

In the following sections, the following information is presented:

- Technical information regarding generic development of ecosystem mapping for the Islands (4.1)
- Additional technical information on the methodologies for each indicator outlined in Chapter 2, where appropriate (4.2 – 4.11)
- Additional results where appropriate (4.2).

4.1. ECOSYSTEMS OF THE ISLANDS: PAST, PRESENT AND FUTURE.

In order to report out, and model through time, the effects on ecosystems on the archipelago, a single base map is required. Although forest cover information is some of the best mapping of forested ecosystems in the world, it also has some difficulties of use for this broader context:

- resolution is relatively low in terms of defining ecosystems (many more ecosystems / site series than are identified in Forest Cover)
- attributes present in Forest Cover data are often unsuitable for modeling or assessing wildlife habitat or plant communities

On Haida Gwaii more detailed ecosystem information (site series) is available for certain areas (Terrestrial Ecosystem Maps, primarily on Tree Farm Licenses), but these data are not available in the same format for all of the Islands.

The PTT worked to provide a map with sufficient resolution to answer important questions about ecosystems, at level lower than that of biogeoclimatic variant (e.g. the existing BEC variant map was insufficiently detailed), and to include as higher proportion of the land base including all the different tenures (TSAs, TFLs, Protected Areas etc) as possible.

The ecosystem map is used

- to provide a common reporting system for ecosystems across the islands, can be rolled back to provide an historical baseline, prior to the onset of industrial forestry activities, and predicted forward to estimate future impacts based on current management or LRMP scenarios.
- As a "forecasting model" to demonstrate how current management rules will result on the ground
- As the baseline for interpreting status of relevant environmental indicators

ANALYSIS UNITS

It was determined that defining ecosystems on the basis of a) leading tree species and b) productivity is the best approach available to the group. Analysis units have a number of interpretation limitations, which are listed below:

a) AU's don't measure ecosystem potential, but simply reflect current condition. This provides a difficulty for interpretation if the unit 'changes' over time (see below).

b) Using leading species results in a fairly coarse resolution of ecosystems identified. For example on HG / QCI many of the ecosystems present have western hemlock as the leading (most abundant) species. However, they may differ in terms of other tree / plant species composition, for example some 'Hw leading' sites may have a high component of spruce, whereas others could have a high component of red cedar. This definition therefore loses some ecosystem resolution.

c) Site productivity estimates are currently in flux. Traditionally, productivity estimates based on growth rates of old growth trees are quite low whereas productivity estimates of second growth trees can be considerably higher (sibec www). As a result, it is necessary to standardise site index over harvested (second growth) and non-harvetsed old growth sites to ensure a consistent map base.

HISTORIC CONDITION

The objective is to produce a map of estimated forest cover, in the year 1800. This would provide the ecological baseline for the representation indicator (Section 2.1). This process required two separate steps:

a) Backcasting forest cover attributes, from current condition to 1800. A simple model was used, taking current forest cover data, and 'standing up' the harvested forest using a number of simple assumptions:

i) all harvested forest was old growth forest (age class 9) prior to harvest, and 251 years ago (in 1800)

ii) all 'assumed' old growth forest in 1800 had a 'gappy' structure, and therefore a crown closure of 5 , in 1800

iii) all 'assumed' old growth forest in 1800 was between height class 4 and 7, i.e. between 36.5 and 56.5m high. No models using this map differentiated between 'old forests' within this range.

iv) within fire area, everything got backcast similar to other areas; except harvest areas, which were set back to the age of surrounding fire stand.

b) Estimating historic 'Analysis Units' for 1800. (Allen Banner MoF Regional Ecologist).

Historic (1800) analysis units are determined using two methods:

- current unharvested stands were assumed to have the same species composition and productivity in 1800 as currently, so were determined from current forest cover data.
- where harvesting has occurred, analysis units had to be estimated because harvesting has resulted in species composition changes (e.g. in some cases cedar / hemlock stands have been replanted back to hemlock / spruce stands), and assumed productivity of stands has also changed over time, with newly harvested stands now assumed considerably more productive than the original old growth stands. A number of steps were used to estimate historic analysis units for these previously harvested areas (A. Banner pers. comm.):

  i) mensuration data plots for the islands were used to estimate leading tree species occurring on sites of different site index (Table 1; sample size = 7xx)

  ii) harvested areas with Terrestrial Ecosystem Mapping (TEM) could then have a site series associated with a leading species, from this distribution.

  iii) productivity codes were assigned using a scaled down set of site indices (A. Banner pers. comm.), so productivity codes matched original productivity codes in surrounding old growth.

LIMITATIONS

A number of assumptions are made using this approach:

- Assumes ecosystems were static in the past (i.e. no natural disturbances occurred) since 1800. Although this is not true it is reasonable to assume that approximately the same amount of disturbance occurred over this timeframe, but likley moved around on the landscape
- Ignores any potential climate change effects over this timeframe (that would negate the assumption made above)
- Ignores historic small-scale harvesting (e.g. A-frame logging)

Table 1. Mean species composition percentages by site series (mature to old-growth plots), for major tree species on the Queen Charlotte Islands / Haida Gwaii. Data are based on 765 old-growth ecology plots, including MoF classification plots and TFL (and other) TEM plots.

		CWH vh 2 /01	CWH vh 2 /02	CWH vh 2 /03	CWH vh 2 /04	CWH vh 2 /05	CWH vh 2 /06	CWH vh 2 /07	CWH vh 2 /08	CWH vh 2 /09	CWH vh 2 /10	CWH vh 2 /11
Tree Species	# Plots	64	2	20	47	5	35	3	14	8	2	23
yellow-cedar		30.1	9.1	25.4	2.9	0.0	5.1	4.3	0.8	0.0	0.0	33.2
Sitka spruce		6.4	0.0	6.6	17.3	34.2	19.3	31.9	37.4	59.3	13.5	1.8
lodgepole pine		5.5	39.8	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.6
western yew		0.5	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
western redcedar		36.3	34.1	26.2	24.5	9.3	17.9	31.9	4.6	1.1	0.0	27.0
western hemlock		19.1	17.0	26.1	53.8	47.6	51.4	31.9	56.2	23.3	0.9	8.0
mountain hemlock		2.1	0.0	0.5	0.8	0.0	0.3	0.0	0.0	0.0	0.0	8.2
red alder		0.0	0.0	0.0	0.7	8.9	5.9	0.0	1.0	16.3	85.6	0.0
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AU Designation		C-P	Pl	C-L	H-M	Ss-G	H-G	Ss-G	Ss-G	Ss-G	Decid	C-L
		(H-P)			C-M	H-G	(Ss-G)	C-G	H-G			
							(C-M)	Hw-G				
AU #		2, (6)	9	3	5, 1	7, 4	4, (7,1)	7,1, 4	7, 4	7	10	3

		CWH vh 2 /12	CWH vh 2 /13	CWH vh 2 /14	CWH vh 2 /16	CWH vh 2 /Wb53	CWH wh 1 /01	CWH wh 1 /02	CWH wh 1 /03	CWH wh 1 /04	CWH wh 1 /05	CWH wh 1 /06	CWH wh 1 /07
Tree Species	# Plots	6	11	2	5	10	121	45	14	27	35	12	13
yellow-cedar		55.2	25.7	0.0	0.0	25.0	0.9	2.0	0.0	8.2	1.7	4.7	0.0
Sitka spruce		0.0	18.3	20.0	62.9	0.0	9.4	14.3	20.3	5.5	29.3	21.1	36.7
lodgepole pine		24.7	4.2	0.0	0.0	75.0	0.0	0.3	0.0	1.2	0.0	0.0	0.0
western yew		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.4	0.0	0.0	0.0
western redcedar		12.7	33.6	60.0	0.0	0.0	23.9	43.1	4.7	42.9	8.6	15.4	3.4
western hemlock		2.9	17.0	20.0	31.4	0.0	65.4	39.4	62.8	40.1	54.1	48.4	58.1
mountain hemlock		4.5	0.0	0.0	0.0	0.0	0.2	0.2	0.0	1.8	0.0	1.1	0.0
red alder		0.0	1.2	0.0	5.7	0.0	0.0	0.4	12.2	0.0	6.3	9.3	1.9
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AU Designation		Pl	C-P	Ss-P	Ss-P	(Pl)	H-M	C-P	H-G	H-P	H-G	H-M	Ss-G
				(H-P)			(C-M)	H-P	Ss-G	C-P	Ss-G	Ss-M	H-G

		(C-P)								
AU #	9	2 8, (6, 2)	8 (9)	5, (1)	2, 6	4, 7	6, 2	4, 7	5, 8	7, 5

	CWH wh 1 /08	CWH wh 1 /10	CWH wh 1 /11	CWH wh 1 /12	CWH wh 1 /14	CWH wh 1 /15	CWH wh 2 /01	CWH wh 2 /02	CWH wh 2 /03	CWH wh 2 /04	CWH wh 2 /05	CWH wh 2 /06	MH wh 2 /01	MH wh 2 /03	MH wh 2 /04	MH wh 2 /06	MH wh 2 /07
Tree Species # Plots	10	37	5	11	5	2	86	5	24	9	13	3	19	3	4	1	4
yellow-cedar	0.0	20.0	12.9	4.0	0.0	0.0	17.8	5.5	22.6	22.4	30.9	18.2	26.1	16.0	26.0	77.3	42.8
Sitka spruce	54.4	5.4	0.0	19.4	63.4	100.0	3.9	2.0	7.6	24.4	9.9	9.4	6.6	23.2	0.1	0.0	14.9
lodgepole pine	0.0	3.6	15.5	0.0	0.0	0.0	0.0	2.6	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
western yew	0.0	0.4	0.0	0.4	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
western redcedar	1.3	38.3	43.8	38.3	4.8	0.0	11.9	39.6	16.6	6.1	12.8	27.6	0.5	0.0	0.0	0.0	0.0
western hemlock	28.9	23.7	5.2	29.6	28.6	0.0	62.3	44.4	52.0	29.4	23.7	43.6	38.2	2.4	34.4	0.0	6.8
mountain hemlock	0.0	8.0	22.7	6.9	0.0	0.0	4.1	4.4	1.2	17.6	20.9	0.0	28.6	58.4	39.5	22.7	35.6
red alder	15.4	0.6	0.0	1.4	3.2	0.0	0.0	0.0	0.0	0.0	0.6	1.1	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AU Designation	Ss-G	C-L	Pl	C-P	Ss-P	Ss-P	H-M	H-P	H-M	H-P	C-L	C-P	H-P	H-P	H-P	C-L	C-P
				Ss-P			(C-M)	C-P	C-M	Ss-P			C-P	(Ss-P)	(C-L)	H-P	H-P
				H-P													
AU #	7	3	9	2, 8, 6	8	8	5, (1)	6, 2	5, 1	6, 8	3	2	6, 2	6, (8)	6, (3)	3, 6	2, 6

ANALYSIS UNITS AND SITE SERIES

There is not a one-to-one relationship between analysis units and site series. However, a cross-walk table between site series and analysis units is available – Table 2 (Allen Banner pers. comm.).

Table 2. Site Series or groups of site series (by BEC Unit) likely associated with each analysis unit. Site series in brackets less commonly associated with the AU.

	Biogeoclimatic variants			
Analysis Unit	CWHvh2	CWHwh1	CWHwh2[c]	Mhwh[e]
Cedar High/ Medium	07, 04, (06)	(01)	03, (01)	N/A[d]
Cedar Poor	01, (14)	02, 04, 12	02, 06	01, 07
Cedar Low	03, 11	10	05	02, 06, 08, 09, (04)
Hemlock High	05, 06, 07, 08	03, 05	N/A[d]	N/A[d]
Hemlock Medium	04	01, 06, 07	01, 03	N/A[d]
Hemlock Poor	(01), (14)	02, 04, 12	02, 04	01, 02, 03, 04, 05, 06, 07
Spruce High	05, 07, 08, 09, (06)	03, 05, 07, 09	N/A[d]	N/A[d]
Spruce Medium / Low	14[a], 16[a], 18[b,] 19[b]	06, 12, 13[a], 14[a], 15[a], 17[c]	04	(03)
Pine	02, 12	11	N/A[d]	N/A[d]
Deciduous	10	09	N/A[d]	N/A[d]

Brackets around site series denote that site series is either restricted in distribution or less commonly associated with that analysis unit

Footnotes:

a: Shorline Forests

b: Brackish Water (Estuaries)

c: Higher elevations; productivity declines; yellow cedar replaces redcedar

d: This analysis unit probably does not occur in this subzone/variant

e: Yellow-cedar and Mountain Hemlock replace Red-cedar and Western Hemlock in the MH zone; productivity declines

CURRENT CONDITION

Current condition of the forest is determined from current (year) Forest Cover data. Leading species and age are determined from polygon codes for the Islands. A single minor change was made to deal with a known data error:

a) In Gwaii Haanas, a data error appeared to exist in the FC, where likely 'old' stands were classifed as mature. In these cases age class 8 stands were altered in the database to AC9 (old growth) (J. Sunde pers. comm.)

FUTURE CONDITION

For this 'base case' analysis, future condition of the landbase resulting from 'current management' is predicted. This involves determination of the longterm sustainable harvest level based on a) the amount of harvestable land available, b) current management constraints, and c) the rate of tree growth after harvest. Full details of all the timber supply assumptions applied to the landbase are provided in the Basecase Analysis Report (Cortex 2004). A number of key assumptions are repeated here:

- The THLB for this analysis as defined in last TSR for last unit, with the exception of additional area added for TSA and TFL47 to include additional havresting occurring outside THLB (Xxha - Leah). In the TSA, the THLB was reduced by removal of riparian exclusions (9700 - 20,000). The net effect was a 2000ha addition ato the THLB over last TSR.
- Assumes clear-cut with reserve harvesting (5 – 10%), plus spatial riparian management areas
- Includes all existing protected areas.

4.2. OLD FOREST ECOSYSTEMS

This section contains additional methodological information, plus the results in full for all ecosystems.

MODEL APPROACH AND ASSUMPTIONS

The approach used is based on the assumption that the current and future state of ecosystem representation can be assessed by comparing the current amount of old forest present in an ecosystem to that predicted to have occurred under natural disturbance conditions.

The key assumption is that the further away from the range of natural variability, the greater the risk and the less likely that values provided by old forests will be maintained.

Table 1. Indicators, and interpretation summary

Assumptions / Limitations
Ecosystems are defined by Analysis Units stratified within biogeoclimatic variants.
Analysis Units reflect current condition, rather than potential condition, and so change as areas are harvested and leading species changes. Backcast original leading species on areas with TEM data, to account for this problem (see Appendix 4.1).
Scale of analysis does not take into account small scale harvesting (e.g. A-frame harvesting), where high value biological elements were removed from the stand.
Analysis assumes that the ecosystem map adequately reflects environmental variability. 45 ecosystems are identified using this surrogate (AU x BEC), which likely underestimates the actual number of ecosystems.
Analysis Units do not adequately identify rare / red / blue listed ecosystems – impacts on rare ecosystems could therefore not be identified using this surrogate.
Analysis Units that reflect the forest cover of today may not adequately reflect 'original' (pre disturbance) forest cover. This is because AU's reflect current vegetation, not potential vegetation (as do site series). As a result, an historic Analysis Unit map was created to remove the biases associated with harvest practices which have resulted in species conversions (see Section 4.1).
Old Forest is defined using available forest cover information
Old forest is defined as greater than 250 years old. Assumes a) that forest cover is current and b) that all forest >250 years old is of equal value, which likely is not true given that forest stands are considerably older than age of individual trees.
Age class (from forest cover) of some stand types is typically under-estimated. These stands tend to be low productivity types which have been typed from air photos as being younger stands when in fact they are likely very old stands, but of low stature. Areas within Gwaii Haanas, where forest cover is known to be under-estimated, were changed to reflect the likely old growth nature of these stands.
Patch size / fragmentation analysis
No patch size / fragmentation analysis was included in this work. I.e. the model assumes that all old forest contributes an equal amount of habitat / ecosystem value, irrespective of its size or location. In reality, this is unlikely to be a reasonable assumption because smaller or linear patches a) have a higher probability of loss from blowdown than do large patches, and b) are known to create different habitat conditions (i.e. they lack interior habitat conditions). A preliminary analysis that summarises the amount of old forest in riparian management areas is provided.

ECOLOGICAL BASELINE

An ecological baseline is available from two sources:

a) predicted from known information about natural disturbance regimes (see Section 2.1, and 1.0).

b) Measured from the predicted 'backcast' of forest cover on the islands.

The current forest cover data for the Islands was 'backcast' in order to create a map of the Islands prior to the onset of industrial harvest (John Sunde pers. comm.). The date of harvest was used to create a number of maps of forest cover back through time over 50 year periods. Assumptions used in creating these maps were simple. Any harvested stands are assumed to be:

- all age class 9 plus
- all height class 4 plus
- all crown closure 4 (i.e. gappy)
- no leading species or productivity is assigned to stands

In addition, an historic Analysis Unit map was created from three sources (see Section 4.1), a) unharvested areas, historic analysis units were taken from current forest cover and b) where harvesting had occurred and Terrestrial Ecosystem Mapping existed, historic analysis units were predicted from information known about the relationship between site series and leading species (A. Banner pers. comm. Section 4.1) and c) where harvesting had occurred and no TEM existed, current forest cover attributes were used to assign historic AU's,

RESULTS

The following tables are related to tables in the main results section for old forests (2.1), but provide data for all Ecosystems.

Table 2. Ecosystem (Analysis Unit within BEC variant) representation in current provincially and federally legislated Protected Areas. Shaded ecosystems are under-represented compared with the average (22%).

Analysis Unit	BECv	Area in Protected Area	Total Area	% PA
Pine	CWHvh2	9,389	11,331	83
CedarGoodMedium	CWHvh2	1,695	3,730	45
SpruceMediumPoor	CWHwh1	8,724	19,177	45
CedarLow	CWHvh2	51,632	120,790	43
HemlockGood	CWHwh2	834	2,008	42
CedarGoodMedium	CWHwh1	5,762	14,423	40
CedarPoor	CWHvh2	3,840	11,934	32
SpruceGood	CWHwh1	4,112	12,786	32
SpruceMediumPoor	CWHvh2	5,326	16,527	32
CedarLow	MHwh1	1,744	5,573	31
CedarPoor	MHwh1	96	362	27
SpruceGood	CWHvh2	1,595	6,735	24
CedarGoodMedium	CWHwh2	284	1,357	21
CedarLow	CWHwh1	38,996	184,663	21
HemlockMedium	CWHvh2	4,381	21,285	21

Analysis Unit	BECv	Area in Protected Area	Total Area	% PA
Pine	CWHwh1	1,973	9,189	21
HemlockPoor	MHwh1	1,342	6,976	19
HemlockPoor	CWHvh2	11,695	61,168	19
HemlockGood	CWHwh1	4,786	26,635	18
SpruceGood	CWHwh2	94	579	16
CedarPoor	CWHwh1	4,065	31,109	13
HemlockMedium	CWHwh1	13,729	112,651	12
HemlockMedium	MHwh1	129	1,111	12
HemlockGood	CWHvh2	715	6,564	11
SpruceMediumPoor	MHwh1	100	896	11
HemlockMedium	CWHwh2	1,612	19,537	8
HemlockPoor	CWHwh1	4,101	53,543	8
CedarLow	CWHwh2	517	16,414	3
HemlockPoor	CWHwh2	579	23,455	2
SpruceMediumPoor	CWHwh2	46	3,007	2

Analysis Unit	BECv	Area in Protected Area	Total Area	% PA
CedarPoor	CWHwh2	45	3,719	1
CedarLow	MHwh2		2,689	0
CedarPoor	MHwh2		466	0
HemlockMedium	MHwh2		1,321	0
HemlockPoor	MHwh2		5,222	0
SpruceMediumPoor	MHwh2		662	0
Grand Total		184,150	820,917	22

Table 3. Area of old forest in three time periods (1800, 2000 and 2250) for 32 ecosystems >500ha. Area of change and percent change compared to natural in old forest summarised for each time period.

Analysis Unit	BECv	Area Old Forest			Change* 1800- 2000		Change* 2000 - 2250		Change* 1800 – 2250	
	YEAR	1800	2000	2250	Area	Percent	Area	Percent	Area	Percent
CedarGoodMedium	CWHvh2	3,557	3,428	2,841	129	96	587	83	716	80
CedarGoodMedium	CWHwh1	14,225	10,649	8,346	3,576	75	2,303	78	5,879	59
CedarGoodMedium	CWHwh2	1,249	1,198	666	51	96	532	56	583	53
CedarLow	CWHvh2	96,111	93,165	90,296	2,946	97	2,870	97	5,815	94
CedarLow	CWHwh1	179,290	151,817	141,359	27,473	85	10,458	93	37,931	79
CedarLow	CWHwh2	15,789	14,611	11,255	1,178	93	3,356	77	4,534	71
CedarLow	MHwh1	4,399	3,573	3,503	826	81	70	98	897	80
CedarLow	MHwh2	2,608	1,962	1,732	646	75	230	88	876	66
CedarPoor	CWHvh2	11,236	10,020	8,554	1,216	89	1,467	85	2,682	76
CedarPoor	CWHwh1	30,618	22,017	13,627	8,601	72	8,390	62	16,991	45
CedarPoor	CWHwh2	3,677	3,499	1,851	178	95	1,648	53	1,826	50
HemlockGood	CWHvh2	5,766	1,805	2,805	3,961	29	+1,000	45	2,961	49
HemlockGood	CWHwh1	25,897	5,889	10,218	20,008	23	+4,329	26	15,680	39
HemlockGood	CWHwh2	1,973	1,081	1,212	893	55	+132	88	761	61
HemlockMedium	CWHvh2	18,821	13,491	11,903	5,330	72	1,588	88	6,918	63
HemlockMedium	CWHwh1	110,141	19,818	30,885	90,323	18	+11,067	44	79,256	28
HemlockMedium	CWHwh2	18,919	5,830	6,286	13,089	31	+456	92	12,633	33
HemlockMedium	MHwh1	1,048	957	808	91	91	149	84	240	77
HemlockMedium	MHwh2	1,167	732	551	435	63	181	75	616	47
HemlockPoor	CWHvh2	53,629	50,204	44,234	3,425	94	5,970	88	9,395	82
HemlockPoor	CWHwh1	47,966	34,149	20,920	13,816	71	13,229	61	27,046	44
HemlockPoor	CWHwh2	22,206	21,227	12,141	979	96	9,086	57	10,064	55
HemlockPoor	MHwh1	5,978	5,853	5,189	125	98	664	89	790	87
HemlockPoor	MHwh2	4,886	4,581	3,160	306	94	1,421	69	1,726	65
SpruceGood	CWHvh2	6,302	4,045	4,434	2,257	64	+389	90	1,868	70
SpruceGood	CWHwh1	12,394	7,091	6,535	5,303	57	556	92	5,859	53
SpruceGood	CWHwh2	571	431	355	139	76	76	82	215	62
SpruceMediumPoor	CWHvh2	15,086	14,050	12,756	1,036	93	1,294	91	2,329	85
SpruceMediumPoor	CWHwh1	17,896	14,140	12,609	3,756	79	1,532	89	5,287	70
SpruceMediumPoor	CWHwh2	2,907	2,777	1,648	131	95	1,129	59	1,260	57
SpruceMediumPoor	MHwh1	820	742	684	78	90	59	92	136	83
SpruceMediumPoor	MHwh2	647	586	398	61	91	188	68	249	62

* All changes are reductions in old forest, unless identified by a + which means an increase in old forest.

Table 4. Area of old forest for Analysis Units within all Landscape Units. Area of change, and percent change compared to natural shown for three time periods (1800 – 2000, 2000-2250 and 1800 – 2250).

		Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
LU	histAU	1800	2000	2250	Area	Percent	Area	Percent	Area	Percent
AthlowBay	HemlockGood	605	229	221	376	38	8	97	384	37
AthlowBay	SpruceGood	805	669	601	136	83	68	90	204	75
AthlowBay	HemlockPoor	11,150	10,773	8,652	377	97	2,121	80	2,499	78
AthlowBay	SpruceMediumPoor	1,050	1,022	826	29	97	196	81	224	79
AthlowBay	HemlockMedium	2,521	2,375	2,020	146	94	356	85	502	80
AthlowBay	CedarLow	13,053	12,747	12,720	306	98	27	100	333	97
Beresford	HemlockGood	387	14	37	373	4	+23	-58	350	10
Beresford	CedarGoodMedium	1,426	1,421	796	5	100	625	56	630	56
Beresford	HemlockMedium	4,954	4,151	2,920	803	84	1,231	70	2,034	59
Beresford	SpruceGood	776	712	460	63	92	253	65	316	59
Beresford	SpruceMediumPoor	3,058	2,940	1,915	118	96	1,025	65	1,143	63
Beresford	CedarPoor	3,118	2,875	2,015	244	92	860	70	1,103	65
Beresford	HemlockPoor	14,468	14,122	10,795	346	98	3,327	76	3,673	75
Beresford	CedarLow	24,363	24,196	23,635	167	99	561	98	728	97
Bigsby	CedarGoodMedium	560	560	560	0	100	0	100	0	100
Bigsby	CedarLow	8,871	8,868	8,871	3	100	+3	100	0	100
Bigsby	CedarPoor	1,343	1,343	1,343	1	100	+1	100	0	100
Bigsby	HemlockGood	41	34	41	7	83	+7	80	0	100
Bigsby	HemlockMedium	504	396	485	108	79	+89	77	19	100
Bigsby	HemlockPoor	1,284	1,236	1,241	48	96	+5	100	43	100
Bigsby	SpruceGood	10	10	10	0	100	0	100	0	100
Bigsby	SpruceMediumPoor	266	266	266	0	100	0	100	0	100
EdenLake	HemlockMedium	12,707	2,482	2,654	10,226	20	+172	93	10,054	21
EdenLake	HemlockGood	1,158	92	257	1,067	8	+165	-80	902	22
EdenLake	CedarPoor	1,427	1,409	509	18	99	901	36	919	36
EdenLake	CedarGoodMedium	1,269	1,269	523	0	100	746	41	746	41
EdenLake	SpruceMediumPoor	1,478	1,454	722	24	98	733	50	757	49
EdenLake	SpruceGood	773	737	381	37	95	356	52	393	49
EdenLake	HemlockPoor	7,576	7,169	4,019	406	95	3,151	56	3,557	53
EdenLake	CedarLow	16,842	16,783	12,735	59	100	4,048	76	4,107	76
Gowgaia	CedarGoodMedium	111	111	111	0	100	0	100	0	100
Gowgaia	CedarLow	12,904	12,917	12,917	+14	100	0	100	+14	100
Gowgaia	CedarPoor	123	123	123	0	100	0	100	0	100
Gowgaia	HemlockGood	125	125	125	0	100	0	100	0	100
Gowgaia	HemlockMedium	1,922	1,912	1,912	10	100	0	100	10	100
Gowgaia	HemlockPoor	5,802	5,802	5,802	0	100	0	100	0	100
Gowgaia	SpruceGood	19	19	19	0	100	0	100	0	100
Gowgaia	SpruceMediumPoor	2,029	2,025	2,025	3	100	0	100	3	100
Gudal	HemlockPoor	4,797	4,525	4,521	272	94	4	100	276	94
Gudal	CedarGoodMedium	114	110	104	4	96	6	94	10	100
Gudal	CedarLow	5,445	5,387	5,398	58	99	+11	100	47	100
Gudal	CedarPoor	795	709	689	86	89	20	97	107	100

		Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
Gudal	HemlockGood	498	239	310	259	48	+72	70	188	100
Gudal	HemlockMedium	639	600	558	39	94	42	93	81	100
Gudal	SpruceGood	383	87	240	296	23	+153	-75	143	100
Gudal	SpruceMediumPoor	797	699	718	98	88	+20	97	79	100
Hibben	SpruceGood	1,157	780	883	377	67	+103	87	274	76
Hibben	CedarPoor	2,161	2,188	1,702	+27	99	486	78	459	79
Hibben	HemlockGood	1,243	454	1,027	789	37	+573	-26	217	83
Hibben	HemlockPoor	8,246	7,262	7,115	984	88	147	98	1,131	86
Hibben	HemlockMedium	2,297	2,124	2,020	173	92	105	95	277	88
Hibben	SpruceMediumPoor	3,333	3,023	2,994	310	91	30	99	339	90
Hibben	CedarLow	5,403	4,999	4,947	403	93	52	99	456	92
Hibben	CedarGoodMedium	269	224	148	45	83	76	66	121	100
Honna	HemlockGood	5,177	180	953	4,997	3	+773	-329	4,225	18
Honna	SpruceGood	2,905	720	750	2,185	25	+30	96	2,155	26
Honna	HemlockMedium	1,918	758	531	1,160	40	227	70	1,386	28
Honna	CedarGoodMedium	837	615	249	222	73	367	40	589	30
Honna	CedarPoor	1,501	1,388	719	113	92	669	52	782	48
Honna	HemlockPoor	3,656	3,014	1,876	642	82	1,138	62	1,780	51
Honna	SpruceMediumPoor	2,619	2,327	1,577	293	89	750	68	1,042	60
Honna	CedarLow	5,804	5,622	4,700	182	97	923	84	1,105	81
Ian	HemlockMedium	3,980	698	690	3,282	18	9	99	3,290	17
Ian	CedarPoor	2,247	1,761	483	486	78	1,278	27	1,764	21
Ian	HemlockPoor	5,842	4,328	1,293	1,514	74	3,035	30	4,549	22
Ian	HemlockGood	475	206	123	269	43	83	60	352	26
Ian	CedarLow	11,163	11,114	3,649	49	100	7,465	33	7,514	33
Ian	SpruceMediumPoor	381	323	134	58	85	190	41	248	35
Ian	CedarGoodMedium	152	149	24	3	98	125	16	129	100
Ian	SpruceGood	375	308	195	67	82	112	63	180	100
Jalun	CedarPoor	1,804	1,804	801	0	100	1,003	44	1,004	44
Jalun	CedarGoodMedium	494	494	231	0	100	264	47	264	47
Jalun	HemlockMedium	1,433	1,408	678	26	98	730	48	756	47
Jalun	SpruceMediumPoor	991	962	479	30	97	483	50	512	48
Jalun	HemlockPoor	3,306	3,246	1,927	61	98	1,318	59	1,379	58
Jalun	CedarLow	16,613	16,603	15,345	11	100	1,258	92	1,269	92
Jalun	HemlockGood	53	45	35	8	84	10	78	18	100
Jalun	SpruceGood	278	236	156	42	85	80	66	122	100
KunghitIsland	CedarGoodMedium	85	85	85	0	100	0	100	0	100
KunghitIsland	CedarLow	3,218	3,218	3,218	0	100	0	100	0	100
KunghitIsland	CedarPoor	228	228	228	0	100	0	100	0	100
KunghitIsland	HemlockGood	63	63	63	0	100	0	100	0	100
KunghitIsland	HemlockMedium	858	858	858	0	100	0	100	0	100
KunghitIsland	HemlockPoor	1,077	1,076	1,076	1	100	0	100	1	100
KunghitIsland	SpruceGood	389	389	389	0	100	0	100	0	100
KunghitIsland	SpruceMediumPoor	1,691	1,690	1,690	0	100	0	100	0	100
LouiseIsland	HemlockGood	2,521	16	489	2,504	1	+473	-2808	2,032	19
LouiseIsland	HemlockMedium	7,504	827	1,599	6,677	11	+772	7	5,905	21

		Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
LouiseIsland	SpruceGood	333	111	81	222	33	30	73	252	24
LouiseIsland	SpruceMediumPoor	435	399	214	37	92	185	54	221	49
LouiseIsland	CedarPoor	1,429	1,220	738	209	85	482	60	691	52
LouiseIsland	HemlockPoor	5,223	4,233	2,708	991	81	1,525	64	2,516	52
LouiseIsland	CedarLow	4,176	4,081	2,467	94	98	1,615	60	1,709	59
LouiseIsland	CedarGoodMedium	129	128	61	1	99	68	47	69	100
LowerYakoun	CedarPoor	2,400	1,202	505	1,198	50	698	42	1,895	21
LowerYakoun	HemlockMedium	7,995	1,345	1,855	6,650	17	+509	62	6,140	23
LowerYakoun	HemlockPoor	3,886	1,763	1,049	2,123	45	715	59	2,837	27
LowerYakoun	HemlockGood	1,154	96	406	1,058	8	+310	-224	748	35
LowerYakoun	CedarLow	9,361	5,895	3,596	3,466	63	2,299	61	5,765	38
LowerYakoun	CedarGoodMedium	175	18	39	157	10	+22	-24	136	100
LowerYakoun	SpruceGood	232	155	158	77	67	+3	98	74	100
LowerYakoun	SpruceMediumPoor	134	113	85	22	84	28	75	50	100
LyellIslandGroup	CedarGoodMedium	3,299	3,285	3,285	15	100	+1	100	14	100
LyellIslandGroup	CedarLow	3,135	3,129	3,129	6	100	0	100	6	100
LyellIslandGroup	CedarPoor	140	139	139	1	100	0	100	0	100
LyellIslandGroup	HemlockGood	3,398	3,015	3,254	383	89	+239	92	144	100
LyellIslandGroup	HemlockMedium	10,513	3,646	10,645	6,866	35	+6,998	-92	+132	100
LyellIslandGroup	HemlockPoor	889	830	848	59	93	+18	98	41	100
LyellIslandGroup	SpruceGood	1,295	1,172	1,175	123	91	+3	100	120	100
LyellIslandGroup	SpruceMediumPoor	405	335	390	70	83	+55	84	15	100
MassetInlet	HemlockMedium	21,576	3,417	5,440	18,159	16	+2,023	41	16,136	25
MassetInlet	CedarLow	5,495	5,433	1,694	61	99	3,739	31	3,800	31
MassetInlet	CedarPoor	2,145	1,730	673	415	81	1,057	39	1,472	31
MassetInlet	HemlockGood	2,593	459	999	2,134	18	+540	-18	1,595	39
MassetInlet	HemlockPoor	12,072	10,049	4,864	2,023	83	5,185	48	7,208	40
MassetInlet	SpruceMediumPoor	741	628	319	113	85	310	51	423	43
MassetInlet	CedarGoodMedium	119	118	21	1	100	98	18	98	100
MassetInlet	SpruceGood	281	61	89	220	22	+28	55	192	100
Naikoon	HemlockMedium	731	386	326	345	53	60	84	405	45
Naikoon	HemlockGood	1,507	144	766	1,363	10	+622	-331	741	51
Naikoon	CedarGoodMedium	2,050	673	1,252	1,378	33	+580	14	798	61
Naikoon	HemlockPoor	3,865	1,485	2,805	2,380	38	+1,321	11	1,059	73
Naikoon	SpruceGood	2,155	1,205	1,597	950	56	+393	67	558	74
Naikoon	CedarPoor	4,398	3,054	3,655	1,344	69	+600	80	744	83
Naikoon	SpruceMediumPoor	8,112	5,587	7,468	2,524	69	+1,881	66	643	92
Naikoon	CedarLow	47,320	32,868	44,304	14,452	69	+11,436	65	3,016	94
Otun	HemlockGood	885	318	134	567	36	185	42	751	15
Otun	HemlockMedium	475	403	116	72	85	287	29	359	24
Otun	CedarGoodMedium	1,372	1,249	467	123	91	782	37	905	34
Otun	CedarPoor	3,201	3,172	1,138	29	99	2,034	36	2,063	36
Otun	HemlockPoor	2,451	1,994	1,000	457	81	995	50	1,452	41
Otun	SpruceGood	1,239	1,059	611	180	85	448	58	629	49
Otun	SpruceMediumPoor	1,323	1,281	724	43	97	557	57	600	55
Otun	CedarLow	39,875	39,451	36,477	424	99	2,974	92	3,398	91

		Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
Rennell	SpruceGood	1,639	388	954	1,251	24	+566	-46	685	58
Rennell	HemlockGood	2,367	569	1,385	1,798	24	+816	-43	983	58
Rennell	HemlockMedium	2,882	2,760	2,194	122	96	565	80	687	76
Rennell	HemlockPoor	10,986	10,072	9,102	915	92	970	90	1,885	83
Rennell	SpruceMediumPoor	1,918	1,760	1,631	158	92	129	93	287	85
Rennell	CedarLow	7,608	7,333	7,091	274	96	242	97	517	93
Rennell	CedarGoodMedium	320	286	271	34	89	15	95	49	100
Rennell	CedarPoor	942	918	789	24	98	129	86	153	100
Sewell	HemlockMedium	12,263	1,030	1,609	11,233	8	+579	44	10,654	13
Sewell	HemlockGood	2,742	627	742	2,115	23	+115	82	2,000	27
Sewell	HemlockPoor	8,516	7,193	5,073	1,322	84	2,121	71	3,443	60
Sewell	SpruceMediumPoor	1,620	1,336	989	285	82	347	74	631	61
Sewell	CedarLow	10,962	8,140	6,793	2,822	74	1,347	83	4,168	62
Sewell	CedarPoor	1,315	1,068	870	247	81	198	81	445	66
Sewell	CedarGoodMedium	691	649	572	42	94	77	88	119	100
Sewell	SpruceGood	415	224	233	191	54	+9	96	182	100
SkidegateLake	HemlockMedium	30,872	2,302	3,681	28,571	7	+1,380	40	27,191	12
SkidegateLake	HemlockGood	2,296	121	503	2,176	5	+382	-217	1,794	22
SkidegateLake	HemlockPoor	3,872	1,661	865	2,212	43	796	52	3,007	22
SkidegateLake	CedarGoodMedium	1,257	1,207	407	50	96	800	34	850	32
SkidegateLake	CedarPoor	4,508	3,575	1,752	933	79	1,823	49	2,756	39
SkidegateLake	CedarLow	1,857	1,608	863	249	87	745	54	994	46
SkidegateLake	SpruceGood	458	237	221	222	52	16	93	237	48
SkidegateLake	SpruceMediumPoor	726	534	452	192	74	82	85	274	62
Skincuttle	CedarGoodMedium	2,018	2,015	2,018	3	100	+3	100	0	100
Skincuttle	CedarLow	17,913	17,919	17,919	+6	100	0	100	+6	100
Skincuttle	CedarPoor	2,563	2,566	2,566	+3	100	0	100	+3	100
Skincuttle	HemlockGood	1,270	1,131	1,169	139	89	+37	97	102	100
Skincuttle	HemlockMedium	3,730	3,456	3,811	274	93	+356	90	+81	100
Skincuttle	HemlockPoor	2,970	2,926	2,927	44	99	+2	100	42	100
Skincuttle	SpruceGood	1,530	1,456	1,456	75	95	0	100	75	100
Skincuttle	SpruceMediumPoor	1,125	1,094	1,101	31	97	+7	99	24	100
Tasu	HemlockGood	1,174	74	121	1,100	6	+47	36	1,053	10
Tasu	HemlockMedium	4,241	413	519	3,829	10	+106	74	3,722	12
Tasu	CedarPoor	1,589	617	542	972	39	76	88	1,047	34
Tasu	SpruceGood	473	304	222	169	64	82	73	251	47
Tasu	CedarLow	8,998	6,636	4,430	2,361	74	2,207	67	4,568	49
Tasu	SpruceMediumPoor	1,190	826	623	364	69	203	75	566	52
Tasu	HemlockPoor	3,800	3,201	2,599	600	84	602	81	1,201	68
Tasu	CedarGoodMedium	142	107	69	35	75	38	65	73	100
Tlell	HemlockMedium	3,963	1,175	724	2,788	30	451	62	3,239	18
Tlell	HemlockPoor	4,210	3,868	1,132	342	92	2,736	29	3,078	27
Tlell	CedarPoor	5,299	1,702	1,496	3,597	32	206	88	3,803	28
Tlell	HemlockGood	390	35	110	356	9	+76	-120	280	28
Tlell	CedarGoodMedium	2,168	533	616	1,635	25	+83	84	1,552	28
Tlell	SpruceGood	1,240	516	417	724	42	100	81	824	34

		Area of old forest			Change* 1800 – 2000		Change* 2000 – 2250		Change* 1800 – 2250	
Tlell	SpruceMediumPoor	1,371	1,133	487	238	83	646	43	884	36
Tlell	CedarLow	14,684	7,077	9,041	7,607	48	+1,964	72	5,643	62
YakounLake	HemlockMedium	9,619	1,909	2,591	7,710	20	+682	64	7,028	27
YakounLake	SpruceMediumPoor	565	541	268	24	96	273	50	297	47
YakounLake	HemlockPoor	4,723	4,189	2,358	534	89	1,831	56	2,365	50
YakounLake	HemlockGood	1,751	556	1,079	1,195	32	+523	6	672	62
YakounLake	CedarLow	3,137	3,104	2,206	33	99	898	71	931	70
YakounLake	CedarPoor	1,203	1,068	887	135	89	181	83	316	74
YakounLake	CedarGoodMedium	203	199	139	4	98	60	70	65	100
YakounLake	SpruceGood	289	167	144	122	58	24	86	145	100

* All changes are reductions in old forest, unless identified by a + which means an increase in old forest.

4.3. PLANT SPECIES AND COMMUNITIES

Table 1. Rare and endemic plant speciesRed font = red-listed taxon; Blue font = blue-listed taxon; yellow fill = unlisted taxon; grey fill = taxon now considered synonymous with other taxon. Compiled for Ministry of Forests (J. Pojar) by Paula Bartemucci, Smithers.

Scientific Name	Common Name	Rare on QCI	Endemic?	Unusual Disjunction	Range Extension	Habitat	Reference
Abronia latifolia	yellow sand-verbena	4			N limit	sandy beaches	
Aconitum delphiniifolium	mountain monkshood	4				subalpine meadows	Calder & Taylor 1968; Roemer & Ogilvie 1983
Agrostis pallens	dune bentgrass	4			N limit	beaches	
Ambrosia chamissonis	silver burweed				N limit	sandy beaches	
Amsinckia spectabilis	seaside fiddleneck	4			N limit (?)	sandy beaches	
Anemone multifida	cut-leaved anemone	4		QCI - Interior BC	W limit; 1 QCI record	limestone bluffs, Limestone I.	
Anemone narcissiflora	narcissus anemone			QCI - Brooks Pen.	W limit	rocky high elevations	
Anemone parviflora	small-flowered anemone	4		QCI-Interior BC	W limit	limestone outcrops	Calder & Taylor 1968; Roemer & Ogilvie 1983
Angelica genuflexa	kneeling angelica	4				beaches, roadsides, clearings	Lomer & Douglas 1999
Aphanes occidentalis	western parsley-piert	4			W limit	dry coastal bluffs	
Artemisia norvegica ssp. *Saxatilis*	mountain sagewort	4			W limit	rocky slopes, high elevations	
Astragalus robbinsii	Robbins' milk-vetch	4		QCI - Interior BC	W limit	limestone	Roemer & Ogilvie 1983
Atriplex alaskensis	Alaskan orache	4			S limit; 1 QCI record	seashores	Douglas and others 1998; extirpated?; doubtful taxon?
Boschniakia hookeri	Vancouver groundcone	4			N limit	open hemlock-redcedar-salal forest	Lomer & Douglas 1999
Bromus vulgaris	Columbia brome	4			N limit	gravelly roadside	Lomer & Douglas 1999
Calamagrostis purpurascens ssp. *tasuensis (C. sesquiflora)*	Tasu purple reedgrass		N coastal BC	QCI - Brooks Pen.	N limit?	limestone; high elevations	now submerged in *C. sesquiflora* (Douglas and others 2001)
Callitriche hermaphroditica	northern water-starwort	4				aquatic	Lomer & Douglas 1999
Callitriche heterophylla ssp. *heterophylla*	two-edged water-starwort	4				aquatic	Douglas and others 1998
Callitriche palustris	spring water-starwort	4				aquatic	Lomer & Douglas 1999
Campanula lasiocarpa	mountain harebell	4				alpine ridges	
Cardamine angulata	angled bitter-cress					moist forest	
Carex cusickii	Cusick's sedge	4			W limit	peatlands	
Carex glareosa var. *amphigena*	lesser saltmarsh sedge	4			S limit	tidal marshes	

Scientific Name	Common Name	Rare on QCI	Endemic?	Unusual Disjunction	Range Extension	Habitat	Reference
Carex gmelinii	Gmelin's sedge	4				shoreline bluffs , meadows, marshes	
Carex lenticularis var. *dolia*	lens-fruited sedge	4				high-elevation ponds	Lomer & Douglas 1999
Carex pansa	sand-dune sedge	4				shorelilne forests & meadows, sandy beaches	
Carex stipata	awl-fruited sedge	4				wet ditches, swamps	Lomer & Douglas 1999
Cassiope lycopodioides ssp. *cristapilosa*	crinkle-haired club-moss mountain-heather		N.coastal BC	QCI - Brooks Pen.		high elevation heaths	now submerged in *C. lycopodioides s. lat.* (Douglas and others 1999)
Cerastium fischerianum	Fischer's chickweed	4			S limit?	limestone	Roemer & Ogilvie 1983
Chimaphila menziesii	Menziesii's pipsissewa	4			now several QCI records	mossy conifer forests	Lomer & Douglas 1999; Stockton and others 2002
Convolvulus soldanella	beach morning-glory	4				sandy beaches	
Cystopteris montana	mountain bladder fern	4			SW limit	limestone	Roemer & Ogilvie 1983
Dodecatheon pulchellum	pretty shootingstar	4				rocky shores; limestone	Roemer & Ogilvie 1983
Douglasia laevigata	smooth douglasia	4		QCI - N Van. Isl.		meadows	
Draba lonchocarpa var. *vestita*	lance-fruited draba	4				rocky alpine slopes	
Eleocharis acicularis	needle spike-rush	4				mudflats	
Eleocharis kamtschatica	Kamchatka spike-rush	4			near S limit	wet ditches, swamps	
Eleocharis obtusa	blunt spike-rush	4			N limit	mudflats	
Eleocharis parvula	small spike-rush	4			N limit	estuarine mudflats	Lomer & Douglas 1999
Enemion savilei	Queen Charlotte isopyrum		N. BC coastall	QCI - Brooks Pen.		shady, rocky habitats; usually high elevations	
Epilobium ciliatum ssp. *Watsonii*	purple-leaved willowherb	4				wet disturbed areas	
Epilobium hornemannii ssp. *Behringianum*	Hornemann's willowherb	4				wet cliffs, meadows, streambanks	
Epilobium latifolium	broad-leaved willowherb	4				gravelly shores, wet rocky slopes	
Epilobium leptocarpum	small-flowered willowherb	4				moist meadows, streambanks	
Epilobium minutum	small-flowered willowherb	4			NW limit	dry open coastal bluffs	
Eerigeron humilis	arctic daisy	4				meadows & rocky slopes at high elevations	Calder & Taylor 1968; Roemer & Ogilvie 1983
Gentiana glauca	inky gentian	4			1 QCI record	high elevation heaths & meadows	Lomer & Douglas 1999
Gentiana platypetala	broad-petalled gentian			QCI - Brooks Pen.		meadows & rocky slopes at high elevations	
Geranium richardsonii	white geranium	4		QCI - Interior BC	1 QCI locality	limestone bluffs, Limestone I.	

Scientific Name	Common Name	Rare on QCI	Endemic?	Unusual Disjunction	Range Extension	Habitat	Reference
Geum schofieldii	Queen Charlotte avens	4	N. BC. Coast	QCI - Brooks Pen.		rocky slopes, esp. high elevations	
Glyceria leptostachya	slender-spiked mannagrass	4				marshes, shores, wet meadows	Douglas and others 2002
Glyceria occidentalis	western mannagrass	4			N limit	marshes, shores	Douglas and others 2002
Helictrotrichon hookeri	spike-oat	4		NE BC - QCI	W limit	grassy slopes	Douglas and others 2002; doubtful record?
Isolepis cernua	low clubrush	4			N limit	tidal mudflats & runnels	
Juncus triglumis	three-flowered rush	4		QCI - Interior BC	S limit	sloping bogs	
Lathyrus littoralis	grey beach peavine	4			N limit	sandy beaches	
Lemna minor	common duckweed	4		QCI - S and NE BC	W limit	aquatic	Lomer & Douglas 1999
Ligusticum calderi	Calder's lovage		n coastal BC - se AK			peaty & rocky slopes, heaths	
Lilaeopsis occidentalis	western lilaeopsis				N limit	tidal mudflats & runnels	
Lloydia serotina var. *flava*	yellowish alp lily		N. BC Coast	QCI - N Van. Isl.		rocky slopes, esp. high elevations	
Lobelia dortmanna	water lobelia	4			N limit	aquatic	
Lupinus littoralis	beach lupine				N limit	sandy beaches	
Malaxis brachypoda	white adder's-mouth orchid	4			W limit	moist forests, streambanks, fens	
Malaxis diphyllos	Aleutian adder's-mouth orchid	4		QCI - Aleutian Islands	S limit	bogs & moist forests	
Malaxis paludosa	bog adder's-mouth orchid	4				bogs	
Hymenophyllum wrightii	Wright's filmy fern	4		W BC - Japan, Korea		shaded clliff faces, tree bases	
Mertensia maritima	sea bluebells				S limit	sandy beaches	
Mimulus guttatus ssp. *Haidensis*	Haida yellow monkey-flower		QCI?			rocky slopes and streambanks, often subalpine	now submerged in *Mimulus guttatus s. lat.* (Douglas and others 2000)
Minuartia tenella	slender sandwort	4			N limit	gravelly or rocky slopes	Calder & Taylor 1968; Roemer & Ogilvie 1983
Myriophyllum quitense	waterwort water-milfoil	4				aquatic	Douglas and others 2002
Najas flexilis	wavy water nymph	4				aquatic	Lomer & Douglas 1999
Oxalis oregana	redwood sorrel	4		QCI-s. Van. I.-Olympic Pen.	N limit	moist forests	Ogilvie and others 1984
Oxytropis campestris var. *varians*	field locoweed	4		QCI - Interior BC	W limit	rocky slopes at high elevations; limestone	Roemer & Ogilvie 1983
Pedicularis lanata	woolly lousewort	4			SW limit	rocky alpine ridges	
Pedicularis oederi	Oeder's lousewort	4			SW limit	moist rocky slopes, usually high elevations	

Scientific Name	Common Name	Rare on QCI	Endemic?	Unusual Disjunction	Range Extension	Habitat	Reference
Pedicularis parviflora ssp. Parviflora	small-flowered lousewort	4			SW limit	boggy subalpine slopes	
Pedicularis verticillata	whorled lousewort				SW limit	heath, tundra, peaty slopes	
Penstemon davidsonii	Davidson's penstemon	4			N limit		
Pinguicula villosa	hairy butterwort	4				sphagnum bogs	
Poa arctica ssp. arctica	arctic bluegrass	4			W limit	subalpine meadows	Lomer & Douglas 1999
Poa stenantha	narrow-flowered bluegrass	4				limestone scree, bluffs	Calder & Taylor 1968; Roemer & Ogilvie 1983
Polemonium pulcherrimum	showy Jacob's-ladder	4		QCI - Interior BC	W limit	limestone bluffs	Roemer & Ogilvie 1983
Polygonum amphibium	water smartweed	4				aquatic	Taylor 1989
Polygonum viviparum	alpine bistort	4			W limit	high elevation heath	
Polypodium hesperium	western polypody	4			N limit; 2 QCI records	limestone cliffs, Takakia Lake	Calder & Taylor 1968
Polypodium scouleri	leathery polypody	4		QCI - Van Isl and Sunshine Coast.	N limit		
Polystichum setigerum	Alaska holly fern	4				moist forests, shaded rocky slopes	Douglas and others 2002
Potamogeton alpinus	northern pondweed	4					
Stuckenia (Potamogeton) filiformis	slender-leaved pondweed	4					Lomer & Douglas 1999
Potamogeton foliosus	closed-leaved pondweed	4					Lomer & Douglas 1999
Potamogeton nodosus	long-leaved pondweed	4			N limit		
Stuckenia (Potamogeton) pectinata	fennel-leaved pondweed	4					
Potamogeton praelongus	long-stalked pondweed	4					Lomer & Douglas 1999
Potamogeton robbinsii	Robbin's pondweed	4			N limit		
Pyrola asarifolia	pink wintergreen	4			1 QCI record	limestone ridge, Tasu	Roemer & Ogilvie 1983
Pyrola minor	lesser wintergreen	4		QCI - Van Isl and E Coast Mtns.	1 QCI record	scree slope, Slatechuck Mtn.	Lomer & Douglas 1999
Pyrola secunda	one-sided wintergreen	4				mossy forest	
Rorippa curvipes	blunt-leaved yellow cress	4		QCI - Van Isl and E Coast Mtns.	1 QCI record	pool margins, Tlell	Lomer & Douglas 1999
Sagina saginoides	Arctic pearlwort	4			2 QCI records	scree slopes, high elevations	Lomer & Douglas 1999
Salix hookeriana	Hooker's willow	4			N limit	shores, beaches, swamps	
Salix reticulata ssp. glabellicarpa	smooth-fruited net-veined willow		QCI - se AK			rocky high elevations	
Salix stolonifera	creeping willow	4			SW limit; 1 QCI record	limestone crevices, Mt. La Perouse	Roemer & Ogilvie 1983
Sanguisorba menziesii	Menzies' burnet	4				wetlands, wet meadows	Calder & Taylor 1968
Sanicula crassicaulis	Pacific sanicle	4			NW limit		

Scientific Name	Common Name	**Rare on QCI**	Endemic?	Unusual Disjunction	Range Extension	Habitat	Reference
Saussurea americana	American sawwort	4				high elevation meadows	
Saxifraga caespitosa	tufted saxifrage	4				limestone bluffs	Calder & Taylor 1968
Saxifraga nelsoniana ssp. *carlottae*	dotted saxifrage		nwBC - se AK			rocky slopes, gravel bars	
Saxifraga oppositifolia	purple saxifrage	4				rocky alpine ridges	
Saxifraga taylori	Taylor's saxifrage		N. BC Coast	QCI - Brooks Pen.		cliffs & rocky slopes	
Saxifraga tolmiei	Tolmie's saxifrage	4				high elevation snowbeds	
Schoenoplectus (Scirpus) americanus	Olney's bulrush	4			N limit; 1 QCI report	aquatic, Tlell R.	Lomer & Douglas 1999
Sedum divergens	spreading stonecrop				N limit	dry rocky headlands & bluffs	
Selaginella densa	compact selaginella	4		QCI - Interior BC	NW limit	limestone ridges & crags	Roemer & Ogilvie 1983
Selaginella wallacei	Wallace's selaginella				N limit	dry coastal bluffs & mountain ridges	
Senecio cymbalaria	northern butterweed	4			S limit; 1 QCI record	bogs & wet meadows, Port Chanal	Douglas and others 2002
Senecio lugens	black-tipped groundsel	4		QCI - Interior BC	W limit; 1 QCI record	limestone scree & crevices, Mt. La Perouse	Roemer & Ogilvie 1983
Senecio moresbiensis	Queen Charlotte butterweed		N. BC Coast; se AK	QCI - N Van. Isl.		bogs and peaty slopes	Douglas and others 2002
Senecio pseudarnica	beach groundsel	4		QCI only in BC, AK	E coast disjunct	sandy beaches	Calder & Taylor 1968
Silene acaulis	moss campion	4				rocky alpine ridges	
*Sinosenecio newcombei**	Newcombe's butterweed		QCI			rocky & peaty slopes, open forests	
Sparganium fluctuans	water bur-reed	4			NW limit; I QCI record	aquatic, Skidegate Lake	Lomer & Douglas 1999
Taraxacum ceratophorum	horned dandelion	4			1 QCI record	limestone gully, Tasu	Roemer & Ogilvie 1983
Thalictrum alpinum	alpine meadowrue	4		QCI - Interior BC	W limit	alpine heath and rocky slopes	Calder & Taylor 1968; Roemer & Ogilvie 1983
Triglochin concinna	graceful arrow-grass	4			N limit	tidal marshes	Lomer & Douglas 1999
Trisetum spicatum	spike trisetum	4				rocky slopes, high elevations	
Viola biflora ssp. *carlottae*	twinflower violet		n coastal BC - se AK			moist rocky slopes & meadows	
Vulpia megaleura	rattail fescue	4		QCI - se Van. I.	NW limit; 1 QCI record	around hotspring pools	Calder & Taylor 1968; now submerged in *V. myuros*, an introduced species
**Sinosenecio newcombei* found only on Haida Gwaii in the world.							
Red font>>Red listed taxon							
Blue font>>Blue listed taxon							
Unlisted taxon							
Taxon now considered synonymous with other taxa.							

Table 2. Rare plant Communities (BC CDC).

Scientific name	English name	Biogeoclimatic Site Unit(s)	Provincial Rank	Provincial List
Alnus rubra / Maianthemum dilatatum	Red alder / false lily-of-the-valley	CWHvh1/10 CWHvh2/10	S3	Blue
Picea sitchensis - Tsuga mertensiana / Calamagrostis nutkaensis	Sitka spruce - mountain hemlock / reed grass	MHwh1/03 MHwh2/03	S3	Blue
Picea sitchensis / Calamagrostis nutkaensis	Sitka spruce / reedgrass	CWHwh1/15 CWHvh1/16 CWHvh2/16	S3	Blue
Picea sitchensis / Carex obnupta	Sitka spruce / slough sedge	CWHvh1/18 CWHvh2/18 CWHwh1/17	S3	Blue
Picea sitchensis / Kindbergia oregana	Sitka spruce / Kindbergia	CWHvh1/15 CWHwh1/14	S3	Blue
Picea sitchensis / Maianthemum dilatatum Wet Hyperemaritime 1	Sitka spruce / false lily-of-the-valley Wet Hypermaritime 1	CWHvh2/08 CWHwh1/07	S2	Red
Picea sitchensis / Malus fusca	Sitka spruce / Pacific crabapple	CWHvh1/19 CWHvh2/19 CWHwh1/18	S3	Blue
Picea sitchensis / Polystichum munitum	Sitka spruce / sword fern	CWHvh1/17 CWHvh2/17	S3	Blue
Picea sitchensis / Trisetum canescens	Sitka spruce / Trisetum	CWHvh1/09 CWHvh2/09 CWHwh1/08	S2	Red
Thuja plicata - Picea sitchensis / Conocephalum conicum	Western redcedar - Sitka spruce / Conocephalum	CWHwh1/06 CWHwh2/04	S3	Blue
Thuja plicata - Picea sitchensis / Oplopanax horridus Very Wet Hyperemaritime 2	Western redcedar - Sitka spruce / devil's club Very Wet Hypermaritime 2	CWHvh2/07	S3	Blue
Thuja plicata - Picea sitchensis / Polystichum munitum	Western redcedar - Sitka spruce / sword fern	CWHvh1/05 CWHvh2/05 CWHwh1/03	S2S3	Blue

Thuja plicata/Picea sitchensis - Lysichitum americanum	Western redcedar/Sitka spruce - skunk cabbage	CWHvh1/13 CWHvh2/13 CWHwh1/12 CWHwh2/06 CWHmm1/12 CWHdm/12 CWHxm1/12 CWHds1/12 CWHds2/12 CWHxm2/12 CWHms1/11 CWHms2/11 CWHvm1/14	S3	Blue
Tsuga heterophylla - Picea sitchensis / Rhytidiadelphus loreus	Western hemlock - Sitka spruce / lanky moss	CWHvh1/04 CWHvh2/04 CWHwh1/01 CWHwh2/01	S3	Blue

4.4. WATERSHED CONDITION

WATERSHED IDENTIFICATION

Watersheds used as the basis for this analysis were defined by the Process Technical Team. There are aproximately 28,607 actual watersheds that contain water features on HG/ QCI, however a more management set of watersheds were required to provide a basis for analysis. A total of 145 watersheds were identified using the following analysis:

The TRIM watershed atlas provided positionally accurate heights-of-land that were used to define the PTT watershed unit boundaries. The original intention was to use 3rd order watersheds from the watershed atlas. However, the geography of Haida Gwaii does not lend itself to a tidy heirarchy of watershed orders. Few true 3rd order watersheds exist on the islands and their size is quite variable. Using the available 3rd order watersheds as a starting point, other watershed orders and watershed breaks were used to define major heights-of-land, from which the PTT then identified its own watershed units. Logical breaks between watershed units were used and a generally consistent watershed size was maintained (average size ~7,000 ha). Other than to shift the original NTS heights-of-land to align with their TRIM equivalents, landscape unit boundaries were respected and PTT watershed units were created to nest within landscape units; no PTT watershed unit crosses a landscape unit boundary. The application of the 1:20,000 watershed atlas also enabled a minor refinement of the original LU boundaries to match true heights-of-land. One significant LU boundary change was made between the Gudal and Honna landscape units in the form of a split between the Dawson Harbour and Trounce Inlet watershed units to harmonize the boundaries with the ecosections of the islands.

DETERMINING AND ANALYSING RIPARIAN FISH FOREST ZONES (J. BROADHEAD GOWGAIA INSTITUTE)

In order to provide an analysis of ecologically relevant 'riparian' areas on the Islands, a process was used to determine a layer termed the Ripairan Fish Forest zone. This zone for the Islands is shown in Map 16.

Steps to produce this layer are itemised below:

1. All known point source data about the presence or absence of salmon, trout and char in streams and lakes from several hundred survey records, maps and databases at scales ranging from 1:5,000 to 1:50,000 were collected and geo-referenced to the TRIM 1:20,000 scale stream coverage.

2. All known point source data for waterfalls, cascades and other obstacles to fish passage (FISS, SISS, watershed assessments) were collected. Redundant data and misplaced points were corrected and all were anchored to the TRIM stream line work.

3. A network model of the stream line work was created and intersected with the TRIM elevation contours to calculate the gradient of each stream segment. Data points for known elevation limits (200 metres) and gradient barriers (from 20 to 30 percent) for salmon, trout and char were created and adjusted until they reached a logical fit with the known fish records.

4. A software routine (line route event) was written to visit the mouth of each TRIM stream, determine which species of fish are known to inhabit it, then populate all uphill stream segments until a known or modeled gradient barrier is encountered. Various maps illustrating the known and inferred distribution of sockeye, coho, chum, pink and chinook salmon, steelhead, cutthroat trout and dolly varden char were generated. A summary map theme illustrates all known or inferred stream habitation by residents-only and anadromous fish.

5. A fish abundance ratings table was created by correlating stream order, fish distribution and salmon escapement data into five classes: 1 no fish; 2 residents only; 3 just a few salmon; 4 some salmon; 5 many salmon; each segment in the stream event map from step 4 was attributed with a corresponding fish abundance index number.

6. GIS Riparian forest buffers ranging in radius from 20 to 100 metres were applied to every stream segment according its fish abundance rating. Buffers were checked visually against colour orthophotos and Terrestrial Ecosystem Mapping polygons for spatial coherence with detectable riparian features.

7. Larger riparian features (delineated as TEM polygons) that intersect with TRIM stream segments were selected, extracted and assigned a fish abundance rating of 1 to 5 consistent with the intersecting streams.

8. The coverages from steps 6 and 7 were merged into a single GIS shape file delineating the distribution of *riparian-fish forest*, themed into five classes of fish abundance. The result is illustrated and summarized in a poster called Riparian Fish Forest of Haida Gwaii – Map 16.

Harvest to date of the RFF layer was by determined by:

1. Creating a 1:20,000 scale GIS shape file of annual logging and major road-building from AD 1900 to 2003 from Forest Cover data (year logged), Landsat 5 satellite imagery and historic records.

2. The logging history was intersected with the Riparian Fish Forest coverage (RFF) to measure and map the area disturbed by logging in any given year, within each of 145 watershed units (delineated by the Process Technical Team for landscape level analysis).

A potential risk assessment was produced by measuring the percentage of riparian forest logged to date in each watershed unit and classifying it as either high >30 percent, moderate 20–30, some 10-20, or low <10 percent. A risk level rankings table was produced, indicating that 44 watershed units are at a high potential risk level, 20 at medium, 7 at medium and 74 at low. (see Chapter 2.3 for details).

HAIDA LAND USE VISION WATERSHEDS

A number of watersheds are identified by the Haida Land Use Vision. The HLUV 'Watersheds of Concern' were identified through an HLUV Committee review of watersheds known by the Haida to contain culturally significant salmon populations in decline and indications of habitat damage caused by logging. 'No logging' interim reserves were identified for portions of watersheds around Ian Lake, Crease Creek and Datlamen Creek.

Some of these areas consist of multiple 'PTT watersheds'. A list of PTT watersheds that are part of HLUV identified watersheds is shown in Table 1.

Table 1. Watersheds identified in the Haida Land Use Visions, their associated PTT watersheds, and potential risk levels as identified using two indicators (see Chapter 2.3 for details). Colours are associated with potential risk: 'high' = red, yellow = moderate, green = low.

HLUV Watersheds	PTT Watershed	Potential Risk based on	
		% watershed logged	% RFF logged
Ain	Ain River		
	Crease Creek		
	Ian Lake		
	Ian Northeast		
	Ian Southwest		
	Tara Creek		
Awun	Awun River		
Bonanza	Bonanza Creek		
Copper	Skidegate Lake		
Davidson	Davidson Creek		

Datlaman	Datlamen Creek		
Deena	Deena Creek		
Mamim	Blackwater Creek		
	Mamin River		
Mathers	Mathers Creek		
Naden	Naden River		
	Roy Lake		
Riley	Riley Creek		
Yakoun	Blackbear Creek		
	Brent Creek		
	Canyon Creek		
	Florence Creek		
	Ghost Creek		
	Gold Creek		
	King Creek		
	Log Creek		
	LowerYakoun River		
	Phantom Creek		
	UpperYakoun River		
	Yakoun Lake		

4.5. CEDAR

D. Amount of old growth cedar harvested from the Islands. As outlined above, no data are available on monumental cedar. Instead, as a surrogate, we examine the amount of old growth cedar removed from the Islands through time – estimated from the difference in cedar on the Islands in 1800 compared to 2000. In addition, trends in tall old cedar through time are also provided. These analyses were undertaken by MSRM (John Sunde) for this chapter –

Methods: -

1. Using species and percentage codes from the inventory, the redcedar component of every polygon was isolated by searching for redcedar in all of the species fields and recording its associated percentage in a separate field.

2. For each polygon the 'net cedar area' was calculated by multiplying the polygon area by the cedar %. This reflects the amount of cedar present in the inventory in all age classes in 2003.

3. In order to distinguish current cedar area from estimated historical cedar area, based on the assumption that there is less cedar present on logged stands that there might have been before logging: Looking only at stands with age class 7, 8 or 9, the average % of cedar for every AU/BEC combination across the landbase was calculated. Because the averages were calculated for older stands only, these values provide an estimate of cedar % prior to harvest.

4. Historical old cedar percent were assigned. If the stand was old (not logged), the historical cedar % was assigned the current cedar %. If the stand was young (logged), the historical cedar % was assigned the appropriate value from the AU/ BEC calculations above.

5. Historical old cedar area was then calculated and compared to current old cedar area ('Area Old Cedar 2003'), from which a % reduction was calculated.

6. For the analysis of 'tall old cedar' through time, the same methodology was used except it was performed only on 'tall' (greater than **or equal to** height class 4) stands. To create the historic amount of tall cedar it was assumed that all harvested stands were greater than **or equal to** height class 4 originally (>**=**28.5 m).

4.6. NORTHERN GOSHAWK

MODEL APPROACH AND ASSUMPTIONS

The model uses habitat suitability information collected from field studies undertaken on HG / QCI to predict the number of Goshawk territories that could be located on the Islands under different land use scenarios. A base layer of potentially suitable Goshawk territories has been developed using information from field studies on the Islands. Key assumptions are outlined in Table 1.

Table 1. Goshawk Indicators, and interpretation summary

Assumptions / Limitations
Life-history
Assuming that Goshawks are evenly spaced over the landscape, with a distance of 11.3km between nest sites. The model assumes that nest sites are central in territories, which may be correct on average, but is not expected to hold for all future nest sites found. Data based on field sampling (Doyle 2003).
Potential nest sites are assumed to occur primarily in the Skidegate Plateau and transition areas. Nests may also occur in the Queen Charlotte Mountains but likely not in extreme wet areas. Nests thought generally unlikely in the Queen Charlotte Lowlands. Habitat considered unlikely to ever support Goshawks was not included when laying out potential territories.
Ecological Baseline
Defined as the total number of potential territories, overlaid with the backcast forest cover data. Assumes original old forest was suitable for Goshawks in areas with current potential suitability.
Habitat Use Threshold
Goshawks forage primarily in old / mature forest on HG / QCI. Prey availability is likely the key factor limiting population size. It is assumed in this analysis that mature / old forest provides forage of similar quality. This is a landscape level analysis – it focuses on potential territories, determined from spacing information. A threshold based on the amount of remaining old forest is used to determine whether current / future use is likely. At the landscape scale this assumption is realistic, however at a finer scale forage quality does vary within different types of old forest (e.g. forage availability changes by site series, with more productive sites tending to have higher numbers of prey items). This level of detail is not included in the model.
This is a simple measure, and requires sensitivity analysis and additional research. Additional information on potential forage values is available for some areas of HG/ QCI, but is too detailed to include in the model at this time.
Considering 10 known nests, the minimum amount of Mature and Old (forests >80 years old in Forest Cover inventory) forest available in any hypothesised territory is 41% and 61% when considering all known and only active nests respectively. Additionally, the average amount of Mature and Old forest found using all known nests is 61%. These two thresholds are used to output the number of nests active through time, and to create a sensitivity analysis, i.e. determining how 'sensitive' the output is to the choice of the threshold. Sensitivity analyses are particularly important for determining the sensitivity of results to variables which may be known with little confidence.

Key uncertainties

Assuming that goshawk territories are represented by circles, however this may not well reflect habitat use by the birds. Although they are territorial (i.e. .they defend their territories), and nests tend to be spaced at about 11km from each other, the layout of foraging habitat may be more important that absolute availability within a territory. The threshold for turning territories on or off is estimated here, but does not include other likely parameters of importance, such as patch size, habitat fragmentation, potential for disturbance, local prey abundance etc.

Forage availability: is hypothesised to be the primary agent influencing Goshawk territory size, Goshawk population density, and likely reproductive success. Understanding the complex relationship between original prey based on HG/ QCI (which has a much smaller array of potential prey species than for other populations), combined with introduced species which provide additional prey (e.g. red squirrels), but also likely impact natural prey (e.g. blue grouse impacted by deer browsing/ nest predation from raccoons, squirrels etc) is key, but highly complex. In this model, it is assumed that forage quality is linked to availability of old and mature forest cover within potential territories.

The potential total number of territories is determined from a combination of field sampling (which has focused on Graham and North Moresby Islands) and expert opinion, plus observations of Goshawks throughout the Islands. It is assumed that the Skidegate plateau and transition zones are the primary areas capable of supporting Goshawk territories.

It is thought, from field sampling, that not all potential territories are used each year. The numbers of 'potentially active territories' provided are therefore likely a maximum number and we would not expect them all to be filled every year. The numbers provided are assumed to be maximum potential numbers of territories possible.

The extent to which HG / QCI is a self-supporting population of Goshawks is unknown. Better data on immigration and emigration would be required to fully understand metapopulation dynamics for this species.

Table 2. Summary of old and mature forest found in hypothetical territories of 10 known goshawk nests from the Islands. Minimum = 41%, Average = 61%.

Known Nest	Percent Old + Mature Forest
Blackbear	41
Survey	49
Ian-SW	60
Demon	61
Windy Bay	63
Ain	64
Yakoun Lake	64
Datlamen	65
Ian-NE	72
Bonanza	76

POPULATION VIABILITY ANALYSES (STEVENTON FROM DOYLE 2003).

Population growth trends can be determined from combining adult and juvenile survivorship (probability of surviving over time) with reproductive success, using the equation:

Population growth rate = adult survivorship + (reproductive success) * juvenile survivorship

Data on breeding rate are available from field data on HG/ QCI (Table 3), and survival estimates were taken from a range of other studies (Table 3).

Table 3. Breeding rate data (from HG/ QCI), and Survivorship Data (other study

areas). Compiled from Doyle 2003.

Study Area	Variable	Sample Size	All Years (SD)	Last 3 years (SD)
	Sample size		21	12
HG/ QCI	Annual Breeding rate (assuming that at all sites where reoccupancy occurred bred successfully)	21 / 12	33%	17%
HG/ QCI	Annual Breeding rate (assuming only those with nests bred successfully)	21 / 12	19%	17%
HG/ QCI	# Chicks fledged per breeding attempt	8 (3)	1.38 (0.5)	1.25 (0.5)
Sweden	Adult Survival Juvenile Survival (1st year) Juvenile Survival (2nd year)	318	0.81 0.71 0.71	
Arizona	Adult Survival	200	0.87	
S.E. Alaska	Adult Survival	39	0.72	

The model used is very simple, and is useful in providing a general overview of potential implications of the data being generated from the Islands. However, there are significant limitations in its use, including:

- Very simple model – that does not fully include stochasticity and external factors
- Data concerns include: a) very small sample sizes for parameters available from local data and b) significant parameters are from other study areas. Relevance to this population unknown.
- Assumes no immigration or emigration from HG/ QCI. This hypothesis is untested.
- Assumes number of territories alone is the key factor influencing population trends. Does not consider territory quality. Forage availability is likely to be important here.

4.7. MARBLED MURRELET

MODEL APPROACH AND ASSUMPTIONS

Table 1 summarises key elements and assumptions used in the Marbled Murrelet model presented in Chapter 2.6.

Table 1. Marbled Murrelet Indicators, and interpretation summary

Assumptions / Limitations
Life-history Key life-history parameters identified for HG and other study areas are summarised in Table 2. Those included in final PTT model for HG / QCI are shown in Table 2 with rationale. Using Forest Cover information to predict Marbled Murrelet habitat quality is somewhat tenuous because attributes that truly distinguish habitat quality are not very well reflected in Forest Cover data. For example, canopy closure is a key attribute, but is often poorly defined in FC data. Forest cover data also does not predict nest platform density, and instead uses age class and height class as surrogates for nesting platform density. However, it remains the best available information. For this model, attributes from forest cover were used as the basis for the model. In future predictions from the Haida Gwaii Landscape Model (Cortex), attributes (height class and crown closure) for harvested areas are projected using growth and yield tables. Population Viability Estimates of population size and viability are weak for HG/ QCI. Area of habitat of differing qualities is a reasonable surrogate for population size for this species (Burger pers. comm.; Marbled Murrelet Recovery Team). Habitat Suitability Thresholds The Marbled Murrelet model uses a number of stand and landscape parameters to describe habitat of differing suitabilities (high, medium, low and unsuitable). Some of the attributes are 'required' (e.g. old age stands) whereas others provide a sliding scale of habitat quality. A point system was used to sum values given for each forest cover polygon, and polygons were given a rating based on that point score. Habitat Suitability category cut-offs were determined by detailed examination of an area of the Islands that has had detailed Marbled Murrelet habitat mapping undertaken using air-photo interpretation following the Marbled Murrelet Recovery Team methodology (in Eden Landscape Unit; A. Cober pers. comm.). The amount of habitat in different suitability classes was compared to that suggested by this model, and the category cut-offs scaled appropriately (see below). Note that the different quality habitats likely represent different densities of birds and do not suggest that no birds would ever nest in 'low quality' habitat. Ecological Baseline Marbled Murrelet model run on the 1800 forest cover estimation model. A number of parameters of original forest cover were estimated in order to run this model (see Section 4.1 for details of the FC backcast).

Key uncertainties

Use of Forest Cover as surrogates for habitat attributes that are not designed for the purpose, and do not accurately measure some important habitat variables. In addition, projection of height and crown closure class through growth and yield tables is relatively weak.

The extent to which HG/ QCI acts as an independent population of Marbled Murrelets alters the probability of population persistence. Immigration of birds from the mainland may reduce the probability of local extinction over time, but the extent of immigration / emigration is unknown at this time.

The model assumes that primarily terrestrial factors influence density and population size for Marbled Murrelets. However, oceanic conditions may be equally or more important. For example, changes in ocean temperatures are thought to have reduced use of some areas by Murrelets. This may currently be of lower concern around HG / QCI but may increase in importance in future. Non-terrestrial factors are not included in this model.

Predation affects, landscape fragmentation (edge effects) are largely unknown and may have significant influence on population trends. Landscape pattern, and complex life-history factors are not included in this model.

MARBLED MURRELET HABITAT SUITABILITY MODEL

A number of different models have been produced to predict Marbled Murrelet habitat. In addition, there is much recent research that has not been included in habitat suitability models. The model used in this work is based on that produced for HG / QCI by McClennan et al. 2000. Some minor modifications were made based on more recent information (A. Cober pers. comm.). Table 2 summarises the key components often used in Marbled Murrelet models. An explanation is given for its inclusion or exclusion in this case.

Table 2. Attributes and ecological rationale for MaMu habitat suitability model. Constructed primarily from McClennan et al. (2002), with additional comments from Burger 2000, Dov Lank, SFU, pers. comm.).

Attribute	In PTT model?	Weight in Model	Ecological relevance / comments
Forest Cover Age Class	Y		Relates to number of platforms / moss available for nest sites, within the stand. Good evidence for age related variable.
Age > 200 years		20	
Age 141 – 200 years		10	Some studies (McClennan, and others) have demonstrated that true AC8 is lower habitat value compared to true AC9. However, the FC inventory often incorrectly labels AC 8 as AC9. Hence, we increased this score from 3 to 10 points. We did not consider AC 8 = AC 9 because on HG there is an extensive area of 'true' AC 8 (Tlell fire area).
Age 121 – 140		3	
Age 81 – 120		1	
Age <80		U	No known nests in any stands <80 years of age found on HG. Stands <80 years of age are automatically tagged as 'Unsuitable'.
Forest Cover Height Class	Y		Relates to: - Ease of fledging young and ease for adults bringing food, - Possibly to complexity and number of platforms / moss available for nest site. - Possibly to avoidance of some predator types (mammals)
Height classes >7 (XXm)		20	

Attribute	In PTT model?	Weight in Model	Ecological relevance / comments
Height classes 4,5,6 (>28.5m)		15	
Height class 3 (19.5 – 28.4m)		5	
Height classes < 2 (<19.5m)		1	
Canopy Closure	Y		Relates to accessibility of potential nest sites, for fly in access. Strong evidence that trends used are real. However, FC canopy closure data are weak. Hence the relatively low score differential given.
Canopy closure classes 4, 5 and 6		10	
Canopy closure classes 3 and 7		5	
Canopy closure classes <3 and >7		1	
Elevation Range	Y		Relates to: - Distance to ocean (on HG). - Energetic costs of flying further. Plus energetic costs of flying up. - SFU lab work agrees with energetics hypothesis, but suggests this may be a U-shaped variable (with mid elevation sites have highest useage. Possible interaction with the lower densities of birds close to shoreline. - Topographic variability is lower on HG / QCI than on other areas of the coast. Retained the linear pattern but scaled down the original breaks slightly (from 800 to 1000m). Majority of nests (84%) of all nests found are lower than 1000m in elevation. s
0-300 m		10	
300-600 m		7	
600-800 m		3	
> 800 m		1	
Slope Range Weight	N		Ground based studies tend to suggest that low slope sites are better habitat than steep slopes. This is contradicted by radio collar evidence gathered by SFU lab, which shows strong trend for increased use of steep slopes, particularly in Desolation Sound, but also in Clayoquot Sound.
Site productivity	N		Included in some previous models, but not included here due to confounding with other attributes such as forest cover height already in the model.
Distance to Ocean	N		Suggested by Burger 2002, but not used for HG / QCI due to large number of complex inlets.
Patch size	N		Some evidence that predation increases near non-natural edges. However, not included here because a) scale is not consistent with an island-wide analysis, b)

Habitat Suitability Cut-off Thresholds

Detailed air-photo interpretation work has been completed for the Eden Landscape Unit (Donaldson in prep, following Burger 2002). This work assigns a habitat suitability rating for individual polygons based on the attributes present. Table 3 shows the rating scores used in that analysis.

Table 3. Habitat description and rank using airphoto interpretation (from Burger 2002).

Rank[1]	Habitat value	General description of habitat quality and availability of key habitat features	Percentage of polygon area with habitat feature present[2]
1	Very High	Key habitat features present in abundance; nesting highly likely	50-100%
2	High	Key habitat features common and widespread; nesting likely	25-50%
3	Moderate	Key habitat features present but uncommon and patchy; nesting likely but at moderate to low densities.	6-25%
4	Low	Key habitat features all evident but patchy and sparse; nesting possible but unlikely or at very low density	2-5%
5	Very Low	Key habitat features sparse and might not all be present; nesting highly unlikely	about 1%
6	Nil	All key habitat features absent; nesting impossible (e.g., bogs, bare rock).	0%

In order to calibrate the PTT Habitat Suitability Model (i.e. to determine where the breaks between different classes should come), the scores from airphoto interpretation for polygons in Eden Landscape Unit were compared to the scores attributed from the PTT Habitat Suitability Model described above. Table 4 summarises the relationship between the points allotted from the PTT model compared with the airphoto description of habitat quality, in terms of amount of area in Eden Landscape Unit. The range of scores from the PTT model were determined by examining the distribution of area within in class compared with each individual PTT score.

Table 4. Amount of area found in each air-photo rating class, and each range of scores from PTT model.

	Air-photo rating			
	Amount of area in each class			
Range of scores from PTT Model	Class 1	Class 2	Class 3	4 or less
54-60	2902	2542	408	65
51-53	1542	2072	520	178
46-50	610	868	215	71
<45	66	936	5978	33647

Although there is not an exact fit between the two rating systems this is unsurprising because the scale of analysis is different. This comparison allowed an independent calibration of the PTT Habitat Suitability Model for Marbled Murrelets that previously was unavailable.

4.8. Seabird colonies

Insert details on numbers of colonies protected, and which are currently unprotected, when information becomes available.

4.9. HAIDA GWAII BLACK BEAR

MODEL APPROACH AND ASSUMPTIONS

Incorporate ratings table from Tony.

Additional info re stand level model – Tony.

4.10. SALMONIDS

Authored by L. Lee. Marine Toad Enterprises.

DATA LIMITATIONS

The SED database is the best province-wide information available for salmon escapement over time; however, it has limitations that restrict the confidence and reliability of resulting trend analyses. As a first step in understanding the data, some of the major caveats are discussed.

Overall, the SED is based on field monitoring that targets pink and chum salmon returns primarily for identification of stocks that have 'surplus' escapement available for commercial fisheries. Some of the consequences of this focus are as follows:

- *Escapement estimates soley based on charter patrol counts vary in reliablilty for different salmon species. The escapement estimates for pink and chum salmon are more reliable, compared to estimates for coho and Chinook salmon. Sockeye escapement estimates are relatively reliable due to Fishery Officer and other contract counts specific to the larger sockeye populations.* This difference is due in large part to the fact that pink, chum and sockeye are generally easier to count than coho and chinook and that charter patrolmen specifically target pink and chum while the Haida Fisheries Program targets sockeye. Pink, chum, and sockeye are easier to count based on their spawning behaviour. They generally return to spawn in their natal streams in relatively large numbers over a relatively short period of time, tending to spawn in large aggregations throughout the mainstems of their spawning streams, using habitat from lower to higher along the mainstem and main tributaries depending on the number of returning fish. Coho and chinook salmon generally spawn upstream of chum and pink spawning areas and are typically widely distributed within watersheds. Chinook and coho are not very aggregated when they spawn, and spawn over a long time frame. Coho are especially known for utilizing a wider range of habitats from mainstems spawning sites to very small tributaries at the upper most reaches of anadramous habitat
- *The escapement estimates for larger pink and chum stocks in any given area are more reliable than those for smaller stocks* since effort would be concentrated on larger stocks more likely to show 'surplus' escapement. *Escapement of pink and chum salmon in the small first and second order coastal watersheds may or may not be included and, if included, may not be representative of the actual escapement* since the limited salmon run timing may not coincide well with survey timing. This situation is problematic for determining the extent of impacts of human activities on overall health of salmon stocks on the Islands since these small runs are the most likely to be significantly affected, and possibly extirpated, by human activities. Although they represent a small percentage of the biomass of any given species, they likely represent great genetic diversity that contributes to their intrinsic value and to the natural resilience of salmon stocks to environmental changes;
- *Coho salmon escapement counts are not accurate unless augmented with more reliable counting methods* such as an adult salmon counting fence. In general, the charter patrol survey season does not encompass the coho spawning season, resulting in low estimates of abundance. Coho spawners are also elusive and hard to see even in clear water, again resulting in low estimates of abundance.
- *Sockeye salmon escapement counts are relatively accurate due to sockeye-targeted spawner surveys and/or counting fences*. Although sockeye spawn in places where charter patrol surveys generally do not go, fisheries officers or charter patrolmen have focused relatively consistent effort on surveying known sockeye spawning areas for the SED. Over the past decade, the Haida Fisheries Program has been responsible for conducting sockeye spawner surveys on the Islands' major sockeye stocks.

- *Chinook salmon escapement counts are not accurate unless augmented with more accurate counting methods than charter patrol surveys*. On Haida Gwaii, a few sporadic occurrences of Chinook salmon have been reported spawning in a handful of watersheds, however, the only significant run of Chinook seems to occur in the Yakoun River watershed. A counting fence for pinks has been operated by the Haida Fisheries Program every pink (even) year since 1984, and enhancement of Yakoun River Chinook has been conducted by the Old Massett Village Council since 1979.
- *Overall, the consistency of stream surveys for the SED has been good from 1950 to 1990. From the early 1990s to present, and particularly in the past few years, the number of streams surveyed and the survey frequency has declined dramatically, making stock trend analysis extremely challenging and limiting the ability to compare current data with older data.* As clearly noted throughout Riddell (2004), it is critical to maintain a minimum level of survey effort (which would be much higher than the level occurring today) in order to facilitate meaningful comparisons of future data with the only longer term baseline that we have, particularly for pink and chum salmon. Unfortunately, the stream surveys slated for this coming season on Haida Gwaii are a low point in effort and coverage since funding reductions began in the early 1990s.

Trend analyses results from the SED database should not be confused with trends in natural variability of a salmon run based on ocean survival. Since the SED can only reference the number of salmon spawners returning to spawn in a stream NOT accounting for fish that were caught in fisheries, escapement data tends to represent artificial trends that fisheries management imposes on a salmon run. In most cases, we cannot determine the number of fish caught in commercial, recreational or food fisheries that would have returned to any given stream.

The SED is much more reliable for some part of Haida Gwaii than for others and this should be accounted for when looking for trends in the escapement data*.* For example, there is arguably no reliable salmon population data for streams of the Queen Charlotte Lowlands from Chinukundl Creek north, excepting the years and streams with adult fish counting fences in operation. In this geographic area, that would include the Tlell River watershed for 3 years (1999 to 2001), the Jungle Creek watershed for 2001-2002? years, and the Chown River for ? years. These streams are largely inaccessible with dark, tannin-stained waters that make it logistically impossible to count the number of salmon spawners in the creek. Escapement estimates given for these streams would have been cursory guesswork based at best on consistent observations in a limited portion of the watershed. Streams on the Skidegate Plateau and Queen Charlotte Ranges are relatively better surveyed, particularly from Port Chanal south to Tasu Sound on the west coast, and from Skidegate Inlet south to Skincuttle Inlet on the east coast.

SALMON TRENDS

Methodology for determining salmon trends shown in Section 2.9, Table 2, from available SED database (L Lee pers. comm.). Produced originally for Pic Walker 31 August 2004

Take all escapement records from Fisheries and Oceans Salmon Escapement Database (SEDS):

- Generate spreadsheet of all records from SEDS for Haida Gwaii for each species.
- Add to escapement, the food fishery catch numbers where available for sockeye (Eventually need to incorporate catch numbers in commercial, recreational and other Haida food fisheries).
- Calculate the average yearly return to each stream over the period of records.
- Calculate the percentage of the total average yearly returns accounted for by each stream.
- Calculate the # years of record for each stream.
- Graph escapement for all streams with over 25 years of record (need to convert all non-

integers to blanks) to look at general trends, highs and lows.

- Assess general 4-year periods of highs and lows.
- Screen through escapement data and (in general) knock out all streams without at least 2 years of data over the current (2000-03) and past (1950-53) year periods.

For remaining streams:

- Look at total salmon counts over each year to determine which 4-year periods to use for representative highs and lows.
- Calculate the average yearly values for 4-year periods representing ‘current’, ‘high’, ‘low’ and ‘past’ conditions.
- Knock out streams where average values for any 4-year period are missing.

For remaining streams:

- Calculate the percentage of total returns represented by remaining streams.
- Use the sum of yearly averages from each 4-year time period and the percentage of total returns to calculate the estimated number of fish for each 4-year time period.
- Compare general percentage of high, low and past values against current condition.

Note that these data contain no statistical trends, and no confidence intervals.

Map 1. Stat areas for fisheries conclusions from Section