ENVIRONMENTAL RISK ASSESSMENT

AN INTRODUCTION - WITH EXAMPLES FROM HAIDA GWAII / QUEEN CHARLOTTE ISLANDS

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OVERVIEW

This document is intended to provide a primer on Environmental Risk Assessment (ERA). The methodology is based on that outlined by MoE (2000).

This document is an excerpt from an original ERA document written specifically to support the HG/ QCI land use planning process in 2005.

The full report, including results for both coarse filter and fine filters is available:

Holt, R.F. 2005. Environmental Conditions Report. Prepared for the Haida Gwaii / Queen Charlotte Islands Land Use Plan. Full report available at: http://www.veridianecological.ca/links.php

This primer therefore focuses on the ecosystems of Haida Gwaii, but also provides a generic overview of different elements of the ERA process, including how in that case a suite of indicators were chosen and how ecological benchmarks were examined.

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 appropriate, depending at which place on the "supply curve" we are currently situated.

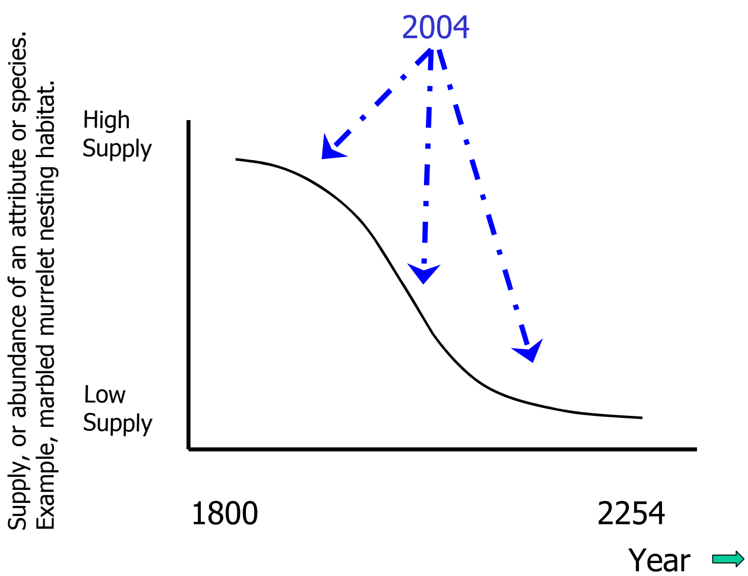

Figure 1. Example of a supply curve. Different land use plan decisions may be made depending on whether we are at the high, middle, or low abundance on a supply curve for attributes such as salmon or suitable bear denning habitat.

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 decision-makers with a view of what the future might hold if current management[2] continues.

The objectives of this ERA were 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.
- 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.

[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.

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 ERA, the intention was 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 Process Technical Team, 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 the results of the ERA[3] 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 were also discussed that are more relevant to a fine filter / single-species management approach (Box 1).

Table 1 provides a summary of which potential ecological values were included in a) the detailed ERA or b) as species of concern but where modeling was not possible due to time or data constraints. Understanding why an element is of course, and how well it can be tracked is an important first step in ERA methodology.

[3] Available online at: http://www.veridianecological.ca/links.php

Table 1. Summary of Potential Indicators and Additional Species of Concern. Indicators were the subject of a detailed ERA where possible, including modeling trends through time[4]. Additional Species of Concern were included because it was assumed they would require fine filter management, but trends analysis was largely not posisble due to lack of data.

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

[4] 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
	Nation. • 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 the Haida Gwaii ERA.

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.

BASELINE INFORMATION

Two pieces of information provide general background for an 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.

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[5] 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

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

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.

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 19^{th} 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**
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.[6] 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. This change has potentially far

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

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 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.

REFERENCES

Arsenault, A. 1995. Pattern and process in old-growth temperate rainforests of southern British Columbia. Dissertation. University of British Columbia, Vancouver, BC.

Brown, K.J. and R. J. Hebda. 1998. Long-term fire incidence in coastal forests of British Columbia. Northwest Science 72:64-66.

Caughley, G. 1994. Directions in Conservation Biology. J. Anim. Ecol. 63: 215-244.

Coast Information Team. 2004. Scientific Basis of EBM. Report prepared for the CIT. Available at: http://www.citbc.org/pubback.html

Dalzell, K. 1989. The Queen Charlotte Islands Volume 1. 1774 – 1966. Harbour Publishing, 340 pages.

Dorner, B., and Wong, C. 2003. Natural disturbance dynamics in the CIT area. Report for the CIT. Available at : http://www.citbc.org/pubback.html

Gavin, D.G. 2000. Holocene fire history of a coastal rain forest, Vancouver Island, British Columbia. Dissertation. University of Washington, Seattle, Washington.

Klinka, K., J. Worrall, L. Skoda, and P. Varga. 2000. The distribution and synopsis of ecological and silvical characteristics of tree species of British Columbia's forests. Canadian Cartographics, Ltd. Coquitlam, BC. 180 pp.

Lertzman, K., D. Gavin, D. Hallet, L. Brubaker, D. Lepofsky, and R. Mathewes. 2002. Long-term fire regime estimated from soil charcoal in coastal temperate rainforests. Conservation Ecology 6:5.

Lertzman, K., G.D. Sutherland, A. Inselberg and S.C. Saunders. 1996. Canopy gaps and the landscape mosaic in a coastal temperate rainforest. Ecology 77:1254-1270.

Ministry of Environment. 2000. Environmental Risk Assessment: A methodology. Unpublished Document.

Noss, R.F. 2001. Beyond Kyoto: forest management in a time of rapid climate change. Conservation Biology. 15(3):578-590.

Noss, R.F. and A.Y. Cooperrider. 1994. Saving Nature's Legacy: Protecting and Restoring Biodiversity. Washington D.C. Island Press.

Ott, R.A. and G.P, Juday. 2002. Canopy gap characteristics and their implications for management in the temperate rainforests of southeast Alaska. Forest Ecology and Management 159: 271-291.

Parminter, J. 1983. Fire history and fire ecology in the Prince Rupert Forest Region. In Ministry of Forests, Land Management Handbook 63: Prescribed Fire – Forest Soils Symposium Proceedings, Research Section, Smithers, BC.

Pearson, A. 2003. Natural and logging disturbances in the temperate rain forests of the Central Coast, British Columbia. Report to the Ministry of Sustainable Resource Management, Victoria BC. Abstract available at: http://www.citbc.org/pubback.html

Price, K. and D. Daust. 2003. The frequency of stand-replacing natural disturbance in the CIT area. Draft Report to the Coastal Information Team. Available at: http://www.citbc.org/pubback.html

Rood, K.M. 1984. An aerial photograph inventory of the frequency and yield of mass wasting on the Queen Charlotte Islands, BC. B.C.Min.For., Victoria, B.C. Land Manage. Rep. No. 34.

Schwab, J.W. 1998. Landslides on the Queen charlotte Islands: processes, rates and climatic events. Pages 41 – 47 in Hogan et al. 1998. B.C.Min.For., Res.Br.,Victoria, BC.

Turner, N. 1995. Food Plants of Coastal First Peoples. RBCM Handbook co-published by UBC Press.

Wong, C., H. Sandmann, and B. Dorner. 2002. Historical variability of natural disturbances in British Columbia: a literature review. Manuscript for submission to Journal of Ecosystem Management. 49 pp.