BIODIVERSITY CONSERVATION IN BC: AN ASSESSMENT OF THREATS AND GAPS

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EXECUTIVE SUMMARY

In British Columbia, the mandate and operating frameworks of land management agencies are currently in flux. Within that change, the Ministry of Water Land and Air Protection has been tasked with devising a Biodiversity Strategy, to be in place by 2004. As a precursor to that strategy, the need for an assessment of the threats to biodiversity and therefore the gaps in protection was recognised. This work has two main components:

- A *strategic level* assessment and ranking of the threats to biodiversity by determining the nature and significance of threats to terrestrial, freshwater aquatic and marine realms at different scales. Inherent in summarising threats to biodiversity is the acknowledgement that in order to detect significant impacts, current approaches to protection or mitigation must be failing to a greater or lesser degree, and

- Identification and summary of the instruments available for conservation of biodiversity in BC, with an assessment of steps required to determine effectiveness of biodiversity protection.

To complete these two tasks we:

- Compile and categorise threats to biodiversity in British Columbia.
- At various ecological scales, compile the biodiversity impacts associated with 84 different Threat Activities.
- Rank threats and impacts for terrestrial, marine and freshwater aquatic realms in terms of ecological severity and extent.
- Summarise key initiatives that aim to conserve biodiversity, including both regulatory and stewardship approaches.
- Provide a composite discussion for a cross-section of threats that a) summarises threats and associated biodiversity impacts, b) examines current approaches to management, and c) identifies potential future options.
- Summarise the results and discuss the implications of outcomes from the above steps

In order to identify the threats and associated impacts to biodiversity we devised a framework that included a) dividing biodiversity in BC into three realms (terrestrial, freshwater aquatic and marine), and identifying geographic groupings and ecological units appropriate for assessment, b) compiling a standardised list of Threat Categories (n=18) and Activities (n=84) that would be assessed, and c) ranking each threat activity within each ecological unit in terms of the severity, persistence, and at what ecological scale the impacts occur. We used a combination of literature, compiled data and expert opinion gathered from a diverse group of individuals (government, industry, consultants) through workshops and interviews, to provide background information for assessing threats and impacts. Buidling on that information, a member of the team completed Assessment Tables for each geographic area of each realm, providing the basis for ranking of Threat Categories and Activities.

Threat Activities were ranked separately for each realm. The ranking combines measures of severity, reversibility and extent to identify threat activities with the greatest ecological impact, and widest distribution, both regionally and provincially. The results are summarised by realm, Geographic Grouping, Ecological Unit, Threat Activity, Threat Category, and on a provincial basis. The database is structured in a manner to allow a wide diversity of output summaries.

Table A. shows the top eight Threat Activities, ranked by magnitude and extent, for each realm on a provincial basis[1]. There was considerable variation between realms, although Climate Change and Non-native species ranked consistently high in all realms. Threat Activities associated with forestry on crown lands were significant in the terrestrial realm, while dams were important in the freshwater realm and

[1] Note that listing the top 8 activities does not suggest that lower ranked activities are not having significant ecological impacts. This is an arbitrary cut-off and should not be considered an ecologically significant threshold.

animal harvest was identified as a critical threat to the marine realm. When summarised by region, the top Threat Activities vary considerably, which highlights the diversity of impacts and the need for a diversity of potential conservation strategies across the province.

Table A. Provincial top eight threat activities*, by magnitude and extent, for each realm.

TERRESTRIAL				FRESHWATER AQUATIC				MARINE			
	Magnitude		**Extent**		**Magnitude**		**Extent**		**Magnitude**		**Extent**
CC	Climate change	CC	Climate change	CC	Climate change	CC	Climate change	HA	Commercial	HA	Commercial
FC	Fire suppression	FC	Stand structure modification	AG	Water demand	FC	Roads	CC	Sea level change	TC	Ocean traffic
DA	Physical obstructions	FC	Landscape level modification	DA	Flow regulation	RD	Habitat conversion	CC	Hydrograph changes	NS	Non-native species
FC	Landscape level modification	FC	Roads	NS	Non-native species	FC	Riparian disturbance/modification	FC	Ocean/lake log handling	AQ	Exotic species use
UD	Habitat conversion	NS	Non-native species	RD	Water demand	NS	Non-native species	RD	Habitat conversion	CC	Sea level change
AG	Cultivation	RE	Motorised terrestrial	DA	Physical obstructions	RE	Motorised aquatic	NS	Non-native species	HA	Aboriginal
NS	Non-native species	FC	Fire suppression	HA	Stock enhancement	FC	Silviculture	AQ	Pen sites – finfish	HA	Illegal
HA	Recreational	FC	Silviculture	AG	Cultivation	OG	Pipelines	UD	Habitat conversion	HA	Recreational

*see Bookmark on p (vii) for explanation of codes.

The methodology for assessing and ranking Threat Activities' impacts provides a relative ranking of the various impacts both provincially and for geographic regions. Using the Summary of Assessment Tables, the approach also highlights what ecological units are impacted by an individual activity. However, the ranking process does not address interactions between realms, which may result in underestimates of the overall impacts of Threat Activities such as forestry that impact terrestrial, freshwater and marine environments. Similarly, the approach does not adequately address cumulative impacts where activities interact and raise the overall magnitude of impacts.

Instruments for protection of biodiversity available in the Province were summarised for regulatory and non-regulatory tools. For the former, the Revised Statutes and Consolidated Regulations of British Columbia was used to identify relevant statutes that were then linked to our Threat Activity list. A background report (Harper 2002) was used as a basis for summarising non-regulatory instruments, and was amended using expert opinion. These tools were categorised and similarly linked to the Threat Activities list. The list of conservation instruments highlight the potential tools that *could* be used to protect biodiversity in the province. We also identify a need to assess the *effectiveness* of the various instruments, and discuss some possible approaches.

The analytical approach used throughout most of the report provides a strategic level overview of the identified threats and their impacts. We also provide examples of more detailed discussions for a selected group of Threat Activities. For five subject areas we give a threat and impact description, discuss the current approach to protection or mitigation, and then identify the key impact/ threat issues that require resolution for a reduction in biodiversity impacts. This more focused approach to identifying the 'required results' for key Threat Activities may provide a pragmatic approach for keying into required action areas.

Options and approaches for further verification and review of the results of this project are discussed, as well as recommendations for subsequent phases of the project.

ACKNOWLEDGEMENTS

This work was a team effort. We thank all who provided their input and worked hard to give us up to date information for the diversity of the Province. We thank Pia Archibald who provided overview, advice and input throughout the project, and who attended all three information workshops providing a useful project perspective for each group.

Individuals from around the province provided their perspectives on specific threats or on matters of provincial scope. A special thanks is extended to Erik Parkinson, Marlene Machmer, Colin Gray, and Steve MacAdam who took the time to give detailed regional threat/impact interpretations. Rowena Rae, Kristy Ciruna, Art Tautz, Geoff Chislett and Malcolm Gray provided helpful information of a provincial nature. Mark Haddock and Laurel Brewster provided summaries of legal instruments for biodiversity protection, and Kim Lisgo and Chris Steeger wrote individual pieces on specific threats and impacts. The BC Conservation Data Centre kindly provided an up to date dataset to aid in this work.

Thanks are also extended to the following technical specialists for their perspectives on specific regional or technical issues: Terry Ahern, Sally Aitken, Dana Atagi, Lynne Atwood, Rick Bailey, Bill Bresser, Brian Chan, Joe DeGisi, Ted Down, Anne Hetherington, Rick Ellis, Tony Hamilton, Doug Heard, Rick Grinrod, Otto Langer, Don Lawseth, Colin Levings, Ken Morgan, Remi Odense, Keith Rande, Jordan Rosenfeld, Donna Romaine, Karen Rothe, Suzanne Simard, Ian Sharpe, Dean Watts, and Elke Wind.

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Thanks also to all the input from people at the original terrestrial based workshops who provided the baseline information for the terrestrial assessment: Mike Fenger provided the initial impetus and inspsiration for the workshops, and input into each of them. Cariboo Region: Ray Coupe, Ken Day, Stan Gripich, Robin Hoffos, Kristi Iverson, Fred Knezevich, Martin Sills, and Ordell Steen; Kamlops Region: Dennis Lloyd, Walt Klenner, Rick Tucker, John Surgenor, Phil Belliveau, Phil Holman, Bob Scheer, Bob Helfrich, Tom Dickinson, Astrid von Woudenburg, Jim Cooperman, Judy Millar, Brian Wikeem, Jeff Morgan, Alison Chutter, Brian Robertson, Brian Harris, Susan Turner. Nelson Region: Pat Field, Tom Braumandl, Rob Walker, Kari Stuart-Smith, Marlene Machmer, Brendan Wilson, Dave White, Gerry Fox, Greg Utzig, Maurice Hanson, Kindy Gosel, Rob Gay, Don Gayton, Val Miller, Guy Woods and Mike Panian. Prince George Region: Dale Seip, Chris Ritchie, Perry Grilz, Craig Delong, Pierre Johnstone, Doug Heard, Hugues Massicotte, Bill Jensen, Geraldine Fitzgerald. Prince Rupert Region: Jim Pojar, Phil Burton, Anne Hetherington, Lyle Gawalko, Karen MacDowell, Sean Sharpe, Rick Trowbridge, Bob Purdon, Don Reid, Bob Drinkwater, Butch Morningstar, Brenda Ramsy; Vancouver Region: Mike Dietsch, Tanis Douglas, Kathy Dunster, Glen Dunsworth, Don Eastman, Malcolm Gray, Julian Grzybowski, Richard Hebda, Tony Hamilton, Jan Kirby, Laurie Kremsater, Andy MacKinnon, Kerry McGourlick, Sal Rasheed, Hans Roemer, Louise Waterhouse.

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We thank Deb Mackillop who provided a diversity of expertise, editing and energy for the project.

All mistakes or misinterpretations remain our own.

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BOOKMARK

We use codes throughout this work, for threat activities. For ease of reading, we provide this page as a 'bookmark' to be printed, cut out and used throughout the text as an aid to reading a printed version of this report.

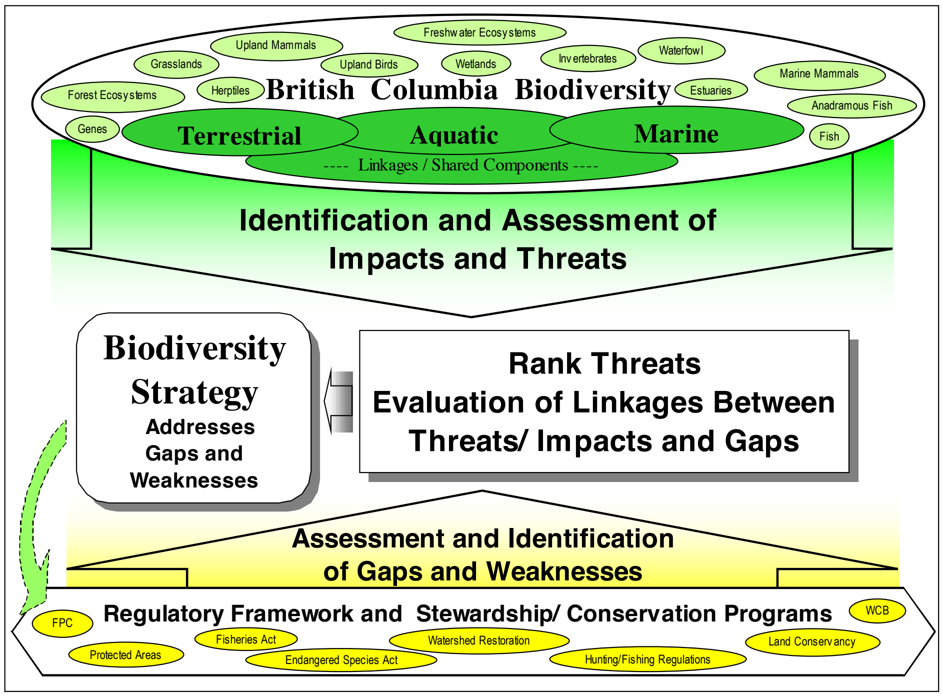
Agriculture	Aquaculture	Climate change	Dams	Forestry_Crown	Forestry_Private	Grazing	Harvest	Industry	Mining and exmploration	Military	Non-native species	Oil and Gas	Rural development	Recreation	Transportation/ corridors	Urban development
AG	AQ	CC	DA	FC	FP	GR	HA	IN	ME	MI	NS	OG	RD	RE	TC	UD

Alternatively review Table 5 which has all the threat activities and codes.

1.0 PROJECT SCOPE

The Ministry of Water Land and Air Protection commissioned this project to assess conservation needs and gaps in BC, in late 2002. Concurrent with our work, a number of related projects were undertaken by other consultants: the Biodiversity Conservation Spatial Assessment (Nicholson in prep.) and the Alien Species Strategy for BC (Rankin in prep.) which are intended to complement, add additional depth and jointly provide a foundation for the Biodiversity Strategy.

In this report, we provide a framework that compiles information and assesses at a strategic level the threats and impacts to biodiversity, and identifies potential protection instruments. Due to the short timeline and simultaneous timing of these three projects, we anticipate that additional review and consolidation of our results with those of Nicholson and Rankin will remain an outstanding task.



Compiling data to assess the threats and impacts to biodiversity for the Province of BC is an extensive task (see figure right), and as a result we took an extensive rather than an intensive approach. However, the broad scope was also balanced with the need to gather sufficient detail to make the results meaningful; a trade-off that was the most difficult aspect to reconcile within the project. We stress that this work is intended to inform provincial and regional decisions *at the strategic level*. Individual experts in a particular field or with a local geographic framework may be dissatisfied with the depth of information assessed and presented and we caution that application at local scales may be inappropriate. We make recommendations as to the need for additional review of the framework and results as required.

1.1. Outline of Report

This report is divided into a number of sections to provide clarity. The methodology is separated into steps and discussed separately. Results are presented for three separate product types – the threat classification scheme and their associated impacts, the ecological ranking, and the protection/ mitigation framework. Five discussion pieces are presented in Section 7.0. The intention of these is to provide a more detailed overview of a cross-section of threat types. In particular, the specific impacts are identified and a results-based approach to protection or mitigation of the threat activity identified. The discussion and recommendations are presented in Sections 8 and 9.

Section 1: Project Scope

Section 2: Overview and Approach

Section 3: Methodology

Section 4: Results: Threats and Impacts Compilation

Section 5: Results: Threat Rankings

Section 6: Results: Conservation Instruments

Section 7: Overview for a Cross Section of Example Threats

Section 8: Discussion

Section 9: Recommendations

In addition, a series of appendices contain additional details and results.

Scope of results presented: The information gathered in this project could be presented in a myriad of different ways. For this report, we chose a number of key presentations (e.g. provincial and regional summaries for each biological realm), however the information could easily be transposed, for example to assess the distribution and magnitude of individual activities across the province.

2.0 OVERVIEW AND APPROACH

In British Columbia, the mandate and operating frameworks of land management agencies are currently in flux. Within that change, the Ministry of Water Land and Air Protection has been tasked with devising a Biodiversity Strategy, to be in place by 2004. The mandate of MWLAP includes a commitment to protecting and enhancing British Columbia's environment, including:

- Limiting the adverse effects of individual and collective activities on the environment;
- Maintaining and restoring the natural diversity of ecosystems, fish and wildlife species and their habitat.

As a precursor to the Biodiversity Strategy, the need for a broad ecological foundation was identified. Hence, the scope of this project is broad, including all ecological units from ecosystems to genes, across three highly individual yet interlinked strata - terrestrial, freshwater aquatic, and marine.

This project has two main components:

- A strategic level assessment and ranking of the threats to biodiversity by determining the nature and significance of threats to terrestrial, freshwater aquatic and marine realms at different scales
- Identification and summary of the instruments available for conservation of biodiversity in BC, and assessment of key steps required to determine effectiveness in biodiversity protection.

Inherent in a summary of threats to biodiversity is the acknowledgement that current approaches to protection or mitigation must be failing to a greater or lesser degree.

2.1. Conceptual framework and steps for completion

The conceptual framework for the project is shown in Fig. 1.

This conceptual framework involved meeting the following goals:

1. Identify the types and extent of :
   a. threats to biodiversity in British Columbia, and
   b. associated impacts on biodiversity at multiple ecological scales.
2. Rank threats and impacts for each ecological realm.
3. Summarise key initiatives that aim to conserve biodiversity, including legislative and stewardship approaches.
4. For a cross-section of threats, provide a composite discussion that a) summarises threats and associated biodiversity impacts, b) examines current approaches to management, and c)

identifies potential future options. These summaries are intended as discussion pieces that present some of the information gathered in an alternative format.

5. Summarise and discuss the implications of outcomes from steps 1 to 4.

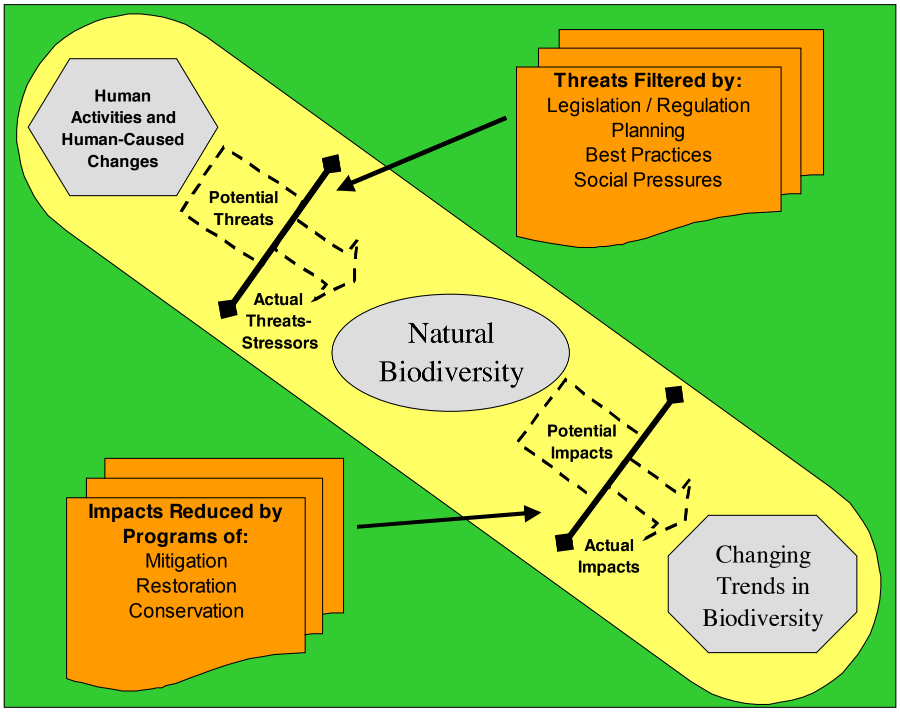


Figure 1. The Conceptual Framework.

2.2. What are threats to biodiversity?

Our objective is to classify and rank the threats to biodiversity in British Columbia, and to assess the current forms of conservation instruments that are currently in use to protect biodiversity.

But what is biodiversity? In essence, biodiversity is all living things on earth, from genetics through to landscapes, including ecological and evolutionary processes. Biodiversity is dynamic not stationary, so what constitutes a threat or a negative change to biodiversity?

Determining what can appropriately be classified as a 'threat' to biodiversity is a matter of scale and perspective. For some people, cutting down a tree could be seen to have a detrimental impact on 'biodiversity', whereas for others, development of extensive human conurbations in place of a unique river delta is all part of 'nature' and therefore just another form of biodiversity.

The underlying assumption of this work is that the natural range of variability of a particular element, species or parameter is the appropriate comparison against which to assess the state of a threat. The use of the range of natural variability concept has been discussed at length elsewhere (e.g. Landres et al. 1999). In this case, the reference timeframe we are using as the benchmark is the state of biodiversity prior to European contact.

The timeframe over which post-European human settlements or developments have impacted biodiversity in BC is relatively short compared to most areas of the world –only in the last 100 years has major industrial development taken off in most areas of BC, and in some areas, this timeframe is even shorter. Our approach to assessing threats to biodiversity did not focus on threats to specific species (as others have done, e.g. Stein et al. 2000), because species data are often lacking, and for some species, impacts of changes may not be detectable at the present time. We therefore took a more comprehensive view and assessed changes to ecosystem elements at multiple scales including ecological processes, ecosystems, habitat elements, species and genes – assuming that higher ecological level impacts will inevitably have cascading species impacts in future.

3.0 METHODOLOGY

The methodology used for each step in this work is outlined below. A number of interim products are also included within the body of the methodology. The overall approach is shown in Figure 2.

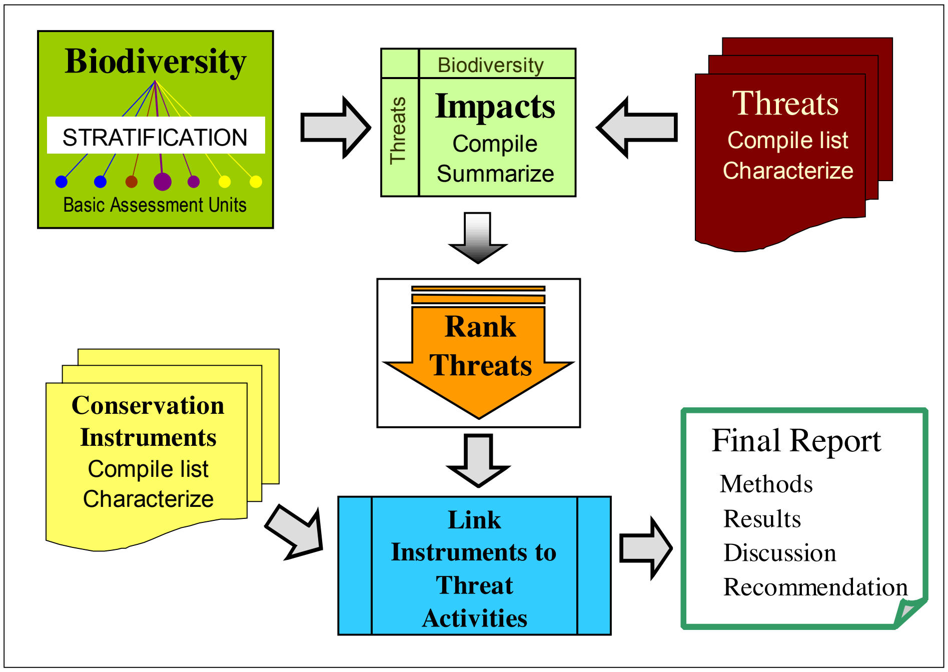


Figure 2. An outline of the specific steps taken to complete the needs and gaps analysis.

Step 1: Stratification of biodiversity and Identification of Basic Impact Assessment Unit

3.1.1. Ecological Stratification for each realm

In order to identify the impacts and threats to biodiversity, it was first necessary to parse the natural world into groups that could then be assessed, mapped and discussed.

We separated the ecological landscape of BC into three major realms – terrestrial, freshwater aquatic and marine, and dealt with each separately. Typically, five realms are identified (marine, freshwater, terrestrial, atmospheric and phreatic[2]; A. Harcombe pers. comm.). However, in this case, we included atmospheric impacts into each of the three realms, and phreatic impacts into freshwater aquatic.

Each of the three realms was additionally separated into geographically distinct units (areas of the province, or marine environment termed Geographic Groupings), plus into ecological units (Table 1). **These individual units – ecological units within geographic units for each realm – constitute the basic assessment unit for this project, and can be summed by ecological unit, regionally or provincially.**

[2] Refering to groundwater zone.

Table 1. Summary of ecological units used within the three realms.

	Marine	FWA	Terrestrial
Geographic Groupings/ Units	Marine Groupings(6)	Watershed Groupings (11)	Ecoprovinces (9)
Ecological Units	Estuaries Backshore Intertidal Nearshore subtidal Offshore subtidal Pelagic	Rivers Streams Wetland Riparian Lakes	Associations of related BEC units *Combined into*: Terrestrial Groupings (6) (Bec by Ecoprovince)

Terrestrial Realm

Geographic Units – Ecoprovinces[3]

- Coast and Mountains
- Georgia Depression
- Central Interior
- Sub-boreal Interior
- Southern Interior Mountains
- Southern Interior
- Boreal Plains
- Taiga Plains
- Northern Boreal Mountains

Ecological Units

Biogeoclimatic Zones and/or Groups of Biogeoclimatic Zones.

For discussion purposes, these zones are further classified into 6 compiled units:

- Coastal Wet: all low / mid elevation CWH BEC variants, except those in Coastal Dry; ICHwet in Coast and Mountains.
- Coastal Dry: CWHdry and moist; IDF and ICHmoist in Coast and Mountains; CDF; CWH in Southern Interior;
- Interior Wet: ICHmoist in Central and Southern Interior and Southern Interior Mountains;
- Interior Dry/ Warm: IDF; BG; PP; ICHdry
- Montane: AT, ESSFMS BEC zones; SBSwet in Southern Interior Mountains and Sub-Boreal Interior

[3] We compiled Assessment Tables by Ecoprovince, but report out by the 6 compiled units (BEC variant by ecosection, see Fig.3)

- Plateaus/ Boreal: BWBS; SBPS; SBS (except wet in Southern Interior Mountains); SWB in Northern Boreal Mountains;

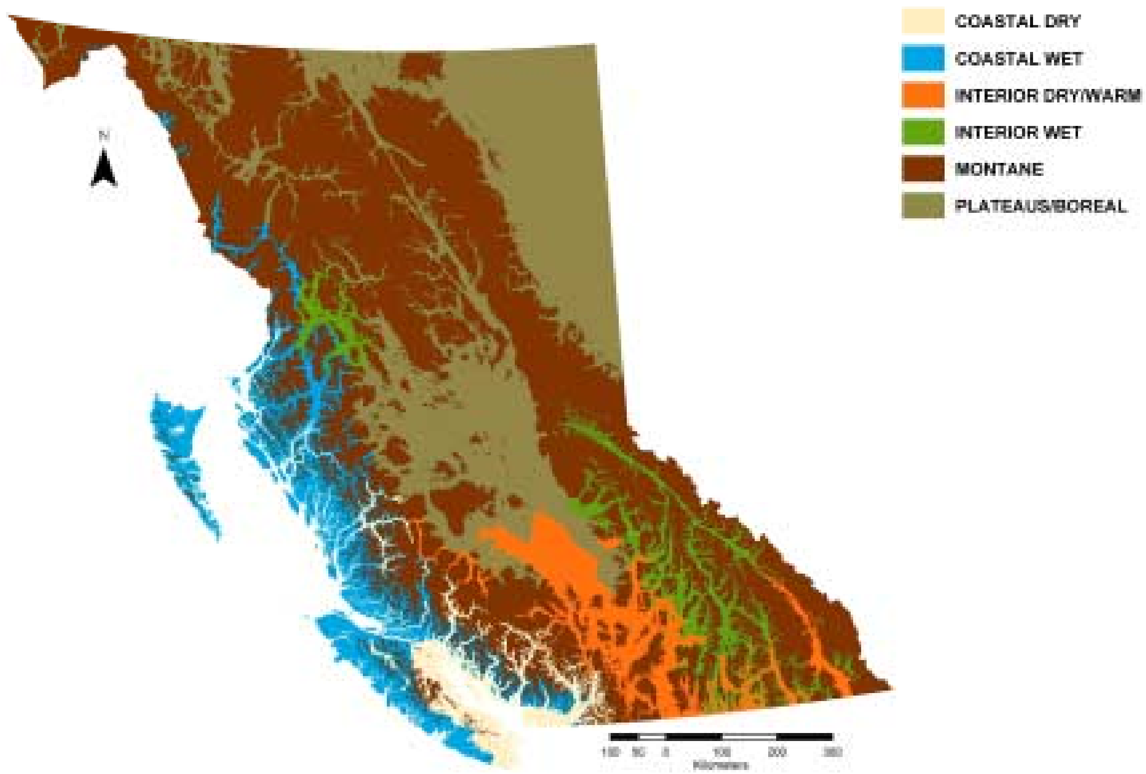


Figure 3. Terrestrial Groupings.

<u>Freshwater Aquatic Realm</u>

Geographic Units – Major Drainage Basins and/or Basin Groupings

- Lower Fraser
- Mid Fraser
- Upper Fraser
- Thompson
- Okanagan
- Columbia
- Coastal Drainages
- Vancouver Island and Queen Charlotte Islands
- Stikine/Alsek/Taku/ Yukon (northern transboundary)
- Skeena/Nass (large northern watersheds)
- Peace/Liard (Arctic watersheds)

Ecological Units

- Rivers (4th order and larger): rivers of 4th order and larger (on 1.:50,000NTS mapping). Although riparian areas remain important to these rivers, they have a diminished role as the river size increases. The behaviour of large rivers including their response to disturbance involves / integrates regional factors.
- Streams (3rd order and smaller): creeks and streams of 1st, 2nd and 3rd order (on 1:50,000 NTS mapping), including smaller ephemeral and discontinuous streams not generally shown on NTS maps. Where they occur in undisturbed forested terrain, the riparian canopy can be closed over the river surface. Riparian vegetation plays a key role in the rivers' ecology.
- Wetlands: areas of land inundated by surface water and/or groundwater with sufficient frequency to support a prevalence of vegetative or aquatic life, and requires saturated soil conditions for growth and reproduction.
- Riparian areas: the terrestrial zone of interaction between aquatic and terrestrial ecosystems, readily distinguished by its distinctive plant communities and/or moisture regimes. Riparian areas border lakes, wetlands and small and large rivers.
- Lakes: naturally occurring inland bodies of standing water of at least 0.5ha in area

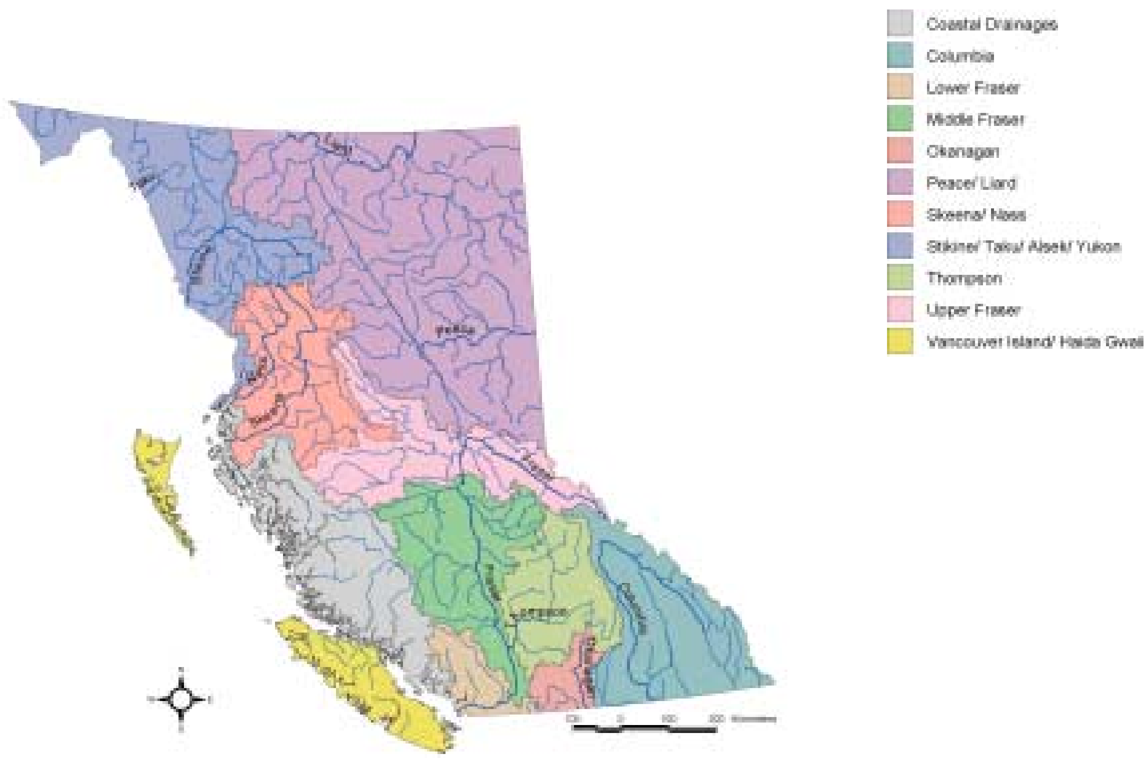


Figure 4. Freshwater Aquatic Watershed Groupings.

<u>Marine Realm</u>

Geographic Units – Groupings of Marine Ecosections[4]

[4] Where threats did not vary significantly between adjacent ecosections (e.g. Sub-Arctic Pacific and Transitional Pacific ecosections), the ecosections were merged into a single region. Conversely, on the west coast of Vancouver and the Queen Charlotte Islands, where part of an ecosection was predominantly coastal and the remaining part offshore, the ecosections were split into the "Offshore" region and the "Exposed Outer Coasts" regions.

- Georgia Basin
- North Island Straits
- Queen Charlotte Sound
- North Coast Fjords
- Exposed Outer Coasts
- Dixon Entrance – Hecate Strait
- Offshore

Ecological Units[5]

- Estuaries – coastal areas where there is significant freshwater input from rivers or streams. These areas are generally low lying and sheltered, and are often highly productive because of the nutrients deposited from upstream terrestrial sources. Often there are associated salt marshes and/ or eelgrass beds.
- Backshore – habitat above the high tide mark influenced by or itself influencing the marine realm (exclusive of upriver areas)
- Intertidal – habitat between the highest high tide and the lowest low tide
- Nearshore subtidal – benthic or bottom habitats in inside waters (as measured headland to headland) or less than 10km from the coast.
- Offshore subtidal – benthic or bottom habitats >10km offshore. This ecological unit is only found in the Offshore, Hecate Strait-Dixon Entrance and Queen Charlotte Sound marine regions.
- Pelagic – the habitat formed by the water column occupied by plankton and free-swimming invertebrates, fish and marine mammals and birds. For this project this habitat was extended to include the airspace above the water where marine birds fly or float over water.

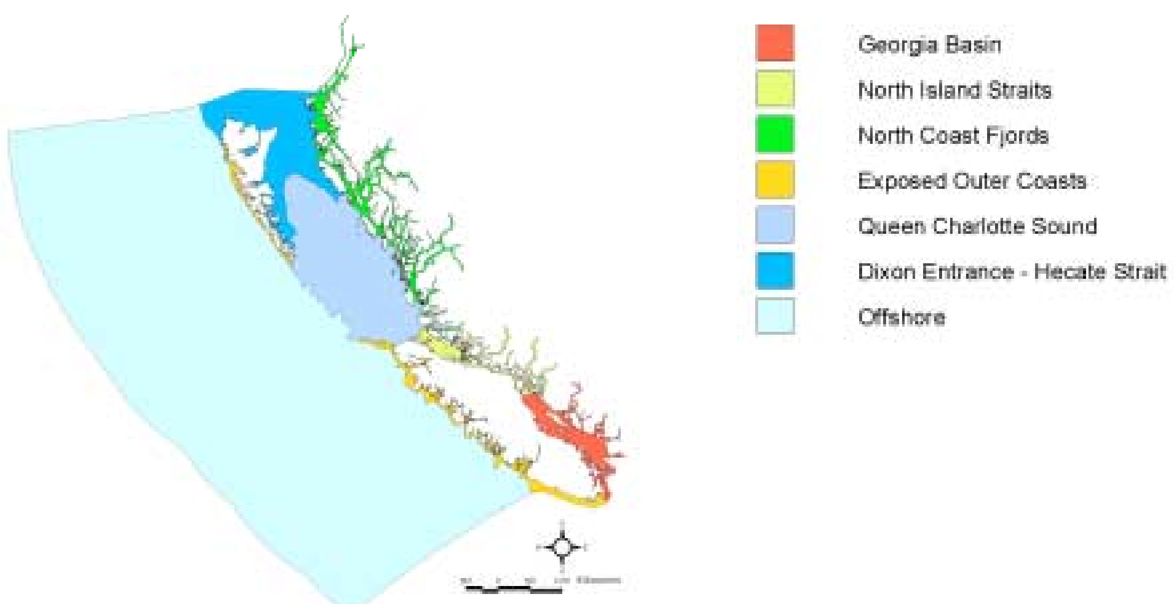


Figure 5. Marine Geographic Groupings.

[5] Note these units are not intended to be synonymous with Ecounits , a measure within the marine classification system equivalent to biogeoclimatic zones.

Step 2: Compile List of Threat Categories and Threat Activities

A standardised 'check list' of human activities that act as stress agents on biodiversity was devised. The basic list was based on the generic outline used in Harper (2002)[6], but differentiated to a larger extent to allow the threats associated with the specific elements of a broad activity to be differentiated. The complete list includes 18 Threat Categories (e.g. agriculture, industry, forestry, urban development etc.), and is further divided into 84 Threat Activities which allow the threat to be assigned at a finer scale. The complete threat list is shown in Table 5, and the wording used was intended to cover off the three realms as much as possible.

Throughout the report we refer to the Threat Categories using 2 letter codes, followed by the Threat Activities where relevant. To aid the reader throughout, we include a 'bookmark' (page vii) which has all the Threat Categories codes for easy reference.

A general description of the range of activities included under each Threat Activity is included in Appendix 2.

Step 3: Compile Impacts from Threat Activities on Basic Assessment Units

A dataset was built for each assessment unit – (ecological unit within geographic region) within each of the three broad realms. An example of this is shown in Appendix 3 for the Marine Realm. The headers correspond directly to the questions outlined in Section 3.1.2, and the ratings given for each threat correspond to the ratings from Table 3.

The baseline information available for the assessments differed for each realm. For the terrestrial realm we used as a baseline the output from a series of workshops held by MWLAP during 2000 (Holt 2001) which brought together a mixture of provincial ministry, industry and private consultant ecologists (e.g. MoF regional ecologists, Forest Ecosystem Specialists, plant specialists, introduced species specialists, fire ecology specialists, etc.) and asked them to summarise those ecosystems and ecosystem elements most 'at risk' from human activities in their region (workshops were held in 6 MoF regions at that time). The workshop approach allowed a large amount of baseline information to be gathered in a fairly short period of time, and also gave the opportunity to canvass a reasonably large number of experts as to the significance of the range of impacts. The output was not quantitative, but provided a basis for assessing the presence and significance of large range of activities across the province in this project.

Based on the format of the Terrestrial workshops, a series of three workshops were held under this contract to repeat this process for the marine and freshwater aquatic realms. Similarly, a range of experts were invited and they provided a similar range of input. A summary of these three workshops and participants is found in Appendix 4. In addition, one member of the team attended a workshop held by the provincial Impacts Assessment Biologists Workshops (Feb 25, 2003) for additional input, particularly in relation to the Freshwater Aquatic realm.

In addition to the baseline information from workshops, each Realm leader (Holt – terrestrial; Carver – freshwater aquatic; Booth – marine), followed up with phone calls and emails to many individual experts around the province for input into a specific activity in specific regions.

There are 26 datasets (Assessment Tables) completed, one for each geographic region in each of the three realms. These data sets include entries for each applicable threat activity for each ecological unit within each geographic area. Primary data sources used to fill in the tables are summarised in Table 2.

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[6] A catalogue of threats and relevant legislation or program instruments intended to aid development of this project.

Table 2. Primary sources of information for threats/ impacts in each realm.

Terrestrial	• Strategic Ecological Restoration Assessment (Holt 2001); regional workshop summaries of threats to biodiversity. • State of the Environment Reporting (2002) • Protected Areas summaries (PASO 2002) • Harding and McCullum (1994) • BC Conservation Data Centre dataset (2002) • Watershed ranking tool (Malcolm Gray pers. comm.) • Expert opinion • Diverse Literature from web and elsewhere
Marine	• Three regional workshops designed to mirror SERA workshops were held under this contract in Jan 2003 (summary of each is in Appendix 4.0) • Key reports: Burke et al. 01; GES AMP 2001. • Expert opinion • Diverse Literature from web and elsewhere
Freshwater Aquatic	• Three regional workshops designed to mirror SERA workshops were held under this contract in Jan 2003 (summary of each is in Appendix 4.0) • State of Environment reporting (2002) • BC Conservation Data Centre dataset (2002) • Watershed ranking tool (Malcolm Gray pers. comm.) • Expert opinion • Diverse Literature from web and elsewhere

3.1.2. Assessment Table Format

We organised the Assessment Tables based on the types of issues or variables we felt important for determining the rankings. Determination of ecological rankings requires assessment of a number of different aspects of the threat. We identified three broad categories which would be used to assess the priority rating of each threat within each assessment unit:

a) ecological significance of the impact,

b) geographic/ repeated significance of the impacts,

c) scientific certainty relating threats to impacts.

The questions below subsume the ideas of ecological significance, geographic significance of impact and scientific certainty, and the codes refer directly to the compilation data tables. For each Threat Activity in each Geographic Grouping within each realm, a rating, based on the Ratings Table (Table 3) was given in answer to each of the questions below. These ratings provide the basis for the ranking process.

P	Persistence	Is the threat creating impacts in the past, present and/or future?
Ev	Evidence	What is the strength of the evidence linking threats to impacts?
DC	Degree of Change	What is the degree of change associated with the impacts?
R	Reversibility	What is the degree of reversibility of the impacts?
Ex	Extent	How extensive are the impacts within the geographic area and basic ecological unit under consideration?
KS	Keystone species[7]	If keystone species are directly impacted, how significant are those impacts? Are the impacts at the species level or genetic level?

[7]Keystone species are those having a larger ecological impact than that suggested by their biomass.

FS Focal species[8]		If non-keystone focal species are directly impacted, how significant are those impacts? Are the impacts at the species level or genetic level?
RS Rare species[9]		If non-keystone, rare species are directly impacted, how significant are those impacts? Are the impacts at the species level or genetic level?
What/ Comments		Comments on the specifics of the impacts, what activities, what processes, functions, ecosystems, spp. are impacted

[8] Focal species is a generic term for any species considered of particular interest in an area.
[9] Rare species are those designated as rare or threatened under the BC Conservation Data Centre rating system or COSEWIC

Table 3. A ratings table for use in compilation of Assessment Tables for each realm.

	Topic	5	4	3	2	1
P	**Persistence of Threat**	Current, and definitely increasing in future	Current and likely to continue, and some chance of an increase in future; or not current, but likely to be very significant in the future	Current, but uncertainty about future, may continue, but may decrease in future; or not current, but some possibility of future significance	Definitely diminishing in future	Past only, threat ceased
Ev	**Evidence**	Strong, undisputed evidence	Strong evidence, but some contrary views	Moderate evidence, but some contrary views	Weak evidence but no contrary views, or moderate with significant contradictory information	Very weak or little evidence; little certainty; or highly contradictory information
DC	**Degree of Change**	Sufficient change to eliminate key functions of an ecosystem process or habitat element, or eliminate a whole ecosystem	Significant change to a key process, ecosystem or habitat element, such that its functioning is severely compromised	Changes that result in significantly reduced functioning to an ecosystem process, ecosystem or habitat element	Changes that result in reduced functioning of an ecosystem process, ecosystem or habitat element in some locations	Minor change to an ecosystem process, particular ecosystem or habitat element, functioning not effected
Ex	**Extent**	Pervasive impacts throughout the applicable area	Numerous moderate to large locations	A few moderate to large locations or numerous well-distributed small locations	A few small or isolated locations within the applicable area	A single isolated location within the applicable area
R	**Reversibility**	Impacts are non-reversible within a century	Impacts can recover naturally within a century or quicker with extensive investment	Impacts take many decades (~5-10) to recover and require moderate investment	Impacts recover naturally in a few decades (~<5) and require minimal investment	Impacts recover naturally in a short period
KS	**Keystone species***	A major factor leading to the significant decline of keystone species – due to direct killing or elimination of critical habitat	Effects keystone species in a significant way, over extensive areas, either directly or via habitat modification	Effects keystone species in a significant way over limited area, or in a moderate way over a large area	Effects keystone species in a limited way over large areas, or in a moderate way over a small area	Effects keystone species, but only in a marginal way in a small percentage of its applicable range

Table 3 (cont'd)

	Topic	5	4	3	2	1
FS	**Focal species***	A major factor leading to the significant decline of focal species – due to direct killing or elimination of critical habitat	Effects focal species in a significant way, over extensive areas, either directly or via habitat modification	Effects focal species in a significant way over limited area, or in a moderate way over a large area	Effects focal species in a limited way over large areas, or in a moderate way over a small area	Effects focal species, but only in a marginal way in a small percentage of its applicable range
RS	**Rare species***	A major factor leading to the listing of rare species – due to direct killing or elimination of critical habitat	Effects rare species in a significant way, over extensive areas, either directly or via habitat modification	Effects rare species in a significant way over limited area, or in a moderate way over a large area	Effects rare species in a limited way over large areas, or in a moderate way over a small area	Effects rare species, but only in a marginal way in a small percentage of its applicable range
What		Comments on the specifics of the impacts, what activities, what processes, functions, ecosystems, spp. are impacted.				

*** see footnotes 7,8,9.**

3.1.3. Limitations of the assessment data

We tried to design a reasonable rating system using subjective judgement based on a wide diversity of expert opinion and reports to fill in the Assessment Tables. This process was limited by the lack of quantitative data and certainty is higher in some areas than others. Due to time limitations, consultation with relevant experts was more thorough for some subjects in some geographic areas than in others and additional review is still required.

Three individuals were responsible for filling in the data for each realm. Although we attempted to maintain consistency in approach and degree of ratings given, we never intended for the assessments to be directly comparable across realms, only within a given realm.

Note that this work is intended to be applied at a strategic provincial or regional scale – and we feel the accuracy of the information included in the assessment table is adequate to do this. However, we do not expect that every cell in the Assessment Tables will capture local variation in threats or impacts especially at a finer scale than our assessment units (ecological units within geographic groupings). As such application of our information at finer scales would not be appropriate without additional review and input.

Step 4: Rank Threat Categories and Threat Activities

A ranking of Threat Activities and their associated impacts was undertaken to investigate which activities were creating the greatest magnitude of impacts, which were most widespread and which threats appeared to have the most overall significance to biodiversity. The combination of characteristics selected for the magnitude ranking included factors that were related to the type and degree of change, and the reversibility of those changes. Characteristics chosen to rank the extent of threat activities included the number of geographic areas and range of ecological units in which the threat created significant impacts, as well as the local distribution within individual geographic areas and ecological units (see Table 4). The threats/ impacts database created in Step 2 was used as the information source for ranking the threat activities (see Appendix 3).

Provincial rankings of individual Threat Activities were performed on provincial summaries for each realm (see Appendix 1) through application of an algorithm that combined the impact characteristics summarized in Table 4. The resulting “magnitude’ and “extent” indices were then used to rank the various threat activities at a provincial scale for each realm (results shown in Section 5.0). Details of the ranking algorithms are provided in Appendix 3.

The broad Threat Categories were also ranked provincially for each realm by rolling up the impact ratings and ranking criteria for the various Threat Activities included under each Threat Category. In this case extent was separated into two parts – “geographic extent” and “ecological amplitude” (results are summarised in Figures in Section 5.0). Geographic extent is based on the number of geographic groups within which the Threat Category occurs, and the number of ecological units and local extent of the Threat Category within each of the geographic groups. Ecological amplitude is based on the percentage of the total ecological unit – geographic group combinations across the province that have impacts. Details of the ranking algorithms are provided in Appendix 3.

Threat activities were also ranked for each geographic grouping for each realm. In this case more emphasis was place on magnitude, while extent only considered local extent and the percentage of ecological units with impacts within each geographic region (termed magnitude weighted mean).

Information regarding persistence of threat activities and the weight of evidence linking activities to impacts were not used in the ranking process, but are treated as accessory characteristics for use in discussion and guiding more detailed priority setting.

Note that the magnitude and extent indices are relative scores but are not quantitatively related, i.e. a score of 10 for magnitude does not imply 5 times the severity of impact as a score of 2.

Table 4. Rating key for ranking threats and impacts.

Threat/ Impact Characteristic	Rating Criteria					Comments
Magnitude						An index based on a summation of the degree of change and reversibility of those changes at various ecological levels.
Type of Change	Processes/ Functions	Whole Ecosystems	Habitat Elements	Individual Species Keystone Rare Focal	Genes	Impacts at various ecological levels are additive (changes at higher levels often have cascading impacts).
Degree of Change	Elimination of key process, habitat element, or whole ecosystem	Severely reduced function of key process, ecosystem or habitat element	Significantly reduced function of process, ecosystem or habitat element	Reduced function of process, ecosystem or habitat element in some locations	Minor changes to process, ecosystem or habitat element, function not effected	Degree of change accounted for 50% of the score at each of the ecological levels (i.e. type of change). At the species/gene level, max. degree of change accounted for 100%.
	High Ranking (5) ←==============================→ **Low Ranking (1)**					Ratings (1 – 5) from Assessment Tables.
Reversibility of Change	Recovery is not possible within a century	Natural recovery almost a century or quicker with extensive investment	Recovery takes decades (~5-10), even with moderate investment	Natural recovery in a few decades (~<5) with minimal investment	Natural recovery in a short period	Reversibility of change accounts for 50% of the score at each of the ecological levels (except species).
Extent						An index based on the percentage occurrence within geographic groups and ecological units, and local distribution within each of those.
Geographic Extent	**100 %** ←——————————————→ **0 %**					Percentage of marine groups, watershed groups or terrestrial groups with an occurrence.
Ecological Amplitude	**100 %** ←——————————————→ **0 %**					Percentage of total possible ecological unit/ geographic unit combinations with an occurrence.
Local Distribution	Pervasive throughout applicable area	Numerous moderate to large locations	Few moderate to large locations or numerous well-distributed small locations	Few small or isolated locations within the applicable area	Single isolated location within the applicable area	The local distribution of impacts throughout individual ecological units within individual geographic areas.
RANKING CLASSES	**Very High**	**High**	**Moderate**	**Low**	**Not Known to Occur**	

Step 5: Summarise conservation instruments.

We have taken a two level approach to summarising instruments that may provide some conservation benefit. The overall aim is to assess the extent to which each potential threat activity (Table 5) is potentially mitigated within both a legislative and a non-legislative framework. We deal with these two approaches separately.

3.1.4. Legislative based programs for biodiversity conservation

A list of statutes that pertain to biodiversity protection was compiled using the Revised Statutes and Consolidated Regulations of British Columbia (available at http://www.qp.gov.bc.ca/statreg/). Statutes in effect as of December 2001 were used**.** Legislation that may be relevant to biological diversity and ecological values may not have been included if it was not directly relevant to one of the identified threats. Changes to legislation subsequent to December 2001 were not included in the summary.

3.1.5. Non-legislative based programs for biodiversity conservation

MWLAP let a contract in 2002 to summarise all the instruments available for biodiversity protection in the province and federally (Harper 2002). This "Annotated Catalogue of Biodiversity Programs in British Columbia" summarises biodiversity related programs, policies, and initiatives by non-government organisations, regional districts, municipal councils, businesses, international agreements, and provincial and federal governments. It was developed as a basis for assessing non-legislative programs within the current project (P. Archibald, pers. comm.). Programs are categorised using activities such as 'Land Securement', 'Environmental Advocacy', 'Research', and 'Conservation Activities' (which includes environmental NGOs advocating for parks as well as local stewardship groups). We used Harper as the basis for our assessment, but modified the categories to fit within our overall framework and have supplemented the information with expert opinion. We did not use Harper 2002 to summarise legal instruments, due to its lack of detail in that area.

Step 6: Link instruments to Threat Activities

3.1.6. Legislative programs for biodiversity protection

For each Threat Activity, we identify those legislative instruments that potentially apply and regulate or mitigate impacts to biodiversity by that activity. Where a particular statute addresses a particular threat, a notation of "X" appears in the table. Due to time constraints and the magnitude of the task, this portion of the analysis did not specifically list regulations under each Act, although regulations were taken into account (in other words, even if an Act did not contain an express provision for a given threat, if the regulations did, then the legislation was noted as addressing the threat. If an Act could potentially apply to a given threat, but there was no express provision to that effect in the legislation or regulations, the legislation was not identified in the gap analysis. No judgement was passed on the effectiveness of the legislation in addressing the threat.

Due to time constraints it was not possible to extend this analysis beyond legislative and regulatory instruments. For future analysis it would be useful to examine the following additional categories of instruments:

- International treaties and agreements;
- Government policies and guidelines (Federal, Provincial and Municipal);
- Government programs and projects (Federal, Provincial and Municipal);

More comprehensive analysis would require significant research and a substantial time commitment to (a) identify all potentially relevant legislative and regulatory instruments (b) establish definitive criteria against which effectiveness could be assessed (c) assess each instrument against these criteria and (d) assess real effectiveness for all elements.

3.1.7. *Non-legislative programs for biodiversity protection*

To complement the summary of legislative programs for biodiversity protection, a similar approach was used for non-legislative instruments. This involved first categorising the diversity of instruments, and then assessing their ability to mitigate each threat activity.

Harper's (2002) catalogue includes 133 Regional or Municipal government programs, 138 Federal or Provincial programs, 135 NGOs, and 17 Businesses. The Municipal and Regional District programs listed focus on 'Restoration' or 'Alien Organisms', 'Land Securement' (for Parks and Recreation), and 'Policy and Planning', although the majority of 'Land Securement' programs emphasise urban and tourism development rather than biodiversity. NGO activities emphasise advocacy, education, land trusts, and restoration. Four of the 10 Land Trust programs are in the Lower Mainland/Gulf Islands where urban development is listed as the primary threat. Within the catalogue, business related activities are limited to 'habitat conservation programs' headed by large forestry companies (e.g. Canfor, Weyerhaeuser, TimberWest, etc.).

There are 423 programs on Harper's list, with an emphasis on government initiatives (from local to international scales). However, the database is uneven in its coverage, particularly for NGOs and non-forestry business initiatives. In addition, there is no explanation of how the list was created, how well it represents each sector and geographic area, or how complete it is considered to be. We found that some programs were listed twice – under different Program Types – while others were notably missing. In particular, there seems to be a systematic bias towards programs in the Lower Mainland, southern Vancouver Island, and highly populated areas of the Okanagan, particularly for NGO activities. There are also problems with the way in which some programs are assessed. For example, the University of Calgary's East Slopes Grizzly Bear Project is listed in the environmental NGO sector with a provincial scope (although it is restricted to the eastern slopes of the Rocky Mountains).

Application of Harper to the current study required combining some of Harper's activity categories such as education and advocacy to make a new list of program types that were then assessed in relation to the Threat Activities. Where several non-legislative programs address a threat, they are identified by a bolded '**X**'. Where the threat is addressed, but only through minor efforts, we used a plain text 'X'. If no programs were listed in Harper, but expert opinion expected programs to exist, we used a '?'.

As with legislative programs, we only assessed the presence of a program and not its effectiveness in mitigating biodiversity impacts. In order to gain a true picture, the extent and effectiveness of these programs would need to be assessed. This would require a significant investment and is not within the scope of the project, although we provide commentary on potential effectiveness in the results.

Step 7: Reporting of results

We present our results as three different outputs:

- the threats and impacts compilation, including a summary of the Assessment Tables for each realm,
- ecological rankings for each realm
- instruments for biodiversity protection.

These are then brought together in the final discussion.

We note that we have chosen to package our approach by identifying threat activities and their impacts in different ecosystems, rather than organising by ecosystem or ecosystem element and then identifying which combination of threat activities impacted that particular element.

It would be possible however, to present our results in this alternative format, for example to take a particular ecosystem (e.g. the Intertidal in the marine, or wetlands in the freshwater aquatic, or a particular biogeoclimatic variant in the terrestrial) and number and rank the threat activities occurring there.

Additionally, it would be possible to reorganise our threat activities into different groupings. Threat Activities could be repackaged into different classes – for example, all roads or trail information would be compiled and analysed as 'access'. This would provide a different perspective on our results.

Step 8: Discussion of results and recommendations

The series of results from each part of our analysis are brought together and discussed in Section 8.0. It was determined that providing specific options to address conservation gaps was not a useful output from this project at this time (R. Davis pers. comm.; P. Archibald pers. comm.). However, we do make some general comments as to how our work would link with that of others, and provide a foundation for a Biodiversity Strategy.

During this project we additionally met with MWLAP staff in March and with ministry staff from MWLAP, MoF and MSRM in April, and presented our general approach and preliminary results. At these times, we received an initial set of feedback and as a result we make some preliminary suggestions as to changes to the framework that may be useful in future. As well, in consultation with MWLAP staff (P. Archibald pers. comm.), some suggestions as to next steps are made.

4.0 RESULTS: THREATS AND IMPACTS COMPILATIONS

We standardised a list of broad classes and activities which could be used to describe the threats to biodiversity across the three realms. The final list included 18 threat categories and 84 threat activities. These are itemised in Table 5 and the code used throughout the remainder of the text. In addition, for each realm, we categorised the types of activities included in each threat category, and also summarised the types of impacts associated with a particular activity – a summary of which is found in Appendix 2.

The threat activities were used as a basis for compiling Assessment Tables, which were then used to rank all the threat activities provincially and regionally. The Assessment Tables are extensive for each realm (in excess of 3500 lines in excel workbooks), and an example of one is shown in Appendix 3. We compiled a summary sheet of the data for each realm, and which are presented for each in Appendix 1. This summary shows the average ratings given for each Threat Activity from the Assessment Tables, and shows how the impacts were distributed over the five ecological levels (process, ecosystems, habitat elements, species, genes). In addition, it shows the percent of the applicable ecological units within the geographic groupings that the Threat Activity occurred in.

5.0 RESULTS: THREAT RANKINGS

5.1. Overview of Results

The procedure to rank threats and their impacts was performed independently for each realm. A brief description of the primary patterns is given for each realm, and the main results are summarised in a number of standard tabular and graphical formats:

a) Provincial Summaries, by realm show the threat activities summarised within a particular ecological / geographic area. The Magnitude, Extent, and Magnitude Weighted Mean descriptors are given for each Threat Activity. (see table 4 for definitions)

b) The Top Ranked Activities by Geographic Grouping figure shows the eight top ranked Threat Activities for each Geographic Grouping within each realm.

c) The Provincial Ranked Threat Categories figure shows the Threat Activities rolled up into Threat Category, ranked, and presented as a bar graph. The average Threat Persistence and Threat Evidence is shown for each Threat Category.

Results are presented separately by realm, and we recommend that direct comparisons among realms (e.g. in terms of the numbers of threat activities applicable to each realm) are inappropriate because the Assessment tables were not completely standardised across realms. Comparisons within each realm by geographic groupings, or ecological units are appropriate.

Table 5. Codes for Threat Categories, and list of Threat Activities.

Agriculture	Aquaculture	Climate change	Dams	Forestry_Crown	Forestry_Private	Grazing	Harvest	Industry	Mining and exmploration	Military	Non-native species	Oil and Gas	Rural development	Recreation	Transportation/ corridors	Urban development
AG	AQ	CC	DA	FC	FP	GR	HA	IN	ME	MI	NS	OG	RD	RE	TC	UD

Code	Activity
AG	Cultivation
AG	Fertilisation
AG	Greenhouses
AG	Hydrologic feature modification
AG	Manure disposal
AG	Pesticide application
AG	Water demand
AQ	Bottom culture – shellfish
AQ	Exotic species use
AQ	Hanging culture – shellfish
AQ	Pen sites – finfish
AQ	Stock enhancement
AQ	Waste disposal
CC	Climate change
CC	Hydrograph changes
CC	Sea level change
DA	Flow regulation
DA	Habitat conversion
DA	Physical obstructions
FC	Fire suppression
FC	Landscape level modification
FC	Ocean/lake log handling
FC	Riparian disturbance/modification
FC	Roads
FC	Silviculture
FC	Stand structure modification
FP	Landscape level modification
FP	Riparian disturbance/modification
FP	Roads
FP	Stand structure modification
GR	Riparian/wetland disturbance
GR	Soil modification
GR	Vegetation modification
HA	Aboriginal
HA	Animal waste dumping
HA	Commercial
HA	Illegal
HA	Recreational
HA	Stock enhancement
IN	Air emissions
IN	Water discharge
ME	Discharges
ME	Gravel extraction
ME	Mine site
ME	Roads/trails
ME	Water demand

Code	Activity
MI	Sonar activities
MI	Waste disposal
NS	Non-native species
OG	Exploration activity
OG	Pipelines
OG	Tanker routes
OG	Well site activity
RD	Habitat conversion
RD	Sewage disposal
RD	Water demand
RE	Cruise ships
RE	Motorised terrestrial
RE	Motorised aquatic
RE	Non-motorised aquatic
RE	Non-motorised terrestrial
RE	Resort development
TC	Aviation
TC	Highways
TC	Highways – bridges/culverts
TC	Light/buoy maintenance
TC	Marinas
TC	Ocean traffic
TC	Ports – ballast dumping
TC	Ports – harbour/channelisation
TC	Ports – waste disposal
TC	Powerlines
TC	Railways
TC	Wind/tide generators
UD	Air pollution
UD	Discharges to water
UD	Disturbance/trampling
UD	Flood control structures
UD	Habitat conversion
UD	Hydrograph changes
UD	Residential chemical use
UD	Sewage disposal
UD	Solid waste disposal
UD	Water demand

UD = Southern Vancouver Island, Lower Mainland, Central Okanagan, Kamloops and Prince George.

5.2. How to find what you want to know

The Impact Assessment data could be summarised for each realm in various configurations. Geographically, summaries can be by Geographic Groupings, or by Ecological Units or Provincially. Data can be summarised and ranked by the Extent of the impact, by the Magnitude of the impact, or by some combination of the two. Additionally, data were gathered at the level of Threat Activity, and these have been summarised into the broader Threat Categories. The resulting combinations of output are therefore very large. For this report we decided to output and discuss a standard set of outputs for each realm. However, the information is available and the reader can interpret the outputs to address their own particular questions. The following examples are given to aid the reader: For example if the question is:

1) **Which detailed threats occur in my region of the province, and which have the highest impacts?**
   a) Find which Terrestrial Grouping, Watershed Grouping and/ or Marine Grouping that most closely matches your region of the province (see Figs 3,4,5).
   b) Look at the Regional Summary Tables (Appendix 1), for each realm, for the region of concern. Threat Activities occurring there are shown a) ranked by the Magnitude of the Impacts b) as the Extent of the Impacts and c) as a combination of the two. You can then determine which description you are most interested in – the Threat Activities that affect the largest number of ecological units in your region (Extent) or the ones that have the most severe impacts (Magnitude), or some combination of the two.
2) **Which threats impact the widest range of ecological units in the province?**
   a) Look at the Provincial Ranked Threat Categories figure for each realm (Figs 6, 8, 10). 'Ecological Amplitude' and Geographic Extent are shown for each threat category (see table 4 for definitions).
   b) Look at the Provincial Summary Table for each realm (Appendix 1)– the % of geographic groupings (Ecoprovinces, terrestrial, marine or watershed groupings) impacted by a particular threat is shown (e.g. %Eps, %PGs for terrestrial).
   c) Look at the Regional Summaries organised by Extent (Appendix 1). High Extent Index values identify those Threat Activities with the highest distribution in each geographic region.
3) **What Freshwater Aquatic Threat Activities are likely to increase in the Province in the future?**
   a) Look at the Freshwater Aquatic Provincial Summary (Appendix 1). The average Persistence (P) Value for each Threat Activity gives an indication, averaged for all occurrences in the province, whether the threat is likely to increase in future (high values in a scale of 1 – 5), or whether the threat is purely an historic threat (low values; see Table 3 for definitions of the 1 – 5 scale). Note that the Provincial Summary gives average values - so if a Threat Activity is highly variable provincially its rating may be in the midrange while being very high or very low in particular areas. At the same time, the Evidence (Ev) Value on that same table will give you an indication of the certainty (of the person who filled in the table) that science shows a solid or a weaker link between the threat activity and the stated impacts (again see Table 3 for definitions of the values 1 – 5).
4) **What Ecological Impacts do oil and gas pipelines have on ecosystems?**
   a) Look at the Provincial Summary tables for each realm (Appendix 1). The OG Pipelines line in each one will tell you whether there are any impacts on that realm (if it isn't there, there are no impacts recorded). Looking at that row will show a) whether the threat is increasing, stable, or decreasing (P), and how certain we were of the impacts (Ev). The five columns on the right side of the table then show whether the impacts are at the level of ecosystem processes, whole ecosystems, habitat elements, species or genes. The Degree of Change (DC) under each Ecological Change gives a measure of the average impact level in that scale (see Table 3 for

definitions), plus the Extent (Ex) and the Reversibility. Under Species and Genes, it shows the level of impact on Keystone (KS), Focal (FS), or Rare (RS) species.

b) To obtain an overall idea of where the effects are, the Provincial Summary tables (Appendix 1) shows the percent of ecological units that are affected by that particular threat, within each Geographic Grouping.

c) To understand the potential impacts in all realms, it would be necessary to review the Provincial Summary table for all three realms.

d) For a small number of threat activities, the report contains a more detailed overview of their impacts - oil and gas is one such example, and this report can be found in Section 7.0.

5.3. Results: Terrestrial

5.3.1. Regional

The Provincial Summary and Geographic Groupings summary data are shown in Appendix 1. The top 8[10] Threat Activities in each Terrestrial Grouping are shown geographically in Fig. 7 (the numbers in the coloured circles indicate the total number of threat activities recorded for each area).

The terrestrial data are presented as six regionally defined Terrestrial Groupings [combinations of biogeoclimatic variants separated into coastal (wet and dry), Interior (wet and dry/warm), Boreal/ plateau, and Montane]. The highest number of Threat Activities occurred in Coastal Dry (42) and Interior Dry/Warm (40) groups. Each of Plateau/ Boreal (32), Interior Wet (27), and Montane (27) had similar numbers of Threat Activities occurring, while Coastal Wet (21) had the smallest number.

The mean magnitude of the top 8 activities differed among the Terrestrial Groupings: Coastal Dry and Interior Dry/Warm had similarly high values (mean = 11 and 11.6 respectively), followed by Interior wet (9.6), Montane (9.5), Plateau/ Boreal (9.4), and Coastal Wet (8.6).

Based on the Magnitude Weighted mean (see Table 4), the highest ranked Threat Activities varied by Terrestrial Groupings, and a total of 18 different threat activities occurred in the top 8 across all areas. Of these, CC climate change occurred in all Terrestrial Groupings, and NS non-native species, FC fire suppression and FC landscape level modification occurred in the 8 top ranked activities for five of six Terrestrial Groupings. DA physical obstructions and UD/RD Habitat Conversion each occurred in 3 or 4 Terrestrial Groupings. FC/FP stand structure modification, AG cultivation, GR riparian/ wetland disturbance occurred in 3 Terrestrial Groupings. The remaining Threat Activities were relatively localised in their impacts, occurring in the top 8 for two or fewer Terrestrial Groupings.

5.3.2. Provincial

A summary of the Impact Assessment Table Ratings is shown in Appendix 1. The Provincial Ranked Activities are shown in Table 6, and the Provincial Ranked Threat Categories are shown in Fig. 6. The Threat Categories summary is a result of summing the individual impacts of the Threat Activities into their constituent categories, and is not derived through a direct assessment of each Category. As a result, this roll-up may contain discrepancies, particularly for the Evidence and Persistence columns.

The total number of Threat Categories and Threat Activities occurring in the Terrestrial realm is 15 (of 18) and 49 (of 84) respectively. The average magnitude of the top 8 Threat Activities is 11.6.

Of the 49 Threat Activities occurring in the Terrestrial realm, 13 rank in the top 8 provincially for Magnitude, Extent, or both. Of the top Threat Activities CC Climate Change, FC Fire Suppression, FC Landscape level Modification and NS Non-native Species rank in the top 8 for both Magnitude and Extent. The remaining 9 Threat Activities are either high in Magnitude, or Extent, but not both. When the

[10] The choice to report out on the top 8 activities is a blance between completeness and keeping the report to a reasonable length. Note that in some areas, many more than 8 Threat Activities may have significant ecological impacts.

mean value of Magnitude and Extent values is taken, the same four Threat Activities (CC Climate Change, FC Fire Suppression, FC Landscape level Modification and NS Non-native Species) are the top four ranked activities.

The result of rolling up the Threat Activities into Threat Categories is shown in the Provincial Ranked Threat Categories (Fig. 6). Here, Magnitude, Geographic Extent, and Ecological Amplitude are shown for each Category. Combining these three measures, Climate Change ranks highest, and also has the highest persistence and a high ranking for Evidence, followed by Forestry Crown, Non-native Species, Dams and Recreation. Looking separately at Magnitude rankings, Forest Crown, Forest Private and Urban Development all rank high, followed by Climate Change, Non-native Species, Recreation, Oil and Gas and Agriculture.

The impacts from Climate Change, Non-native Species, Recreation, and Urban Development are considered most likely to increase in future, with impacts from Dams, Agriculture, Oil and Gas, and Rural Development considered fairly stable with a chance of increase[11]. The scientific certainty of the relationship between the Threat Category and the Impacts is highest for Non-native Species, Climate Change, Grazing and Dams, and less certain for the other Threat Categories.

5.3.3. Examples of Threat Activity rankings

We do not intend to cite rationale for the placement of all Threat Activity ranks, but the following examples provide some description of why some activities ranked as they did.

Threat Activities ranked with the highest magnitude all attain a high ranking because they significantly impact ecological processes (i.e. they have a high degree of change for ecological processes), and have known or suspected cascading impacts down through lower levels of organisation. For example, CC climate change has an average degree of change rating of 4 (with 5 being the highest value – see Table 3 for ratings values), since it has a high likelihood of resulting in significant changes in processes responsible for maintaining ecosystems (see CMI 2003 for local examples). Although we do not attempt to specifically predict cascading effects by ecosystem (something that climate change models do not yet allow), we do hypothesise in our assessment that such cascading impacts *will* occur, and will likely affect for example, rare species in the proportion with which they exist. In response, areas with currently high densities of listed species were given a slightly higher rating for rare species impacts from CC climate change. In the terrestrial environment, although impacts will likely differ by ecosystem, we hypothesise that all ecosystems will be affected to some degree, hence the extent was extremely broad, and CC climate change ranks highest overall.

FC fire suppression also ranks high on the magnitude scale for similar reasons. Fire suppression results in a change in ecosystem processes and is well known to have cascading impacts including effective loss of whole ecosystems (e.g. old ponderosa pine savanna-type ecosystems) or habitat elements (e.g. whitebark pine in high elevation ecosystems), with impacts down to focal species (e.g. loss of ungulate winter range) and rare species, particularly those associated with dry fire-maintained ecosystems (Daigle 1996; Gayton 1996; Arno 1997; Agee 1998). Fire suppression also resulted in a relatively high extent ranking because, although the degree of change is variable by ecosystem (with highest impacts in historically fire-maintained ecosystems), the general impacts are pervasive throughout most of southern or central BC in areas where fire exclusion is relatively effective, and where fire was historically a significant component of the natural disturbance processes (e.g. excluding wet and very wet forests in the Interior and Coastal BC).

DA physical obstructions and FC landscape level modifications had high rankings because they also have implications for ecosystem processes that result in cascading effects throughout the ecosystem. Dams on major river systems have resulted in loss of ecosystem functioning, including removal of massive amounts of biomass (in the form of migrating fish species) which then has cascading effects through the terrestrial ecosystem (for broad review see Gayton 2002). Additionally, dams have blocked the flow of nutrients through large river systems, resulting in the need for extensive and expensive nutrient addition programs in some lakes (e.g. lakes on the Kootenay and Columbia River systems), and having significant

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[11] Note: A threshold of 4.5 was used as the cut-off between threats considered to be increasing and threats considered relatively stable with a chance of increasing.

impacts on resident fish populations, again resulting in significant secondary terrestrial ecosystem impacts. In terms of distribution of impacts, dams on major river systems (e.g. Columbia, Kootenay, Peace Rivers) had the largest extent rankings because of the impacts up and downstream and on tributaries. The overall combined provincial impacts were slightly lower because the extent rating for DA Physical Obstructions was reduced on a provincial scale.

FC Landscape level modifications primarily change the natural seral stage distribution over the landscape resulting in loss of habitat for some species (e.g. spotted owl (Hershey et al. 1998), mountain caribou (Stevenson et al. 2001), many rare lichen species (Goward 1993), and increasing the probability that species adapted to the natural disturbance regime will not be maintained in the long term (Bunnell 1995). In the ranking process, the loss of connectivity, particularly in traditionally highly connected forested landscapes, was assigned as a change in ecosystem process, although it was generally attributed a relatively low degree of change, with cascading impacts only where specific species were thought to be directly affected (e.g. mountain caribou in wet ICH forests). Impacts tended to be highest in ecosystems with a naturally high proportion of old forests where forest harvesting has resulted in a significant change in the seral stage distribution (i.e. coastal and interior wet forest ecosystems). FC Landscape level modifications had both a high magnitude and high extent, and so remained at a high overall ranking provincially.

NS Non-native species impacts were generally not assigned on the level of ecosystem processes, but were related to loss of whole ecosystems (e.g. in dry ecosystems such as the IDF or CDF where high diversities and densities of non-native species are significantly changing ecosystem structure). However, in general, the main impact of non-native species in the ranking process was at the level of habitat elements and individual species, where parts of plant communities and individual species are directly impacted by non-native species.

Some Threat Activities received a surprisingly high ranking. HA recreational in the Interior Wet grouping is an historic impact that caused range contractions for species such as Mountain Caribou. OG Tanker Routes in Coastal Wet received a high ranking, although it was considered a *potential* future impact only.

Other Threat Activities received a moderate or low rating for a number of reasons, including a low degree of change to process, especially if accompanied by a lack of known cascading impacts down through to lower levels (this occurred since the scoring was additive), or if there were only species level impacts with no known effects on processes, ecosystems or ecosystem elements. For example, FC roads ranks 'mid way' for magnitude of impacts within the terrestrial realm. FC roads received an average rating of 2 for change in processes, with some specific areas having additional ratings for specific species level impacts (see Gucinski et al. 2001; Forman and Alexander 1998 for review of the types of terrestrial biodiversity impacts). This is one example where the subdivision of biodiversity into three separate realms results in lower designations for some Threat Activities than would otherwise be expected (see cumulative impacts section below). Note also that FC roads increased its ranking provincially when its extent was included, as the effects of roads are pervasive throughout most of southern, central and eastern BC (see BC MWLAP 2003 for road density information).

Other Threat Activities, such as HA illegal, received a relatively low ranking (an average impact of 2.2 and 2.0 respectively on focal and rare species). In this case, HA illegal also has a low 'Evidence' ranking, suggesting that our confidence that, for example, poaching has an effect on population sizes is also low.

The impacts of some Threat Activities were particularly difficult to summarise using our approach. For example, FC silviculture is a pervasive activity, influencing much of the managed forest landbase of BC. However, the types of silvicultural activities used vary across different regions of the province, depending on land tenure, local site conditions and the decisions of local managers, which makes their impacts difficult to quantify. Additionally, some silvicultural activities may prove to be positive for local biodiversity (e.g. thinning of overstocked stands in the IDF), whereas others may have negative impacts on biodiversity (e.g. sanitation thinning – which reduces the occurrence of wildlife trees). Because of these confounding factors, it was not feasible to generate a generic impact by ecosystem. We assigned a low to moderate impact ranking for habitat elements for FC Silviculture particularly in areas where natural early seral succession is curtailed through silvicultural activities (e.g. wet ICH forests). While a threat to biodiversity, the immediate impact of seral stage alteration is lower, for example, than permanent habitat conversions due to urban development. Although there likely are species level impacts, we could not apply them at this scale of analysis, so no species level impacts were noted. Overall, silviculture received a mid to low rating for magnitude and a fairly high rating for extent.

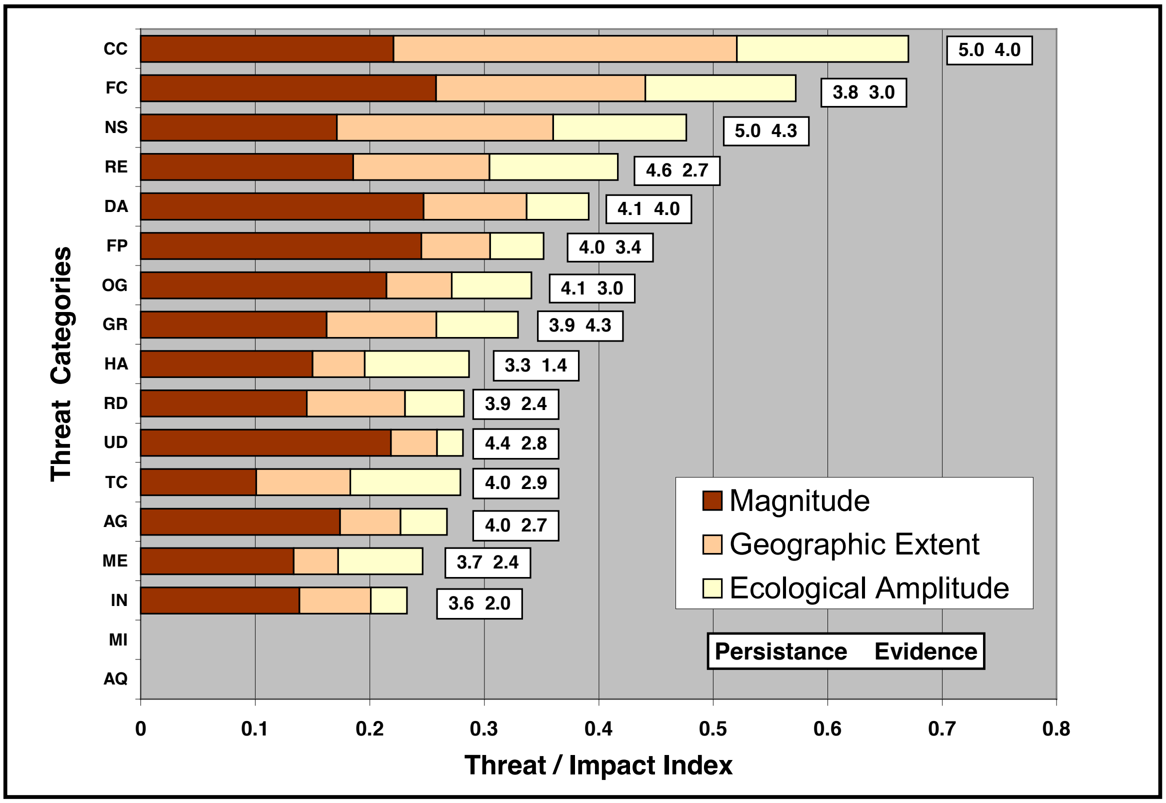

Figure 6. Terrestrial Provincial Ranked Threat Categories show Threat Activities rolled up into Threat Categories, ranked, and presented as a bar graph. The average Threat Persistence and Threat Evidence is shown for each Threat Category

Figure 7. The 8 ranked threat activities by Terrestrial Groupings.

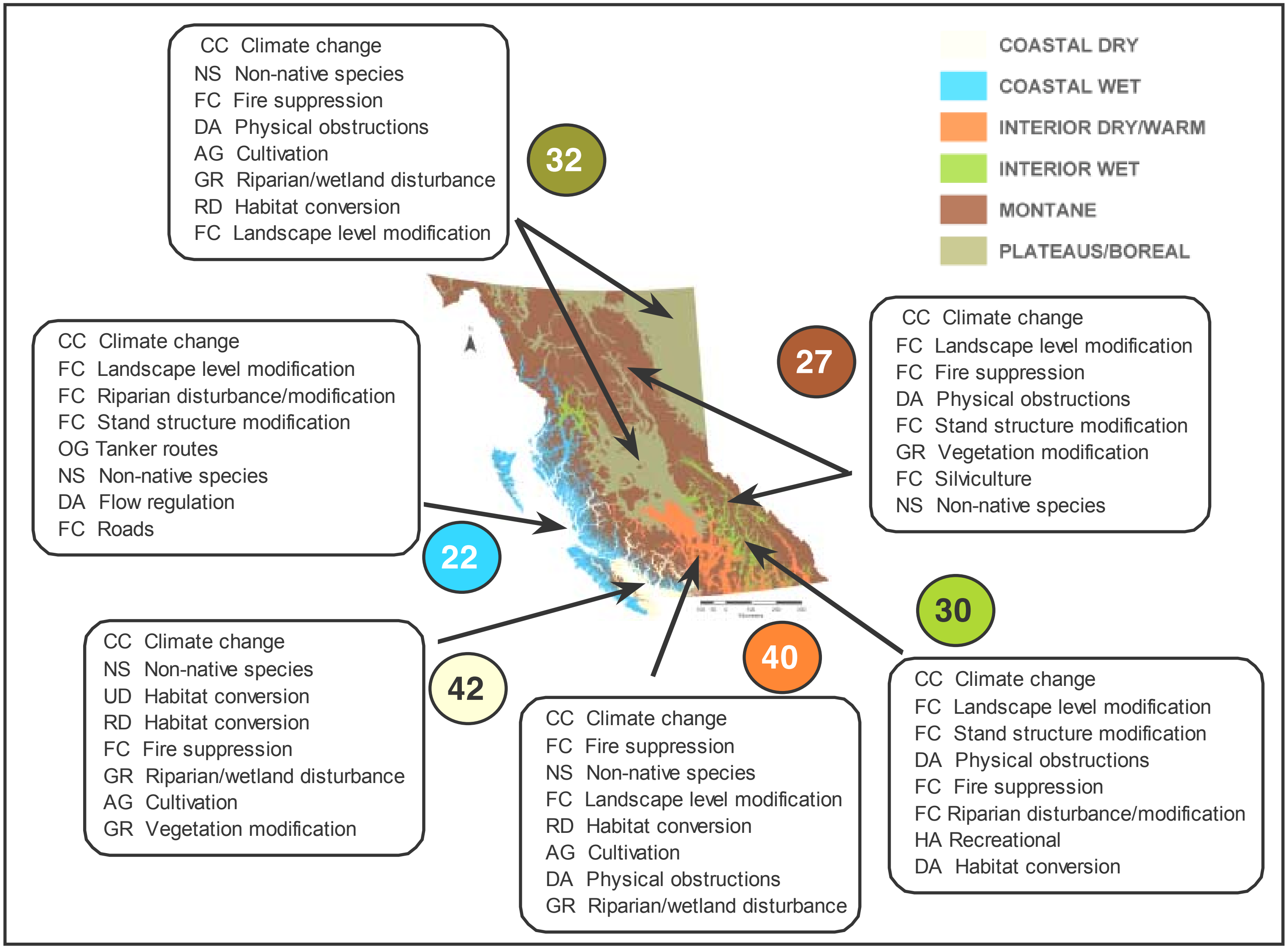

Table 6. Terrestrial Provincial Summary Ratings. Sorted by Magnitude, extent and combined extent and magnitude.

Code	Threat Activity sorted by magnitude	Magnitude Index	Extent Index
CC	Climate change	13.50	20.00
FC	Fire suppression	12.46	12.83
DA	Physical obstructions	12.33	4.78
FC	Landscape level modification	11.68	16.89
UD	Habitat conversion	11.17	3.49
AG	Cultivation	10.68	6.02
NS	Non-native species	10.51	14.04
HA	Recreational	10.50	5.59
RD	Habitat conversion	9.79	7.89
RE	Resort development	9.50	6.87
FC	Riparian disturbance/modification	9.37	12.31
GR	Vegetation modification	9.13	8.07
GR	Riparian/wetland disturbance	8.90	7.61
DA	Flow regulation	8.53	5.78
DA	Habitat conversion	8.44	7.26
OG	Tanker routes	8.00	1.32
AG	Greenhouses	8.00	1.09
FP	Stand structure modification	7.75	5.44
FP	Landscape level modification	7.50	1.31
IN	Air emissions	6.00	4.88
FC	Stand structure modification	5.97	17.01
FC	Silviculture	5.78	12.39
ME	Roads/trails	5.75	2.12
OG	Exploration activity	5.50	3.41
RE	Motorised terrestrial	5.34	13.32
TC	Highways	5.26	7.19
FC	Roads	4.26	16.35
AG	Fertilisation	4.25	2.54
ME	Mine site	4.16	7.58
UD	Air pollution	4.00	1.70
RD	water demand	3.67	4.55
RE	Non-motorised terrestrial	3.55	8.53
FP	Riparian disturbance/modification	3.38	5.85
TC	Aviation	3.00	0.43
OG	Well site activity	2.50	2.42
FC	Ocean/lake log handling	2.50	0.99
TC	Railways	2.42	7.52
AG	Pesticide application	2.33	3.61
IN	Water discharge	2.33	2.07
HA	Illegal	2.25	8.74
TC	Powerlines	2.00	11.60
OG	Pipelines	2.00	9.03
FP	Roads	2.00	4.86
HA	Aboriginal	2.00	3.80
UD	Water demand	2.00	2.54
UD	Residential chemical use	2.00	1.71
UD	Solid waste disposal	2.00	1.71
AG	Manure disposal	2.00	1.30
RD	Sewage disposal	1.75	1.68

Code	Threat Activity sorted by extent	Magnitude Index	Extent Index
CC	Climate change	13.50	20.00
FC	Stand structure modification	5.97	17.01
FC	Landscape level modification	11.68	16.89
FC	Roads	4.26	16.35
NS	Non-native species	10.51	14.04
RE	Motorised terrestrial	5.34	13.32
FC	Fire suppression	12.46	12.83
FC	Silviculture	5.78	12.39
FC	Riparian disturbance/modification	9.37	12.31
TC	Powerlines	2.00	11.60
OG	Pipelines	2.00	9.03
HA	Illegal	2.25	8.74
RE	Non-motorised terrestrial	3.55	8.53
GR	Vegetation modification	9.13	8.07
RD	Habitat conversion	9.79	7.89
GR	Riparian/wetland disturbance	8.90	7.61
ME	Mine site	4.16	7.58
TC	Railways	2.42	7.52
DA	Habitat conversion	8.44	7.26
TC	Highways	5.26	7.19
RE	Resort development	9.50	6.87
AG	Cultivation	10.68	6.02
FP	Riparian disturbance/modification	3.38	5.85
DA	Flow regulation	8.53	5.78
HA	Recreational	10.50	5.59
FP	Stand structure modification	7.75	5.44
IN	Air emissions	6.00	4.88
FP	Roads	2.00	4.86
DA	Physical obstructions	12.33	4.78
RD	water demand	3.67	4.55
HA	Aboriginal	2.00	3.80
AG	Pesticide application	2.33	3.61
UD	Habitat conversion	11.17	3.49
OG	Exploration activity	5.50	3.41
AG	Fertilisation	4.25	2.54
UD	Water demand	2.00	2.54
OG	Well site activity	2.50	2.42
ME	Roads/trails	5.75	2.12
IN	Water discharge	2.33	2.07
UD	Residential chemical use	2.00	1.71
UD	Solid waste disposal	2.00	1.71
UD	Air pollution	4.00	1.70
RD	Sewage disposal	1.75	1.68
OG	Tanker routes	8.00	1.32
FP	Landscape level modification	7.50	1.31
AG	Manure disposal	2.00	1.30
AG	Greenhouses	8.00	1.09
FC	Ocean/lake log handling	2.50	0.99
TC	Aviation	3.00	0.43

Code	Threat Activity sorted - extent and magnitude	Magnitude Index	Extent Index
CC	Climate change	13.50	20.00
FC	Landscape level modification	11.68	16.89
FC	Fire suppression	12.46	12.83
NS	Non-native species	10.51	14.04
FC	Stand structure modification	5.97	17.01
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AG	Pesticide application	2.33	3.61
HA	Aboriginal	2.00	3.80
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UD	Water demand	2.00	2.54
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UD	Residential chemical use	2.00	1.71
UD	Solid waste disposal	2.00	1.71
FC	Ocean/lake log handling	2.50	0.99
TC	Aviation	3.00	0.43
RD	Sewage disposal	1.75	1.68
AG	Manure disposal	2.00	1.30

5.4. Results: Freshwater Aquatic

5.4.1. Regional

The Freshwater Regional summaries are shown in (Appendix 1) and the top 8 Threat Activities in each freshwater Grouping are shown graphically in Fig. 9 (the numbers in the coloured circles indicate the total number of threat activities recorded for each area).

The freshwater data are presented regionally using eleven Watershed Groupings – Lower Fraser, Middle Fraser, Thompson, Upper Fraser, Okanagan, Columbia, Vancouver Island & Haida Gwaii, Skeena-Nass, Stikine-Alsek, and Peace-Liard. The Watershed Groupings are combinations of watersheds having similar physical characteristics (see methods for further details). The highest number of threats were observed in the Lower Fraser (56), Thompson (55), Upper Fraser (54), Okanagan (53) and Vancouver Island-Haida Gwaii (49) Groupings. The Columbia and Peace-Liard each have 41 threat activities. The Skeena-Nass (33), Coastal Drainages (28), and Stikine-Alsek (24) have the least number of threat activities.

The mean magnitude of the top eight activities differed among the Watershed Groupings and the Okanagan (11.3), Thompson (11.0), and Columbia (11.0) stand out at the top of the distribution. Vancouver Island-Haida Gwaii, Middle Fraser, and Upper Fraser were all ranked at 9.8 with the Lower Fraser at 9.7. Magnitude rankings for the Coastal Drainages and Stikine-Nass were both 9.4, and the Peace-Liard was 9.3. The Stikine-Alsek had the lowest ranking at 8.4.

Using the Magnitude Weighted mean (Table 4), the highest ranked Threat Activities varied by Watershed Grouping. In total, 18 different Threat Activities occurred among the top 8 threats across all areas. CC climate change, NS non-native species, FC roads, and FC riparian disturbance occurred among the top 8 Threat Activities for all Watershed Groupings, and RD habitat conversion, CC hydrograph changes, and HA stock enhancement occurred in the top 8 for at least nine Watershed Groupings. UD habitat conversion and AG water demand occurred in four and three Watershed Groupings. The remaining eight Threat Activities (AG cultivation, FP riparian, and HA commercial, DA flow regulation, DA physical obstructions, OG pipelines, RE motorised aquatic, and FP roads) were relatively localised in their impacts, occurring in the list of top 8 Threat Activities for just one or two Watershed Groupings.

5.4.2. Provincial

A summary of the Impact Assessment Table Ratings is shown in Appendix 1.The Provincial Ranked Activities are shown in Table 7, and the Provincial Ranked Threat Categories are shown in Fig. 8.

The Threat Categories summary is a result of summing the individual impacts of the Threat Activities into their constituent categories, and is not derived through a direct assessment of each Category. As a result, this roll-up may contain discrepancies, particularly for the Evidence and Persistence columns.

In total, 16 (of 18) Threat Categories and 60 (of 84) Threat Activities occur in the Freshwater realm. The average magnitude of the top 8 Threat Activities is 9.9.

Provincially, 14 Threat Activities rank in the top 8 for magnitude, extent, or both. Of the top 8 Threat Activities, only CC climate change and NS non-native species rank in the top 8 for both Magnitude and Extent. The remaining 12 Threat Activities are either high in magnitude, or extent, but not both. When a mean of magnitude and extent is taken, the same two Threat Activities (CC climate change and NS non-native species) have high rankings. FC roads and FC riparian disturbance/ modification ranked high overall (provincially) and were among the top 8 threats in all Watersheds.

When Threat Activities are combined into Threat Categories, as shown in the Provincial Ranked Threat Categories figure (Fig. 8), Climate Change ranks highest, with the highest persistence possible (5.0) and a moderately high ranking for Evidence. Crown Forestry, followed by Rural Development, Dams, Non-native Species, and Agriculture have the next highest rankings (Fig. 8). Private Forestry, Urban Development, Grazing and Transportation Corridors have also high magnitude rankings.

The impacts from Climate Change, Non-native Species, Recreation, and Urban Development, Transportation Corridors, and Oil and Gas are considered most likely to increase in future (4.5-5.0). All other applicable threat activities are considered fairly stable with a chance of increase (3.7-4.4) except for Industry, which may decline. The scientific certainty of the relationship between Threat Categories and the Impacts is highest for Rural Development, Urban Development, Dams, Non-native Species, and Grazing.

5.4.3. Examples of Threat Activity rankings

The process used to develop magnitude rankings used the degree of change to ecosystems, the reversibility of that change, and impacts to ecological processes that cascade through other levels of ecosystems. CC climate change, which was consistently at the top of the rankings, perhaps provides the best example of cascading effects. Although current climate-change models do not allow prediction of specific outcomes, they do predict cascading consequences throughout ecosystems and they forecast changes of a large magnitude. Climate change models also predict a comprehensive range of expected impacts. These factors pushed CC climate change to the top of the magnitude and extent rankings.

Provincially, AG water demand ranked second in magnitude overall and was among the top 8 threats in the Middle Fraser, Okanagan and Thompson watersheds. Where it occurs, it is a central threat to ecosystems and biodiversity. Its high magnitude rating comes about for similar reasons to that of CC climate change. When water loss due to irrigation demand is severe, the entire freshwater ecosystem is jeopardised – processes, ecosystems, and habitats. The semi-arid regions where this is often a problem also possess important species and hence species impacts are also expected. Because high agricultural water demand is not widespread across the province, it rates somewhat lower overall when extent is factored in. Where RD water demand, UD water demand, and ME water demand occur in a localised area in addition to AG water demand, the aggregate problem may be of greater concern than CC climate change (the highest-magnitude activity).

On a provincial scale, RD water demand ranks higher in magnitude than RD habitat conversion, although RD habitat conversion ranks higher overall and in extent. This is not surprising given that RD habitat conversion results in impacts widespread across much of the province and is generally situated in high biodiversity value valley bottoms. It is, however, somewhat surprising to see that UD habitat conversion does not rank higher given the severity to biodiversity of the activity where it occurs. Its lower ranking provincially results from averaging severe impacts in some locations (e.g. Lower Fraser) with more modest impacts in the smaller urban centres (Kamloops, Prince George) and in Watershed Groupings without large urban centres. UD habitat conversion is listed among the top 8 threat Activities in the Watersheds where it occurs. If RD habitat conversion and UD habitat conversion were combined, it is expected that the magnitude and extent would both increase yielding a high ranking overall.

DA flow regulation and DA physical obstructions rated high in magnitude due to their acute impacts on processes and habitats in addition to their known impacts to aquatic species. The impact of dams has its strongest expression in the Columbia where magnitude is roughly equivalent to CC climate change. It may be surprising to see these activities rank lower in the Peace-Liard but this is due to the large size of this Watershed Grouping in comparison with the extent of impacts from the Williston Dam, the primary dam activity in that grouping. The Upper Fraser, Middle Fraser, Thompson, Okanagan, and Vancouver Island-Haida Gwaii all have dam impacts, but only some of them are due to hydroelectric dams. In the semi-arid parts of the province, these dams are often associated with water supply systems. Although not included in the analysis, there is a high potential for large-scale expansion of run-of-the-river hydroelectric dams in the province. It is not known what the impacts will be should this occur, but some of these may involve significant dams. In the analysis, all dam activities were given the highest ratings for evidence (5.0) indicating very high confidence that the impacts indicated result from the activities specified.

NS non-native species were assigned impacts to ecological processes because of changes to community structure, to whole ecosystems, and to many individual native species. The issues are similar across the province and NS non-native species rank high in all Watershed Groupings, but exotic and invasive species are expected to be more of a concern in the southern parts of the province largely due to higher human populations and a higher degree of access.

On a provincial scale, FC roads and FC riparian disturbance/modification are rated high in magnitude but not as high as many of the activities mentioned above. It is their very high extent (second only to CC climate change) that pushes their rankings to the top few when considered on a combined extent-magnitude basis.

Surprising rankings come from all three grazing Threat Activities in addition to OG pipelines and some TC activities. Grazing activities are unique in the analysis in having middle ranking magnitude in addition to middle ranking extents. This yields overall rankings that are central on the entire list. Grazing delivers impacts to processes (riparian functions, runoff dynamics, etc) and simultaneous impacts to ecosystems or habitats. These factors contribute to its average ranking overall.

OG pipelines and some TC activities rank fairly high overall given their generally limited distribution across the landscape. This may be an artefact of the class limits in the assessment scheme (not ideally suited for linear developments), it is also expected that these are real rankings given their past and/or potential impacts. (For example, oil and gas pipelines can rupture causing spills.)

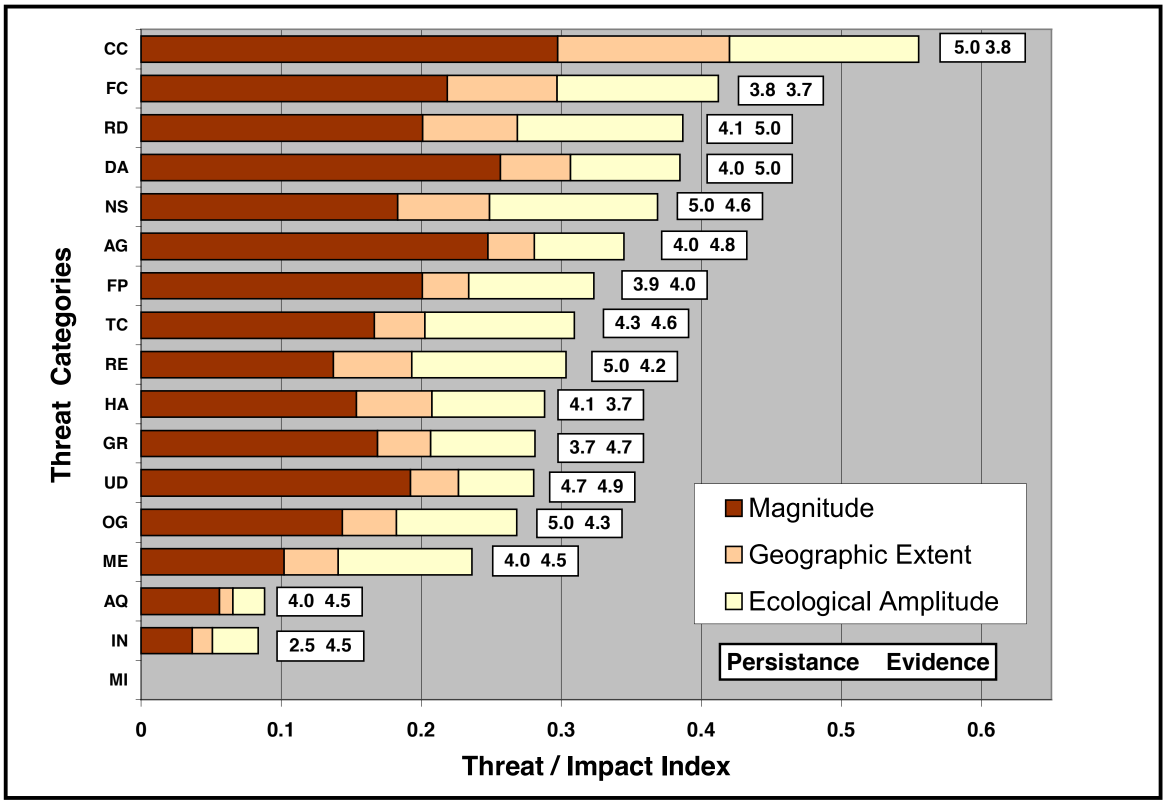

Figure 8. Provincial Freshwater Aquatic Ranked Threat Categories shows Threat Activities rolled up into Threat Category, ranked, and presented as a bar graph. The average Threat Persistence and Threat Evidence is shown for each Threat Category.

Figure 9. The 8 ranked threat activities by Freshwater Aquatic Groupings

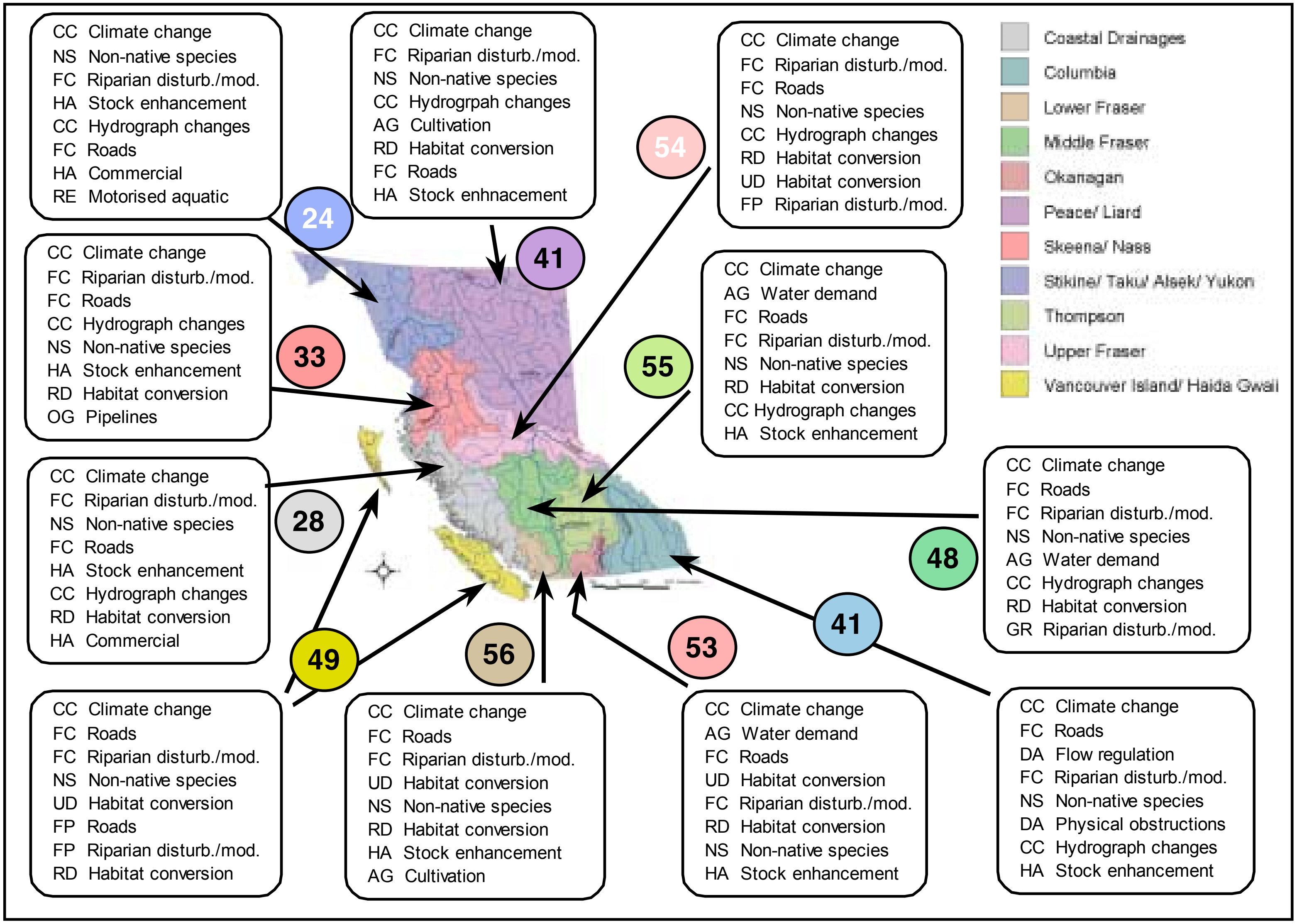

Table 7. Freshwater Aquatic Provincial rankings.

Code	Threat Activity (sorted by magnitude)	Magnitude Index	Extent Index
CC	Climate change	17.64	14.55
AG	Water demand	12.65	2.87
DA	Flow regulation	12.08	5.67
NS	Non-native species	10.44	10.18
RD	water demand	10.00	4.66
DA	Physical obstructions	9.28	5.47
HA	Stock enhancement	8.83	8.20
AG	Cultivation	8.45	6.67
FC	Riparian disturbance/modifn	8.33	11.11
FC	Roads	7.89	13.39
AG	Hydrologic feature modification	7.88	3.85
FP	Riparian disturbance/modin	7.83	6.81
FP	Roads	7.13	8.66
HA	Recreational	6.92	5.50
CC	Hydrograph changes	6.91	8.73
HA	Commercial	6.69	5.77
UD	Habitat conversion	6.54	5.83
UD	Water demand	6.40	3.72
TC	Highways	6.25	9.39
UD	Flood control structures	6.13	4.20
OG	Pipelines	6.08	10.02
TC	Railways	6.00	9.09
DA	Habitat conversion	5.95	7.54
RD	Habitat conversion	5.75	11.65
OG	Exploration activity	5.75	1.16
HA	Illegal	5.56	7.49
GR	Vegetation modification	5.00	3.14
GR	Soil modification	5.00	2.40
OG	Well site activity	4.83	0.84
RE	Motorised aquatic	4.50	10.12
TC	Powerlines	4.32	4.78
ME	Gravel extraction	4.00	2.15
RE	Resort development	3.76	7.19
ME	Roads/trails	3.75	9.65
GR	Riparian/wetland disturbance	3.53	7.97
HA	Aboriginal	3.38	3.65
ME	Discharges	3.00	6.35
AG	Pesticide application	2.71	4.01
AQ	Exotic species use	2.50	1.34
UD	Residential chemical use	2.42	3.53
ME	Water demand	2.25	4.59
UD	Hydrograph changes	2.00	2.58
RE	Motorised terrestrial	1.83	7.57
FC	Silviculture	1.63	10.10
UD	Air pollution	1.50	5.95
FC	Stand structure modification	1.50	5.59
FP	Stand structure modification	1.50	3.40
FC	Fire suppression	1.50	2.51
FC	Ocean/lake log handling	1.50	2.20
AQ	Stock enhancement	1.50	1.98
UD	Discharges to water	1.31	1.57
FC	Landscape level modification	1.25	5.59
TC	Highways – bridges/culverts	1.25	4.99
FP	Landscape level modification	1.25	2.98
UD	Solid waste disposal	1.10	2.12
IN	Water discharge	1.08	2.66
AG	Fertilisation	1.00	1.97
RD	Sewage disposal	0.50	9.52
AG	Manure disposal	0.50	5.01
UD	Sewage disposal	0.50	0.43

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DA	Flow regulation	12.08	5.67
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FC	Landscape level modification	1.25	5.59
HA	Recreational	6.92	5.50
DA	Physical obstructions	9.28	5.47
AG	Manure disposal	0.50	5.01
TC	Highways – bridges/culverts	1.25	4.99
TC	Powerlines	4.32	4.78
RD	water demand	10.00	4.66
ME	Water demand	2.25	4.59
UD	Flood control structures	6.13	4.20
AG	Pesticide application	2.71	4.01
AG	Hydrologic feature modification	7.88	3.85
UD	Water demand	6.40	3.72
HA	Aboriginal	3.38	3.65
UD	Residential chemical use	2.42	3.53
FP	Stand structure modification	1.50	3.40
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FC	Fire suppression	1.50	2.51
GR	Soil modification	5.00	2.40
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UD	Solid waste disposal	1.10	2.12
AQ	Stock enhancement	1.50	1.98
AG	Fertilisation	1.00	1.97
UD	Discharges to water	1.31	1.57
AQ	Exotic species use	2.50	1.34
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HA	Stock enhancement	8.83	8.20
OG	Pipelines	6.08	10.02
FP	Roads	7.13	8.66
TC	Highways	6.25	9.39
CC	Hydrograph changes	6.91	8.73
AG	Water demand	12.65	2.87
AG	Cultivation	8.45	6.67
TC	Railways	6.00	9.09
DA	Physical obstructions	9.28	5.47
RD	water demand	10.00	4.66
FP	Riparian disturbance/modifin	7.83	6.81
RE	Motorised aquatic	4.50	10.12
DA	Habitat conversion	5.95	7.54
ME	Roads/trails	3.75	9.65
HA	Illegal	5.56	7.49
HA	Commercial	6.69	5.77
HA	Recreational	6.92	5.50
UD	Habitat conversion	6.54	5.83
AG	Hydrologic feature modification	7.88	3.85
FC	Silviculture	1.63	10.10
GR	Riparian/wetland disturbance	3.53	7.97
RE	Resort development	3.76	7.19
UD	Flood control structures	6.13	4.20
UD	Water demand	6.40	3.72
RD	Sewage disposal	0.50	9.52
RE	Motorised terrestrial	1.83	7.57
ME	Discharges	3.00	6.35
TC	Powerlines	4.32	4.78
GR	Vegetation modification	5.00	3.14
UD	Air pollution	1.50	5.95
GR	Soil modification	5.00	2.40
FC	Stand structure modification	1.50	5.59
HA	Aboriginal	3.38	3.65
OG	Exploration activity	5.75	1.16
ME	Water demand	2.25	4.59
FC	Landscape level modification	1.25	5.59
AG	Pesticide application	2.71	4.01
TC	Highways – bridges/culverts	1.25	4.99
ME	Gravel extraction	4.00	2.15
UD	Residential chemical use	2.42	3.53
OG	Well site activity	4.83	0.84
AG	Manure disposal	0.50	5.01
FP	Stand structure modification	1.50	3.40
UD	Hydrograph changes	2.00	2.58
FP	Landscape level modification	1.25	2.98
FC	Fire suppression	1.50	2.51
AQ	Exotic species use	2.50	1.34
IN	Water discharge	1.08	2.66
FC	Ocean/lake log handling	1.50	2.20
AQ	Stock enhancement	1.50	1.98
UD	Solid waste disposal	1.10	2.12
AG	Fertilisation	1.00	1.97
UD	Discharges to water	1.31	1.57
UD	Sewage disposal	0.50	0.43

5.4.4. Regional

The Marine Regional Summaries data are shown in Appendix 1 and the top 8 Threat Activities in each Marine Region are shown graphically in Fig. 11 (the numbers in the coloured circles indicate the total number of threat activities recorded for each area).

The Marine data were assessed using seven Marine Geographic Regions. The highest number of Threat Activities occurred in the Georgia Basin (48), followed by the North Island Straits (34), North Coast Fjords (30), Exposed Outer Coasts (27) and Dixon Entrance/Hecate Strait (26). It is not surprising that the Georgia Basin contains the most Threat Activities since it is adjacent to British Columbia's major population centres. The lowest number of threats were identified in the Queen Charlotte Sound (18) and Offshore (8) Regions where there are few human settlements or activities.

The mean magnitude of the top 8 Threat Activities differed among the Marine Groupings: Georgia Basin had the highest value (11.6) followed by the North Island Straits, North Coast Fjords and Exposed Outer Coasts (10.44, 10.35 and 10.10 respectively). The Hecate Strait/Dixon Entrance (9.88), Queen Charlotte Sound (6.93), and Offshore (5.85) regions had the lowest mean magnitude scores.

CC sea level change was the top Threat Activity in four of the seven Marine Geographic Regions, and HA commercial, which was present in all Regions, was the primary threat in the remaining three areas. HA illegal harvesting was ranked second in Offshore waters. NS Non-native species was among the top 8 threats in all Marine Regions.

UD habitat conversion received a high rating in the Georgia Basin, where most of B.C.'s population is concentrated. RD habitat conversion ranked high in the Georgia Basin, North Island Straits and North Coast Fjords. Although generally restricted to settlements such as Campbell River, Port McNeill, Port Hardy, Bella Coola, Rivers Inlet, Port Simpson, and Prince Rupert, RD habitat conversion is a significant threat because settlements tend to occur in sensitive estuaries and sheltered inlets.

5.4.5. Provincial

A summary of the Assessment Tables is shown in Appendix 1. The Provincial Ranked Activities are shown in Table 8, and the Provincial Ranked Threat Categories are shown in Fig. 10.

In total, (15 of 18) Threat Categories and 51 (of 84) Threat Activities occur in the Marine Realm. The mean magnitude of the top 8 Threat Activities is 12.3.

On a provincial scale, 16 Threat Activities occur among the top 8 for magnitude, extent or both, although only RD habitat conversion and NS non-native species were the only two that ranked in the top 8 for all three measures. OG pipelines, and FC ocean/lake log handling had high rankings for extent and combined extent/magnitude.

When Threat Activities were rolled-up into Threat Categories (Fig. 10) Animal Harvest ranked highest for combined magnitude, geographic extent and ecological amplitude. Climate Change had the highest magnitude, and ranked second overall. Non-native Species, Aquaculture and Transportation/ Corridors had the next highest rankings.

The Threat Categories summary is a result of summing the individual impacts of the Threat Activities into their constituent categories, and is not derived through a direct assessment of each Category. As a result, this roll-up may contain discrepancies, particularly for the Evidence and Persistence columns.

5.4.6. Examples of Threat Activity rankings

In the analysis, sea level changes and hydrograph changes were considered the main impacts from Climate Change in the marine realm. While both changes are potentially extensive, their impacts are less clear. In some regions, sea level changes could simply shift the location of organisms to allow them to maintain their established depth or relative intertidal location. However, negative impacts could occur from efforts to counter rising waters using shoreline armoring and seawalls, which would result in habitat loss in the intertidal zone. Other cascading impacts from Climate Change include hydrograph changes resulting from modified precipitation/ melting patterns and subsequent changes in the amount and timing of runoff. The most significant impacts would be on salmon runs that are adapted to require a minimum amount of runoff during a particular window of time in order to return to their native spawning beds. Less obvious impacts include changes in nearshore circulation patterns surrounding estuaries and the possible decline in associated eelgrass beds and salt marshes. These cascading impacts increased the rankings for Climate Change.

OG exploration activity and OG well site activity did not rank high in the assessment scheme used for this project because there is currently very little oil and gas activity in Marine environments. Although the impacts on biodiversity are potentially very high, the recent moratorium on offshore oil and gas development, combined with uncertainty regarding commercial quantities of oil and gas, lowered the rating of these threats in the assessment. Similarly the threat from OG tanker traffic was classed as low since a major spill was only considered a possibility. If the *potential* for impacts were included in the analysis, these Threat Activities would likely rank much higher.

Harvesting of marine fish and invertebrates (HA) rated high in all marine regions. Commercial harvesting was ranked as the greatest threat from marine harvesting at a provincial scale and in all Regions, but aboriginal, recreational and illegal harvesting were significant threats (ranking in the top 12 for combined magnitude and extent). In general, the magnitude of these latter threats is less documented than commercial fishing, but is significant in certain areas. For example, the severe depletion of abalone by the commercial fishery, followed by the continued illegal harvest has driven this species to the status of endangered. Recreational fisheries are also a significant cause of the decline of lingcod and inshore rockfish species in the Georgia Basin and many salmon stocks, already stressed by impacts to their spawning habitat, are further stressed by recreational, aboriginal or illegal harvest even when the commercial fishery is closed. The poor state of Coho stocks in the Georgia Basin region are a prime example: populations in short river systems already stressed by forestry activities and urban and rural development have been driven to near extinction by heavy pressures from recreational fishing. Cumulative impacts such as these are poorly captured in our methodology, although animal harvest was ranked as a significant threat provincially, regionally, and when rolled-up into Threat Categories.

Non-native species spread rapidly through Marine Regions by natural dispersal or transported on the hulls or in ballast water of local boat traffic. Many of the most wide spread non-native species in B.C. marine waters have been intentionally introduced for aquaculture, primarily in the southern half of the province. Before proper importation controls were in place, the widespread introduction of Japanese oysters in B.C. marine waters brought many additional species including manila clams (*Tapes philippinarum*), dwarf eelgrass (*Zostera japonica*), soft shell clam (*Mya arenaria*), Sargassum weed (*Sargassum muticum*), and a number of gastropods (including oyster drills such as *Ocenebra japonica, Nassarius obsoletus, Purpura clavigera, Ceratostoma inornatum, Urosalpinx cinerea, Batillaria cumingi)*. Stricter controls on species introductions have been in place since the 1980s, however B.C. continues to focus on production of non-native species such as Atlantic Salmon, Japanese oysters, Manila clams and east coast or New Zealand mussels. The ramifications of these introductions are only now beginning to be understood but it is clear that relatively few coastal habitats resemble pre-human settlement status and that many introductions are irreversible. NS non-native species ranked high in the Marine realm using all analysis approaches.

Habitat conversion was ranked as the highest settlement-related (UD/RD) threat to marine environments due to activities such as filling of coastal wetlands, armouring of shorelines, and building of docks, seawalls and other alterations that change the nearshore sediment transport regime. Changes to stream hydrographs from pavement, storm sewers, and stream channelization were also highly ranked, but waste discharge (solid waste disposal, sewage disposal and industrial discharges to water) received a lower magnitude score because both Vancouver and Victoria are actively addressing waste issues. In addition, industrial waste emissions are considered to be diminishing with the continued implementation of regulations to reduce the toxicity and volume of discharge into the ocean.

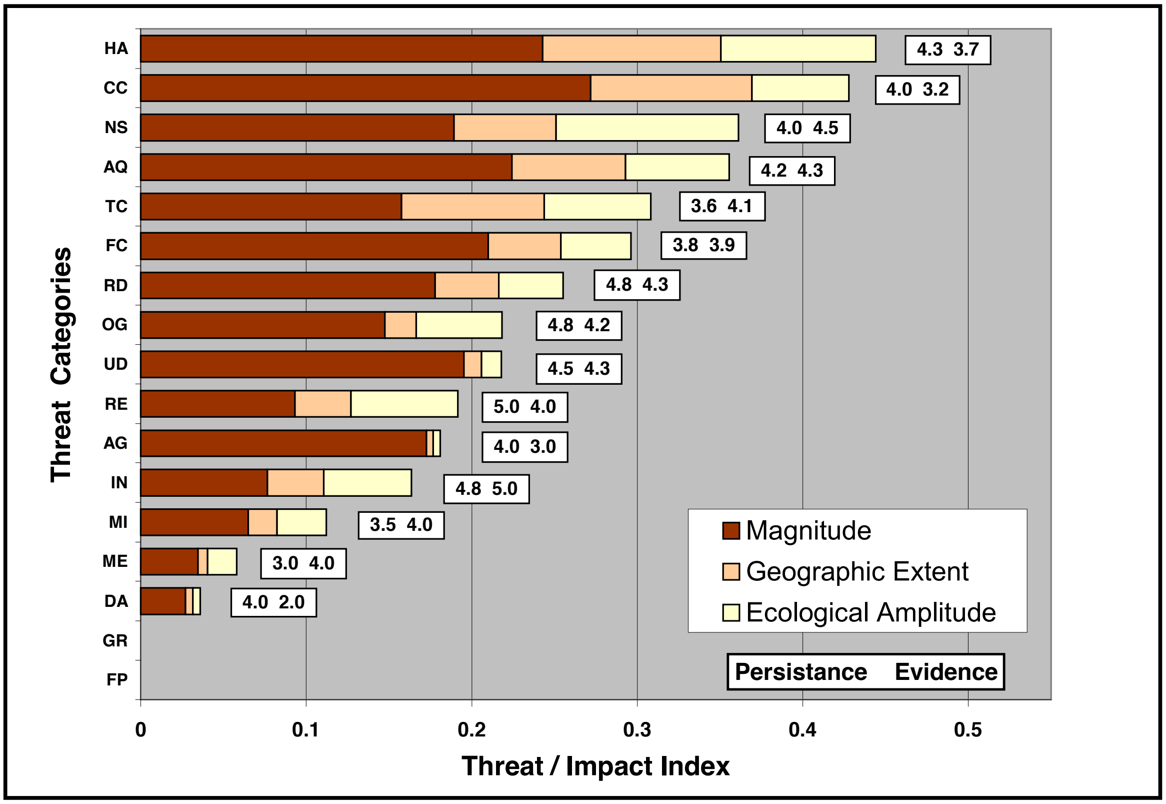

Figure 10 : Provincial Marine Ranked Threat Categories shows Threat Activities rolled up into Threat Category, ranked, and presented as a bar graph. The average Threat Persistence and Threat Evidence is shown for each Threat Category.

Figure 11. The 8 ranked threat activities by Marine Groupings.

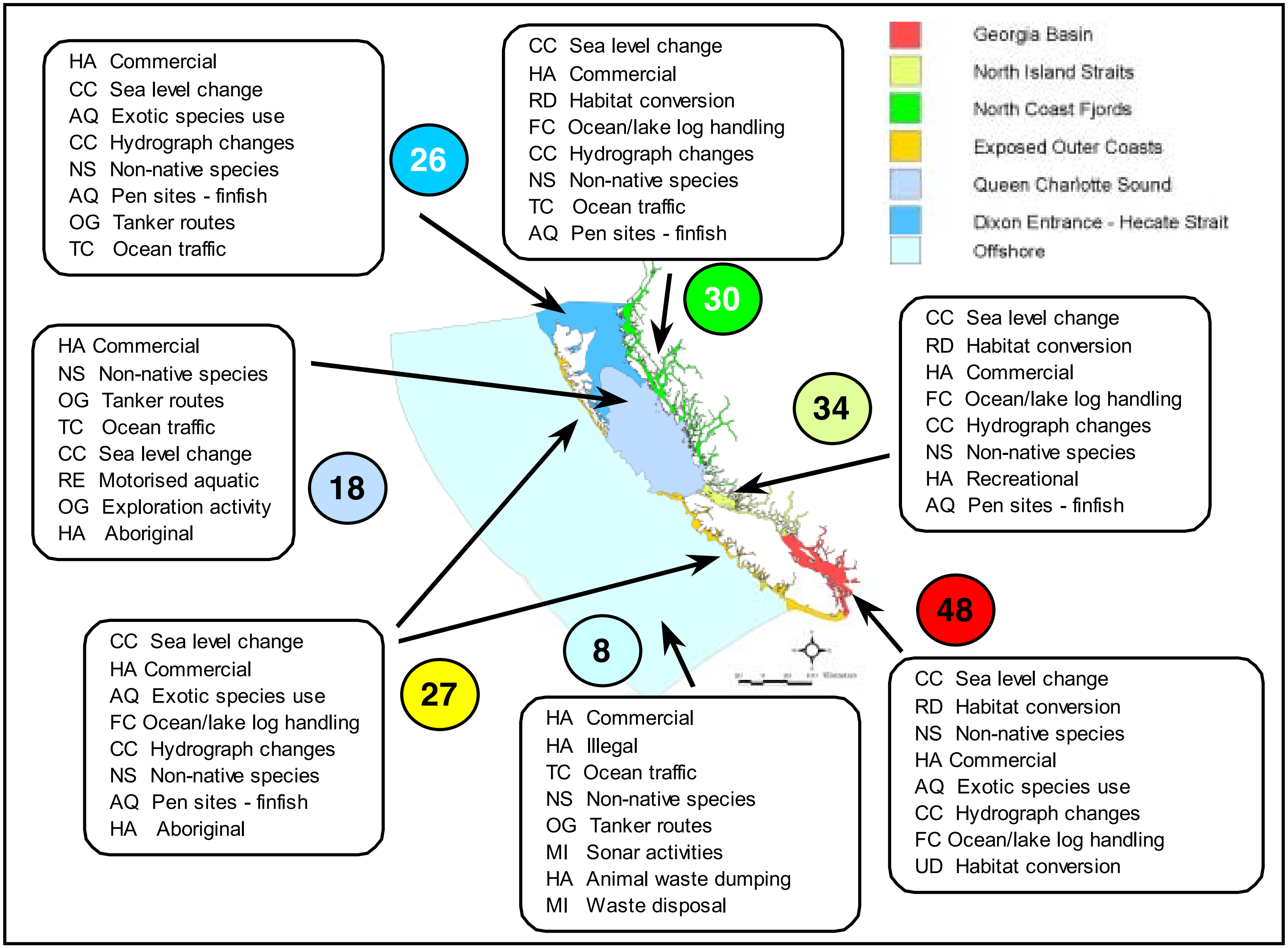

Table 8. Marine Provincial Summary Ratings. Sorted by Magnitude, Extent and 'combined extent and magnitude.

Code	Threat Activity (sorted by magnitude)	Mag-nitude Index	Extent Index
HA	Commercial	13.71	11.95
CC	Sea level change	13.65	8.63
CC	Hydrograph changes	13.40	2.70
FC	Ocean/lake log handling	11.92	5.29
RD	Habitat conversion	11.75	5.29
NS	Non-native species	11.71	9.41
AQ	Pen sites – finfish	11.00	2.01
UD	Habitat conversion	11.00	1.32
HA	Illegal	10.00	8.04
OG	Tanker routes	8.79	5.80
AQ	Exotic species use	8.78	9.38
UD	Hydrograph changes	7.50	0.44
AG	Fertilisation	7.50	0.39
HA	Recreational	6.50	7.75
FC	Riparian disturbance/modification	6.50	4.41
AQ	Bottom culture – shellfish	6.25	3.09
OG	Exploration activity	5.75	0.80
AQ	Waste disposal	5.50	3.43
TC	Ports – ballast dumping	5.50	1.03
UD	Solid waste disposal	5.50	0.78
TC	Marinas	5.42	6.67
RE	Motorised aquatic	5.00	6.76
FC	Landscape level modification	5.00	1.76
HA	Aboriginal	4.67	8.63
IN	Water discharge	4.50	4.66
RD	Sewage disposal	4.50	1.32
AG	Pesticide application	4.50	0.44
HA	Stock enhancement	4.33	2.02
TC	Ocean traffic	4.25	10.88
UD	Sewage disposal	3.67	1.16
AQ	Hanging culture – shellfish	3.50	1.13
TC	Wind/tide generators	3.50	1.08
TC	Aviation	3.25	4.12
OG	Well site activity	3.25	1.74
MI	Sonar activities	3.00	2.02
TC	Ports – harbour/channelisation	2.63	1.37
AQ	Stock enhancement	2.50	2.21
RE	Non-motorised aquatic	2.00	4.08
ME	Discharges	2.00	1.37
UD	Discharges to water	2.00	1.23
TC	Ports – waste disposal	1.67	1.03
TC	Light/buoy maintenance	1.50	4.71
HA	Animal waste dumping	1.50	4.41
RE	Cruise ships	1.50	1.51
OG	Pipelines	1.50	1.18
UD	Disturbance/trampling	1.50	0.88
DA	Flow regulation	1.50	0.44
TC	Powerlines	1.50	0.39
MI	Waste disposal	1.33	2.75
FC	Stand structure modification	1.00	1.72
RD	water demand	1.00	0.78

Code	Threat Activity (sorted by extent)	Mag-nitude Index	Extent Index
HA	Commercial	13.71	11.95
TC	Ocean traffic	4.25	10.88
NS	Non-native species	11.71	9.41
AQ	Exotic species use	8.78	9.38
CC	Sea level change	13.65	8.63
HA	Aboriginal	4.67	8.63
HA	Illegal	10.00	8.04
HA	Recreational	6.50	7.75
RE	Motorised aquatic	5.00	6.76
TC	Marinas	5.42	6.67
OG	Tanker routes	8.79	5.80
FC	Ocean/lake log handling	11.92	5.29
RD	Habitat conversion	11.75	5.29
TC	Light/buoy maintenance	1.50	4.71
IN	Water discharge	4.50	4.66
FC	Riparian disturbance/modification	6.50	4.41
HA	Animal waste dumping	1.50	4.41
TC	Aviation	3.25	4.12
RE	Non-motorised aquatic	2.00	4.08
AQ	Waste disposal	5.50	3.43
AQ	Bottom culture – shellfish	6.25	3.09
MI	Waste disposal	1.33	2.75
CC	Hydrograph changes	13.40	2.70
AQ	Stock enhancement	2.50	2.21
HA	Stock enhancement	4.33	2.02
MI	Sonar activities	3.00	2.02
AQ	Pen sites – finfish	11.00	2.01
FC	Landscape level modification	5.00	1.76
OG	Well site activity	3.25	1.74
FC	Stand structure modification	1.00	1.72
RE	Cruise ships	1.50	1.51
TC	Ports – harbour/channelisation	2.63	1.37
ME	Discharges	2.00	1.37
UD	Habitat conversion	11.00	1.32
RD	Sewage disposal	4.50	1.32
UD	Discharges to water	2.00	1.23
OG	Pipelines	1.50	1.18
UD	Sewage disposal	3.67	1.16
AQ	Hanging culture – shellfish	3.50	1.13
TC	Wind/tide generators	3.50	1.08
TC	Ports – ballast dumping	5.50	1.03
TC	Ports – waste disposal	1.67	1.03
UD	Disturbance/trampling	1.50	0.88
OG	Exploration activity	5.75	0.80
UD	Solid waste disposal	5.50	0.78
RD	water demand	1.00	0.78
UD	Hydrograph changes	7.50	0.44
AG	Pesticide application	4.50	0.44
DA	Flow regulation	1.50	0.44
AG	Fertilisation	7.50	0.39
TC	Powerlines	1.50	0.39

Code	Threat Activity (sorted by extent and magnitude)	Mag-nitude Index	Extent Index
HA	Commercial	13.71	11.95
CC	Sea level change	13.65	8.63
NS	Non-native species	11.71	9.41
AQ	Exotic species use	8.78	9.38
HA	Illegal	10.00	8.04
FC	Ocean/lake log handling	11.92	5.29
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CC	Hydrograph changes	13.40	2.70
TC	Ocean traffic	4.25	10.88
OG	Tanker routes	8.79	5.80
HA	Recreational	6.50	7.75
HA	Aboriginal	4.67	8.63
AQ	Pen sites – finfish	11.00	2.01
UD	Habitat conversion	11.00	1.32
TC	Marinas	5.42	6.67
RE	Motorised aquatic	5.00	6.76
FC	Riparian disturbance/modification	6.50	4.41
AQ	Bottom culture – shellfish	6.25	3.09
IN	Water discharge	4.50	4.66
AQ	Waste disposal	5.50	3.43
UD	Hydrograph changes	7.50	0.44
AG	Fertilisation	7.50	0.39
TC	Aviation	3.25	4.12
FC	Landscape level modification	5.00	1.76
OG	Exploration activity	5.75	0.80
TC	Ports – ballast dumping	5.50	1.03
HA	Stock enhancement	4.33	2.02
UD	Solid waste disposal	5.50	0.78
TC	Light/buoy maintenance	1.50	4.71
RE	Non-motorised aquatic	2.00	4.08
HA	Animal waste dumping	1.50	4.41
RD	Sewage disposal	4.50	1.32
MI	Sonar activities	3.00	2.02
OG	Well site activity	3.25	1.74
AG	Pesticide application	4.50	0.44
UD	Sewage disposal	3.67	1.16
AQ	Stock enhancement	2.50	2.21
AQ	Hanging culture – shellfish	3.50	1.13
TC	Wind/tide generators	3.50	1.08
MI	Waste disposal	1.33	2.75
TC	Ports – harbour/channelisation	2.63	1.37
ME	Discharges	2.00	1.37
UD	Discharges to water	2.00	1.23
RE	Cruise ships	1.50	1.51
FC	Stand structure modification	1.00	1.72
TC	Ports – waste disposal	1.67	1.03
OG	Pipelines	1.50	1.18
UD	Disturbance/trampling	1.50	0.88
DA	Flow regulation	1.50	0.44
TC	Powerlines	1.50	0.39
RD	water demand	1.00	0.78

5.5. Cumulative and Cascading Impacts

The impacts associated with individual activities rarely occur in isolation, and often it is difficult to identify the specific activity that is causing a particular impact. The existence of cumulative and cascading impacts added new challenges to the analysis. Non-native species are a good example of one of the difficulties in assigning the impacts associated with an individual activity. Many impacts are a result of a diverse cross-section of different activities – for example, destruction of grassland / open forest ecosystems results from a combination of fire suppression causing ingrowth, plus invasion of non-native species that arrive through the atmosphere, or on the wheels of vehicles, or via all-terrain vehicles. Over time, grazing pressures may further reduce the native plant community and spread invasive species further. This combination leads to a highly degraded ecosystem. Managing non-native species may then require a focused combination of strategies that address grazing pressures, access issues, forestry stocking standards and fire suppression concurrently.

In the Marine realm, salmon and other anadromous fish are impacted by activities that change their riverine or lacustrine spawning habitat, as well as the water quality or hydrology of their natal streams. Activities such as forestry, agriculture and urban or rural development, as well as dams, log handling, foreshore/backshore habitat alteration, aquaculture (parasite transfer), commercial, recreational, aboriginal and illegal harvesting, and catastrophic oil spills put pressures on salmon throughout all of their lifestages.

Climate change has been identified for a long period of time and in many arenas (e.g. Stein et al. 2000; Harding and McCullum 1994) as a major threat to biodiversity that is likely to exacerbate the impacts of other degrading activities. Changes in climate, precipitation, and stream hydrographs will result in increased stresses in the ecosystem, reducing resilience and increasing the probability of catastrophic change. We did not attempt to incorporate these potential impacts into each threat activity rating, and instead chose to rate climate change itself as having generally high impacts (less so in the marine environment due to the dampening effects of marine water bodies).

A number of threat categories ranked high across all three realms: in particular, Climate Change, Forestry Crown (lower on the marine) and Non-native Species. Interaction zones between the three realms may be key areas where threats should be addressed. For example, estuaries are of particular note because of the many freshwater changes that can occur which can have a knock-on effect on marine aspect of estuaries. HA commercial links the marine and freshwater realms. Although most of the activity and harvest takes place in the marine (and usually is not even under provincial jurisdiction), the implications for freshwater and also terrestrial ecosystems are potentially very high. The movement of salmon biomass through ecosystems is a particular example to note, and loss of individual salmon runs have genetic implications, as well as cascading impacts on the freshwater and the terrestrial environments.

6.0 RESULTS: CONSERVATION INSTRUMENTS

Conservation instruments were divided into two broad categories: regulatory and non-regulatory. The regulatory instruments consisted of federal, provincial and municipal legislation, by-laws and regulations that potentially conserve various aspects of biodiversity by constraining specific threat activities, require mitigation for impacts of certain threat activities, or by directly prohibiting, limiting or requiring restoration of the impacts to particular biodiversity components or processes. Non-regulatory instruments are the collection of other types of programs, projects and activities that attempt to reduce the impact of threat activities by:

- influencing and/or working with perpetrators or implementers of threat activities to modify their actions, and thereby avoid or reduce their impacts on biodiversity,
- ensuring lands important to biodiversity conservation are managed for conservation purposes by directly acquiring private lands, or convincing government to zone and manage key public lands for that purpose,
- implementing stewardship and/or restoration programs and projects,
- carrying out research, inventory or monitoring activities in support of biodiversity conservation,
- providing broad public education on biodiversity conservation issues, or
- providing funding for others to carry out such actions.

6.1. Summary of regulatory instruments

There are numerous federal and provincial legislative and regulatory programs that have biodiversity implications. We have compiled a list of 21 federal and 52 provincial pieces of legislation and sets of regulations (see Tables 9, 10 and 11 left column). In Tables 9, 10 and 11 we have cross-referenced each of those regulatory instruments to our list of threat activities (the first two rows of the tables). Note provincial forestry regulations are pulled out separately to save space in the presentation of the tables.

Tables 9, 10, and 11 show that most threats to biodiversity are addressed by some form of legislation and/or set of regulations. However, we caution that many of the laws have limited applications to biodiversity conservation. For example, there are six federal and five provincial statutes relating to oil and gas exploration; however, there are very few regulations relating to the impact of seismic lines on biodiversity, and those that are available are difficult to enforce. In addition, where there are several legislative instruments for biodiversity (e.g. forestry), there is often considerable disagreement about their effectiveness amongst scientists, regulators, industry and the public. In Section 9 we provide some recommendations for further assessment of the effectiveness of the various conservation instruments.

Table 9. Federal Legislation and programs

Regulatory Instruments	AG	AG	AG	AG	AG	AG	AG	AQ	AQ	AQ	AQ	AQ	AQ	CC	CC	CC	DA	DA	DA	FC	FC	FC	FC	FC	FC	FC	FP	FP	FP	FP
	cultivation	fertilisation	Greenhouses	hydrologic feature modification	manure disposal	pesticide application	water demand	bottom culture - shellfish	exotic species use	hanging culture- shellfish	pen sites - finfish	stock enhancement	waste disposal	climate change	hydrograph changes	sea level changes	flow regulation	habitat conversion	physical obstructions	fire suppression	landscape level modification	ocean/lake log handling	riparian disturbance/ modification	roads	silviculture	stand structure modification	landscape level modification	riparian disturbance/ modification	roads	stand structure modifications
Federal																														
Canada Marine Act																														
Canada Nat'l Marine Cons. Areas Act																														
Canada Nat'l Parks Act																				X										
Canada Oil & Gas Operations Act																														
Canada Petroleum Resources Act																														
Canada Shipping Act																														
Canada Transportation Act																														
Canada Water Act							X																							
Canada Wildlife Act																														
CEAA	X							X	X	X	X		X	X	X	X	X	X	X		X	X	X	X						
CEPA																														
Fisheries Act		X				X	X	X	X	X	X	X	X				X	X	X			X	X	X				X	X	
Forestry Act																														
Indian Act																											X			X
Migratory Bird Convention Act																														
Nat'l Energy Board Act																														
Navigable Waters Protection Act																														
Oceans Act																X														
Oil & Gas Pipelines Act																														
Pest Products Control Act		X				X		X		X	X														X	X				X
Species at Risk Act																		X			X		X			X	X	X		X

	GR	GR	GR	HA	HA	HA	HA	HA	HA	IN	IN	ME	ME	ME	ME	ME	MI	MI	NS	OG	OG	OG	OG	RD	RD	RD	RE	RE	RE	RE	RE	RE
Regulatory Instruments	riparian/wetland disturbance	soil modification	vegetation modification	aboriginal	animal waste dumping	commercial	illegal	recreational	stock enhancement	air emissions	water discharge	discharges	gravel extraction	mine site	roads/trails	water demand	sonar activities	waste disposal	non-native species	exploration activity	pipelines	tanker routes	well site activity	habitat conversion	sewage disposal	water demand	cruise ships	motorised terrestrial	motorised aquatic	non-motorised aquatic	non-motorised terrestrial	resort development
Federal																																
Canada Marine Act																																
Canada Nat'l Marine Cons. Areas Act				X		X	X	X																								
Canada Nat'l Parks Act				X			X	X																					X			X
Canada Oil & Gas Operations Act											X									X	X	X	X									
Canada Petroleum Resources Act																				X			X									
Canada Shipping Act										X	X																X		X			
Canada Transportation Act																																
Canada Water Act											X					X										X						
Canada Wildlife Act				X			X	X																								
CEAA				X		X		X	X	X	X	X		X	X	X		X	X	X	X	X	X				X	X	X			X
CEPA					X					X	X	X						X														
Fisheries Act	X			X	X	X	X	X	X		X	X	X		X	X									X	X	X		X			X
Forestry Act																																
Indian Act				X								X	X							X			X		X							X
Migratory Bird Convention Act				X		X	X	X											X													
Nat'l Energy Board Act																				X	X	X	X									
Navigable Waters Protection Act																													X			
Oceans Act																																
Oil & Gas Pipelines Act																				X			X									
Pest Products Control Act																																X
Species at Risk Act	X			X		X	X	X	X															X								

	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD
Regulatory Instruments	aviation	highways	highways - bridges/culverts	light/buoy maintenance	marinas	ocean traffic	ports - ballast dumping	ports - harbour/ channelisation	ports - waste disposal	powerlines	railways	wind/tide generators	air pollution	discharges to water	disturbance / trampling	flood control structures	habitat conversion	hydrograph changes	residential chemical use	sewage disposal	solid waste disposal	water demand
Federal																						
Canada Marine Act								X														
Canada Nat'l Marine Cons. Areas Act																						
Canada Nat'l Parks Act	X	X	X																			
Canada Oil & Gas Operations Act																						
Canada Petroleum Resources Act																						
Canada Shipping Act				X		X																
Canada Transportation Act	X										X											
Canada Water Act											X											
Canada Wildlife Act																						
CEAA	X	X	X		X	X		X	X	X	X											
CEPA									X				X							X	X	
Fisheries Act			X			X		X	X							X			X	X		
Forestry Act																						
Indian Act																				X	X	
Migratory Bird Convention Act																						
Nat'l Energy Board Act										X												
Navigable Waters Protection Act																						
Oceans Act																						
Oil & Gas Pipelines Act																						
Pest Products Control Act		X								X	X											
Species at Risk Act																	X					

Table 10. Provincial legislation and programs.(continued on next three pages)

	AG	AG	AG	AG	AG	AG	AG	AQ	AQ	AQ	AQ	AQ	AQ	CC	CC	CC	DA	DA	DA	FC	FC	FC	FC	FC	FC	FC	FP	FP	FP	FP
Regulatory Instruments	cultivation	fertilisation	greenhouses	hydrologic feature modification	manure disposal	pesticide application	water demand	bottom culture - shellfish	exotic species use	hanging culture- shellfish	pen sites - finfish	stock enhancement	waste disposal	climate change	hydrograph changes	sea level changes	flow regulation	habitat conversion	physical obstructions	fire suppression	landscape level modification	ocean/lake log handling	riparian disturbance/ modification	roads	silviculture	stand structure modification	landscape level modification	riparian disturbance/ modification	roads	stand structure modifications
Provincial																														
Health Act					X																									
Highway Act																														
Highway (Industrial) Act																														
Local Government Act																														
Mineral Tenure Act																														
Mines Act																														
Oil & Gas Commission Act																														
Park Act																														
Petroleum & Natural Gas Act																														
Pesticide Control Act		X	X			X					X														X	X				X
Pipeline Act																														
Railway Act																														
Range Act																							X							
Riverbank Protection Act				X																										
Utilities Commission Act																	X													
Waste Management Act					X																									
Water Act							X										X	X	X											
Wildlife Act																										X				
Agriculture Land Commission Act	X		X																								X			
Dike Maintenance Act	X			X																										
Ecological Reserves Act																														
Environment Management Act				X	X	X	X	X	X	X	X		X	X	X	X	X	X	X											
Environmental Assessment																	X	X	X											
Farm Practices Protection Act	X	X	X	X	X	X	X																							
Fisheries Act								X	X	X	X	X	X																	
Fish Protection Act				X			X										X	X	X											

	GR	GR	GR	HA	HA	HA	HA	HA	HA	IN	IN	ME	ME	ME	ME	ME	MI	MI	NS	OG	OG	OG	OG	RD	RD	RD	RE	RE	RE	RE	RE	RE
Regulatory Instruments	riparian/wetland disturbance	soil modification	vegetation modification	aboriginal	animal waste dumping	commercial	illegal	recreational	stock enhancement	air emissions	water discharge	discharges	gravel extraction	mine site	roads/trails	water demand	sonar activities	waste disposal	non-native species	exploration activity	pipelines	tanker routes	well site activity	habitat conversion	sewage disposal	water demand	cruise ships	motorised terrestrial	motorised aquatic	non-motorised aquatic	non-motorised terrestrial	resort development
Provincial																																
Health Act					X						X														X							
Highway Act																																
Highway (Industrial) Act																																
Local Government Act																								X								X
Mineral Tenure Act												X	X	X	X																	
Mines Act										X	X	X		X	X	X																
Oil & Gas Commission Act										X	X									X	X		X	X								
Park Act				X	X	X	X	X																				X	X		X	
Petroleum & Natural Gas Act																				X	X		X									
Pesticide Control Act																																X
Pipeline Act																					X											
Railway Act																																
Range Act	X	X	X																X													
Riverbank Protection Act																																
Utilities Commission Act																					X											
Waste Management Act					X					X	X	X											X		X							
Water Act																X										X						
Wildlife Act				X	X	X	X	X	X										X													
Agriculture Land Commission Act																				X			X	X								X
Dike Maintenance Act																								X								
Ecological Reserves Act	X	X	X	X	X	X	X	X							X				X	X								X	X		X	
Environment Management Act				X	X	X	X	X	X	X	X	X				X				X	X	X	X	X	X	X						
Environmental Assessment										X	X	X	X	X	X	X			X		X				X	X						X
Farm Practices Protection Act																																
Fisheries Act					X	X	X		X																							
Fish Protection Act																										X						

	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD
Regulatory Instruments	aviation	highways	highways - bridges/culverts	light/buoy maintenance	marinas	ocean traffic	ports - ballast dumping	ports - harbour/ channelisation	ports - waste disposal	powerlines	railways	wind/tide generators	air pollution	discharges to water	disturbance / trampling	flood control structures	habitat conversion	hydrograph changes	residential chemical use	sewage disposal	solid waste disposal	water demand
Provincial																						
Health Act																						X
Highway Act		X	X																			
Highway (Industrial) Act		X	X																			
Local Government Act													X			X	X		X		X	X
Mineral Tenure Act																						
Mines Act																						
Oil & Gas Commission Act																						
Park Act																						
Petroleum & Natural Gas Act		X																				
Pesticide Control Act		X																	X			
Pipeline Act																						
Railway Act											X											
Range Act																						
Riverbank Protection Act																X						
Utilities Commission Act										X												
Waste Management Act									X				X						X	X	X	
Water Act												X				X						X
Wildlife Act																						
Agriculture Land Commission Act																						
Dike Maintenance Act																X						
Ecological Reserves Act																						
Environment Management Act					X			X	X				X			X	X		X	X	X	X
Environmental Assessment										X		X	X			X				X	X	
Farm Practices Protection Act																						
Fisheries Act																						
Fish Protection Act																						X

Table 11. Provincial forestry related legislation.

	FC	FC	FC	FC	FC	FC	FC	FP	FP	FP	FP
Provincial Forestry Programs	fire control	landscape level modificn	ocean log handling	riparian disturbance/	Roads	stand structure modificn	silviculture	landscape level modifications	riparian disturbance/	roads	stand structure modificn
Forest Act		X	X		X						
Cut Control Regulation		X									
Designated Areas Under Section 169 of the Act- Notice		X									
Innovative Forest Practices Regulation		X		X	X	X	X				
Log Salvage Regulation for the Vancouver Log Salvage District			X								
Forest Land Reserve Act		X									
Forest Land Reserve Procedure Regulation		X						X			
Forest Land Reserve Use Regulation		X						X			
Private Land Forest Practices Regulation								X	X	X	X
FPC Act		X		X		X	X			X	
Bark Beetle Regulation		X				X					
Community Forest Regulation		X		X				X			
Forest Fire Prevention and Suppression Regulation	X	X									
Forest Road Regulation		X			X						

	FC	FC	FC	FC	FC	FC	FC	FP	FP	FP	FP
Provincial Forestry Programs	fire control	landscape level modifications	ocean log handling	riparian disturbance/ modification	roads	stand structure modifications	silviculture	landscape level modifications	riparian disturbance/ modification	roads	stand structure modifications
Forest Service Road Use Regulation					X						
Health, Safety and Reclamation Code for Mines (Part 11) Exemption Regulation					X						
Operational Planning Regulation		X		X	X	X	X				
Provincial Forest Use Regulation		X						X			
Range Practices Regulation				X							
Silvculture Practices Regulation				X		X	X				
Strategic Planning Regulation		X									
Timber Harvesting Practices Regulation				X	X	X					
Tree Cone, Seed and Vegetative Material Regulation						X	X				
Woodlot Licence Regulation		X		X		X	X				
Forest Stand Management Fund Act						X	X				

6.2. Summary of non-legislative instruments

We developed eight categories of non-legislative instruments, subdivided by their focus or jurisdiction. These are land acquisition, environmental education, environmental advocacy, biodiversity funding, municipal/ regional districts environmental programs, inventory, monitoring and research, restoration/ stewardship and voluntary 3rd party certification programs (see left column of Table 12). We then cross-referenced these categories with the threat activities, and provided an initial assessment of the degree to which each threat activity is addressed by the non-regulatory instruments (see Table 12). Threat activities with a bold '**X**' are addressed by significant programs or projects, while those with a plain text 'x' have limited programs or projects, and those with a '?' may have some programs or projects, but we are unsure. The categories of non-regulatory instruments are described below.

Land Acquisition – Municipalities and Regional Districts

Regional District and municipal land acquisition programs focus on parks and recreation activities and are spread throughout the province. Harper (2002) lists regional districts from the Peace River to Comox-Strathcona Central Kootenay, and the Capital Regional District. Individual cities like Prince George, Coquitlam and Grand Forks also have land acquisition programs. The primary threats addressed by these initiative are rural/urban development and tourism, although it is not clear whether the programs are working to increase tourism or see it as a threat to biodiversity. Parks programs that promote recreation (e.g. picnic areas, playgrounds, and sports fields) likely increase the risk to biodiversity.

Land Acquisition – NGO Land Trusts

Several non-governmental land acquisition groups exist within British Columbia, including organisations such as The Land Conservancy, Turtle Island Earth Stewards, and the Saltspring Island Conservancy.

Their goals are generally to reduce habitat conversion in urban and rural areas, or to protect forested areas. Most groups focus on the Lower Mainland, southern Vancouver Island and the Gulf Islands, although they are active throughout the province. Some groups offer tax deductions and other incentives to private landowners as a means of increasing the amount of area protected under land covenants. Land Trusts address biodiversity in select areas, but are often limited by interest from private landowners, availability of high priority biodiversity areas for purchase, and crown owned properties.

Environmental Education – NGOs

There is considerable overlap between groups doing education and advocacy. Groups that are working on biodiversity education generally focus on a range of activities including forestry, streams and rivers, fish and wildlife, and local issues. Groups listed in Harper (2002) range from the Georgia Straight Alliance to the East Kootenay Environmental Society, but almost half of the groups listed are located in the Lower Mainland (area code = 604).

Environmental Advocacy – NGOs

Many of the groups cited by Harper (2002) advocate for wilderness preservation and increased parks. Groups include Greenpeace, Western Canada Wilderness Committee, David Suzuki Foundation, and the BC Endangered Species Coalition, but smaller organisations (not listed in Harper 2002) are active at a local level. Advocacy for crown forestry issues is very well addressed within most of British Columbia, but conservation of biodiversity is not maintained through advocacy and these groups are only successful when they sway government or industry decisions.

Table 12. Non-legislative programs by Threat Activity.

(contd on next 4 pages)

	AG	AG	AG	AG	AG	AG	AG	AQ	AQ	AQ	AQ	AQ	AQ	CC	CC	CC	DA	DA	DA
PROGRAM	cultivation	fertilisation	greenhouses	hydrologic feature modification	manure disposal	pesticide application	water demand	bottom culture - shellfish	exotic species use	hanging culture- shellfish	pen sites - finfish	stock enhancement	waste disposal	climate change	hydrograph changes	sea level changes	flow regulation	habitat conversion	physical obstructions
Land Acquisition																			
Municipal/ Regional Districts	x																		
Land Trust NGOs	x																		
Environmental Education																			
NGOs			x			X			x		x	x	x	x	x	x			
Environmental Advocacy																			
NGOs						x			x		x	x	x	x					
Biodiversity Funding																			
NGOs/Business						x													
Environment Programs																			
Municipal/Regional District					?	?	?						?						
Inventory, Monitoring and Research																			
Government																	x	x	x
NGO/Business																	x	x	x
Restoration/ Stewardship																			
Stewardship Groups				x														x	
Voluntary 3rd Party Certification																			
NGO/ Business	x	X	x		x	X	x												

X = significant programs or projects; x = limited programs or projects; ? = unsure, possible programs or projects.

	FC	FC	FC	FC	FC	FC	FC	FP	FP	FP	FP	GR	GR	GR	HA	HA	HA	HA	HA	HA
PROGRAM	fire suppression	landscape level modification	ocean/lake log handling	riparian disturbance/ modification	roads	silviculture	stand structure modification	landscape level modification	riparian disturbance/ modification	roads	stand structure modification	riparian/wetland disturbance	soil modification	vegetation modification	aboriginal	animal waste dumping	commercial	illegal	recreational	stock enhancement
Land Acquisition																				
Municipal/ Regional Districts																				
Land Trust NGOs								x	x	x	x			?						
Environmental Education																				
NGOs	x	**X**	x	**X**	**X**	**X**	**X**	x	x	x	x						x	x		
Environmental Advocacy																				
NGOs		**X**		**X**	x	x	x										x	x		x
Biodiversity Funding																				
NGOs/Business	x	x		x	x	x	x													
Environment Programs																				
Municipal/Regional District																				
Inventory, Monitoring and Research																				
Government	x			x		x	x													
NGO/Business	x	x		x	x	x	x	x	x	x	x									
Restoration/ Stewardship																				
Stewardship Groups				x					x			?	?	?						x
Voluntary 3rd Party Certification																				
NGO/ Business	x	x	x	x	x	x	x	x	x	x	x									

X = significant programs or projects; x = limited programs or projects; ? = unsure, possible programs or projects.

	IN	IN	ME	ME	ME	ME	ME	MI	MI	NS	OG	OG	OG	OG	RD	RD	RD	RE	RE	RE	RE	RE	RE
PROGRAM	air emissions	water discharge	discharges	gravel extraction	mine site	roads/trails	water demand	sonar activities	waste disposal	non-native species	exploration activity	pipelines	tanker routes	well site activity	habitat conversion	sewage disposal	water demand	cruise ships	motorised terrestrial	motorised aquatic	non-motorised aquatic	non-motorised terrestrial	resort development
Land Acquisition																							
Municipal/ Regional Districts															**X**								
Land Trust NGOs															**X**								
Environmental Education																							
NGOs	x	x								x					**X**								
Environmental Advocacy																							
NGOs	x	x													x	x	x		x	x			x
Biodiversity Funding																							
NGOs/Business										x					x								
Environment Programs																							
Municipal/Regional District	?	?					?		?	x					x	x	x		?	?		?	x
Inventory, Monitoring and Research Government																							
NGO/Business	?	?		?	?	?																	?
Restoration/ Stewardship																							
Stewardship Groups										**X**					**X**								
Voluntary 3rd Party Certification																							
NGO/ Business	x	x								?													

X = significant programs or projects; x = limited programs or projects; ? = unsure, possible programs or projects.

	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	TC	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD
PROGRAM	aviation	highways	highways - bridges/culverts	light/buoy maintenance	marinas	ocean traffic	ports - ballast dumping	ports - harbour/ channelisation	ports - waste disposal	powerlines	railways	wind/tide generators	air pollution	discharges to water	disturbance / trampling	flood control structures	habitat conversion	hydrograph changes	residential chemical use	sewage disposal	solid waste disposal	water demand
Land Acquisition																						
Municipal/ Regional Districts																	**X**					
Land Trust NGOs																	**X**					
Environmental Education																						
NGOs													x				x		x		x	x
Environmental Advocacy																						
NGOs									x	x	x		x				x		x	x	x	
Biodiversity Funding																						
NGOs/Business													x				x		x	x	x	
Environment Programs																						
Municipal/Regional District													x			x	x		x	x	x	x
Inventory, Monitoring and Research																						
Government										x												
NGO/Business											x											
Restoration/ Stewardship																						
Stewardship Groups																	**X**					
Voluntary 3rd Party Certification																						
NGO/ Business																						

X = significant programs or projects; x = limited programs or projects; ? = unsure, possible programs or projects.

Biodiversity Funding

Foundations, businesses, and NGOs all provide funding for biodiversity projects at multiple scales, as well as land acquisition. The focus of these funding sources varies from sustainable urban development, to transportation, forestry, research and restoration. Groups include WWF, foundations such as the Vancouver and Bullitt Foundations, and businesses including Mountain Equipment Co-op, Canada Trust, and VanCity Credit Union (not listed in Harper 2002). In many ways, funding sources mirror Education, Advocacy and Restoration activities identified by Stewardship and Environmental Groups, although each funding source generally identifies particular interests.

Municipal / Regional District Environmental Programs

Many government Policy and Planning initiatives are listed in Harper (2002), but most references relate to Official Community Plans (OCPs), which generally include environmental protection as an issue. Although identified as an issue, the actual role of OCPs in conserving biodiversity is not clear. For example, the Nelson Environmentally Sensitive Areas Program is listed in the database with the following mandate: “Natural attributes will be protected by ensuring all development proposals within these (Sensitive) areas will be subject to a review of their environmental impacts.” In reality, these reviews appear to have provided little or no significant contribution to biodiversity conservation since the requirements for reviews don't specifically define biodiversity as one of the environmental impacts to consider (D. Macdonald, Nelson City Councillor, pers. comm.). Programs like this use a reactionary response to developments rather than a proactive attempt to identify and protect biodiversity. Other municipal projects include programs such as noxious weed control, sewage and water use, agricultural practices, and pollution (in larger centres).

Environment programs developed by regional districts include programs like the Capital Regional District Roundtable on the Environment, River of Golden Dreams Watershed Management Plan and other processes that develop ‘visions’ for sustainability that are not necessarily enforceable.

Inventory, Monitoring and Research – Government

We have only included activities relating to specific, multi-stakeholder government led initiatives like the provincial Wildlife Tree Program, Coastal Information Team (Ecosystem Based Management on Coastal BC), Columbia Basin and Peace-Williston Fish and Wildlife Compensation Programs (which apply to business as well), and the EMBERS program (restoration using prescribed fire in the Rocky MountainTrench). Harper (2002) does not list very many of these programs and, from the database, it is not easy to identify which are applied and which are mere policy ‘directions’ or ‘visions’. Parks research and some programs from the MoF Research Branch could also apply. Funding for these projects is linked to legislative and regulatory initiatives.

Inventory, Monitoring and NGO/Business

Programs in this category include NGO’s and corporate research programs designed explicitly to develop management activities that enhance biodiversity. In filling in the table, we have only included research activities with an explicit conservation and *management* agenda. Forrex, the Eastslope Grizzly Project, and the Pacific Seabird Group are the only NGOs with applied research that are listed in Harper (2002). Eight forest companies are listed in Harper (2002) as having ‘Habitat Conservation Programs’. These companies (and others) spend some of their own funds on biodiversity related research and often partner with Ministry of Forests or Water, Air and Land Protection for research initiatives. The Canadian Pacific Railway company is also listed in Harper (2002) for its terrestrial and aquatic wildlife protection programs and BC Rail has a vegetation (pest) management program. Agriculture, aquaculture, and recreation research are not listed in Harper (2002), but some applied research is conducted.

Restoration/ Stewardship – Stewardship Groups

Stewardship groups include local or regional organisations that are run by volunteers who partake in hands-on activities, but may also participate in ongoing planning and management of an area. Groups cited in Harper (2002) include the Powell River Salmon Society and the Osoyoos Desert Society, but could also include local Rod and Gun Clubs, school groups, and Naturalist clubs. Harper (2002) includes stewardship groups under ‘Conservation Activities’, but we have separated them out to acknowledge their hands-on focus. Most stewardship groups are in urban or semi-urban areas (cities/large towns) and focus on stream restoration or invasive species eradication and control (e.g. purple loosestrife). The stewardship groups listed in Harper are concentrated in the Lower Mainland and Vancouver Island, although groups are listed in the Okanagan and Quesnel. Harper's (2002) list is very short relative to the groups that are known to be active.

The federal and provincial governments have produced a series of Stewardship Guidebooks for local governments, developers, school groups, communities and the farming sector. The agriculture guidebook was produced in conjunction with the BC Cattlemen's Association and provides information on fish and wildlife habitat needs as well as stewardship activities. It is intended for individual farmers rather than Stewardship Groups. Other guides provide useful background information on planning and hands-on activities for individual landowners or volunteer led groups.

Voluntary 3rd Party Certification

Certification programs are well established within the agriculture sector for organic foods and, although not listed in Harper (2002), are included in the table. We also identify several forest certification schemes including FSC, CSA, ISO, and SFI, as well as ISO certification schemes for industrial air and water emissions.

7.0 IMPACTS AND GAPS FOR A CROSS SECTION OF EXAMPLE THREATS

Given the extremely broad scope of this project, it was determined appropriate to provide a discussion on only an example set of threat categories/ activities. We chose five subject areas that are intended to span the breadth of potential areas for discussion. The five chosen are NOT intended to be 'highest ranked' or 'most important' – simply a range of those possible across the three realms.

The intention of these summary pieces is to provide an option for MWLAP of the kind of summarising that would be possible for all threats and threat activities. Given the extremely broad task of identifying the effectiveness of all regulations and programs aimed at a particular threat activity (see Section 6.0 and Discussion), these more detailed discussions were intended to provide one approach to addressing threat activities of particular concern to MWLAP by identifying their key impacts, and using a results-based framework, identifying the key factors that would need to change in order to address those impacts.

The five titles are :

- A Cross-Cutting Threat – the Demand for Freshwater
- Commercial Fishing in BC
- Forestry on Crown Land: Stand Structure Management
- Terrestrial Oil and Gas Development
- Aquaculture – Intertidal bottom culture of Manila Clams

For each area, we give a Threat and Impact Description, discuss the current approach to protection or mitigation, and then identify the key impact / threat issues that require resolution if the impacts on biodiversity are to be reduced.

Section 7A. A Cross-cutting Threat – The Demand for Freshwater

Threat Description and Interactions

Demand for freshwater originates from many human activities, including widespread uses such as agricultural irrigation (AG-water demand) and domestic human consumption in both urban centres (UD-water demand) and in larger rural concentrations (RD-water demand). There are also more localised industrial activities such as mining (ME-water demand, e.g., the Highland Valley Mine) and off-site hydroelectric installations (DA-flow regulation, particularly the Nechako River). The water removed may end up evaporated (via irrigation), pirated to another drainage (due to intentional inter-drainage transfer), or directly consumed.

Reductions in streamflow due to water removals have existed for decades however the last ten to twenty years have seen an increase in removals to the point that ecosystem functions are no longer served adequately in some parts of the province. The problem has become a leading threat to biodiversity in semi-arid areas with either high human populations or intensive irrigated agriculture, or both. These conditions exist in an extensive way in the Okanagan, the Thompson, and the East Coast of Vancouver Island.

In many areas, there is not only reduced total basin water output, but also additional changes to the hydrograph (i.e. seasonal flow patterns) caused by land-use induced modifications in watershed hydrology. These changes act as a secondary stressor, exacerbating the primary problem of total water loss. Reduced low flows are generally the greatest concern, though other issues such as earlier peak flows can also be problematic. Additional threat activities which can significantly modify hydrograph shape include forestry (FC/FP-landscape-level modification – increased ECA; FC/FP-roads – runoff patterns), dams for hydro-electric power, water consumption and flood control (DA-flow regulation), climate change (CC-hydrograph changes), urban development (UD – hydrograph changes) and any other threats that significantly increase road density. Other threats which can also have significant effects on flow regimes are those associated with loss or modification of wetlands- examples include AG-cultivation, UD-conversion, RD-conversion, GR-soil modification and GR-vegetation modification. Other threats with more indirect but also, sometimes, significant impacts include TC-railways, TC-highways, and OG-pipelines. High groundwater withdrawals (for irrigation and human consumption) can cause reduced seepage resulting in a potential further loss of wetlands and changes to streamflow and lake levels.

Water loss and reduced stream flows also mean a diminished potential for dilution of any materials discharged in river systems (e.g. ME-discharges, UD discharges to water, UD-sewage disposal) or other change in water quality. The problem can be acute in those instances where water loss and increased contamination act synergistically to reduce water quality. A similar phenomenon occurs where both reduced water flows and a loss of shade interact to increase water temperatures. Extensive removal of riparian vegetation can increase stream temperatures in some systems. The key activities that affect riparian vegetation extensively in the province are FC/FP - riparian disturbance/modification and GR – riparian disturbance/modification. Where many of these factors occur simultaneously, increased stream temperatures may result. A good example is the many fisheries streams in the Thompson-Okanagan area (see Nicola River case study). In addition, groundwater can be an important factor in regulating stream temperatures – a reduction in groundwater could theoretically lead to higher stream temperatures. Obstructions by dams are an additional concern in some situations.

Climate change (CC-climate change) is a key future concern, as it may create new semi-arid conditions in areas formerly more humid. This would directly reduce total water available. Where streams are already fully allocated (or over-allocated), a loss in overall water availability will have ever-increasing impacts on ecosystem functions as water users struggle to meet their needs. In the Okanagan and Thompson areas where water loss is already a problem, climate change may make the situation even more severe. Depending on the particular changes in climate that occur, water loss could also become a problem in parts of the Columbia, Mid-Fraser, Upper Fraser, and potentially other areas.

Substantial water loss is also often associated with small and medium dams. Dams create other challenges to aquatic ecosystems (DA-obstructions and DA-habitat conversion) and these concerns are often in place as an attendant impact associated with the water loss. Unfortunately, it is difficult to describe the magnitude of this problem provincially due to the lack of an accessible database on smaller water-supply and flood-control dams. Anecdotally, specialists in the Okanagan and Thompson areas stress that these are extensive and are one of the major issues facing aquatic systems in these locations. The BC Outdoor Recreation Council did a survey of dams in need of decommissioning (Scott and Smith 2001). This study highlights the potential magnitude of the problem of small and medium dams in British Columbia. They reviewed the 2500 small and medium dam structures in BC officially known to provincial agencies and found a high degree of redundancy, obsolescence, and marginal benefits. In addition, they noted estimates from random surveys that the number of smaller diversion or impoundment structures not officially classified as dams may equal or exceed the total number of licensed dams. They recommended dozens of specific dams for modification or decommissioning.

Impact Description

Although aquatic systems possess resiliency to changes in flow regimes, when water removal becomes severe, declines in ecosystem viability can result due to the lack of channel maintaining flows, the lack of fish passage, and the degradation or loss of stream and riparian habitats.

Channel-Maintaining Flows

In cases of severe water loss, there may be insufficient water to maintain channel-forming processes. The magnitude and variation of annual peak flow and other flushing flows are essential characteristics of the annual flow regime for maintaining overall stream channel structure. For example, the movement and redistribution of gravel is important in many British Columbian streams for bar formation and the maintenance of channel habitat elements such as pools.

Fish Passage and Fish Habitat

Reductions in water flow can lead to a direct loss of fish passage, particularly if the reductions are during the low flow period. Habitat-quality declines are also to be expected as water yield declines well below the natural range of variability. The loss of channel-structure maintenance (see above) generally also represents a decline in the quality of fish habitat, especially spawning areas, due to the decline in reworking of gravels and steady loss of gravel entrainment. High temperatures can result in certain environments when water loss is severe (see Nicola River case study). Potential reductions in the viability of benthic populations can add to the decline in the quality of the stream as fish habitat.

Loss of Amphibian Habitat

Amphibian habitat can also be impaired due to excessive water demands. High extraction rates from aquifers can lead to a decline in the output of springs and the desiccation of amphibian habitat. Severe reductions in peak flows can impair the formation of back and side channels and reduce overbank flows which maintain floodplains. These changes all have the ability to degrade amphibian habitat.

Loss of Riparian Habitats

Riparian condition may decline on flood plains and along the margins of streams where water loss is severe. Conversion to drier species or later successional species can result in changes to riparian habitat, which may affect birds, amphibians, and some mammals.

Impacts in Other Realms

Although overwhelmingly a concern for freshwater aquatic ecosystems, there are impacts which directly and indirectly involve marine and terrestrial ecosystems.

Marine. Where water withdrawal is from streams and rivers emptying into estuaries, the hydrology of the estuaries can be altered, thereby affecting one of the most valuable types of marine areas. Given that most of British Columbia's semi-arid areas do not drain to estuaries, it is unlikely that this is a problem in British Columbia. However, other related threats that modify the shape of hydrographs and water quality are likely affecting estuaries negatively.

Terrestrial. Where a decline in salmonid populations results from the water loss, a decline in nutrient sources for associated terrestrial ecosystems and specific terrestrial species can be expected. In addition, many off-channel and other riparian habitats are essential in the mosaic of species habitat needs. Where these habitats are not maintained by flood flow regimes, effects on terrestrial species can be expected.

Evidence

There is little controversy about the potential impacts of a decline in total water yield. Where disagreement may exist is in the role of other related threats which can bring about a change in hydrograph shape and/or a reduction in water quality - especially in those situations where multiple factors may be leading to the same outcome (see Nicola River case study).

CASE STUDY: THE NICOLA RIVER – EXTREME PRESSURE ON WATER RESOURCES

The Nicola River flows through Merritt BC draining 7,227 km^2 of the Thompson Plateau including a small portion lying within the Cascade Mountains – a total area equivalent to $1/8^{th}$ of the Thompson River drainage. Its mouth with the Thompson River is situated a short distance upstream of where the Thompson River empties into the Fraser River. The Thompson River and its large tributaries, such as the Nicola River, support world-renowned runs of salmonids (DFO 1998). The Nicola River is the major chinook, coho, and steelhead producer in the Thompson-Nicola Habitat Management Unit (HMU). Water temperature is recognised as an extremely important variable that can affect the distribution, growth, behaviour, metabolism, disease resistance, survival, and productivity of juvenile and adult salmonids (Walthers and Nener 1997). Results of a 1993 study (Lauzier et al 1995) suggested that the Thompson River exerts a warming trend on the Fraser River (Walthers and Nener 1997). This finding prompted an interest in examining water temperature dynamics in the Thompson River system and the role of land use in increasing Thompson and Fraser River temperatures.

Water temperatures in the Thompson River are inherently susceptible to warming trends during the summer months due to regional climatic conditions. Summers are characteristically hot and dry and air temperatures can exceed 40 deg C. Annual precipitation ranges from 250-500 mm per year (DFO 1999). Many land uses prevalent throughout the Interior Plateau are capable of exacerbating this natural susceptibility. For example, high water removal decreases flows, allowing more extreme temperature fluctuations. In addition, removal of riparian vegetation decreases shading and can increase channel width - these changes can increase water temperatures in many situations.

DFO has conducted temperature monitoring during 1994-1996 in the Nicola River watershed (Walthers and Nener 1997; Walthers and Nener 1998; Walthers and Nener 2000). This area was selected because of its high salmonid spawning and rearing values and because it was deemed typical of many of the Thompson River's large watersheds in terms of land-use practices and physical makeup. The study results revealed temperatures frequently within the ranges considered unsuitable or lethal to salmonids. The preferred range for salmonid spawning is from 4-14 C. Cessation of spawning and increase in disease occurs above 16 C with 21-25 C being the range of temperatures lethal to salmonid survival (Walthers and Nener 1997). 1994 was the hottest year with average mid-summer temperatures exceeding 21 C at almost all sites. At two sites on July 24, 1994, maximum recorded temperatures reached 29 C, well above the lethal tolerance range for Pacific salmonids. The total time above 25C in

1994 ranged from 33 to 93 hours with the maximum consecutive periods above 25C ranging from 9 to 18 hours. The lower temperatures measured in 1995 and 1996 reflected a slight cooling trend in climate but again revealed temperatures stressful and even lethal to salmonids.

In addition to the commercial, recreational and First Nations fisheries supported by the Nicola system, extensive forestry and agriculture takes place in the Nicola drainage. Over 26% of the watershed has been logged, 10% recently (DFO 1998), and agricultural activity is intensive and concentrated along the lower, more productive reaches. Upland areas are used for summer grazing with winter cattle feeding taking place in the valley bottoms. Boeckh et al. (1991) documented at least 2500 water licenses in the Thompson-Nicola HMA, the majority of which had license restrictions as early as 1991. In addition, development is concentrated along the Coldwater River, a major tributary to the Nicola River, and includes the Coquihalla Highway, a Telus fibre optic line, Trans Mountain Pipelines, Westcoast Energy oil/gas pipeline, and an abandoned railway. The Highland Valley copper mine - the fifth largest open pit copper mine in the world - is active in the drainage in addition to other mining activities. DFO (1998) reported 27 closed mines and a moderate degree of exploration.

The Nicola River situation highlights how a natural vulnerability – in this case, to temperature increases – can be severely exacerbated by resource development to the point that ecosystem viability and the sustainability of major fish populations are seriously threatened. This situation is expected to be widespread in the Thompson and Okanagan areas where licensed water use is removing a high percentage of annual low flows in many systems. In the present example, Rood and Hamilton (1995) have estimated that 50% of the summer flow volume is removed from the Nicola River system due to licensed withdrawals. In addition, loss of riparian vegetation is widespread. For example, in a recent study, Beeson and Doyle (1995) quantified the loss of riparian vegetation in various tributaries to the Thompson. They found that 46-63% of reaches were without their natural forest vegetation. Based on their work, Walthers and Nener (2000) have suggested that the situation is similar in the Nicola system. Given the warming trends in the Fraser that are expected with climate change (Morrison et al. 2002), it will be vitally important to freshwater ecosystems in these areas that steps are taken immediately to address the cumulative impacts of combined resource users. For example, a three-year operational study of temperature patterns in the Nicola system should help forest managers by providing a procedure to determine the effects of riparian logging on stream temperature (Henderson Environmental Consulting 2002). Given the extent of water removals in many systems such as the Nicola, water quality impacts are less diluted and therefore also need urgent attention.

Current Approach to Conservation of Aquatic Ecosystems

The current approach to conservation of freshwater resources and aquatic ecosystems is highly fragmented and *ad hoc* at best, and counter-productive at worst. There is no single entity responsible for water management, but rather a myriad government agencies at both the federal and provincial levels responsible for the regulation of various activities that potentially impact on water quantity, quality and timing of flow. One branch of government, and more recently a Crown corporation, grants licenses for the diversion of water for most uses, but this agency has no power to regulate other land uses within the watersheds from which the water flows, nor any responsibility to ensure the ecological integrity of the aquatic ecosystems potentially impacted by the granting of those rights. Rights to divert water have often been granted with limited data regarding how much water is likely to be present in a stream on average, or even less information regarding dry years. The rights are often granted in perpetuity, and the grounds for cancelling the rights generally do not include provisions related to maintaining ecological integrity or limiting impacts to biodiversity. Although fisheries biologists often argue that there is a need for maintaining flows appropriate for the season, currently there is no mechanism to enforce these requirements, unless it was included as a clause in the water license at the time it was granted. However, some water rights holders have voluntarily agreed to these provisions (see below).

The other threats and activities mentioned above that interact with water diversions (e.g., forestry, industrial discharges, road construction) are regulated by a complex set of contrasting agencies. There is no legislation or regulatory body that has specific responsibility for coordinated water planning with specific objectives for maintaining the integrity of hydrologic systems, nor all aspects of aquatic ecosystems. There is no effective mechanism for evaluation of and response to the cumulative impacts that often accrue from water diversion in concert with other changes to watersheds, flow regimes, channel processes, riparian areas, floodplains, wetlands, water quality and groundwater.

Surface water uses are licensed through the Water Act. Woodward and Healey (1993, p.3) identified some of the problems associated with how water use is licensed. While water licenses can be obtained for over 45 different categories of water use, the distinction between categories is not readily apparent. “A water license can be granted in perpetuity if it is used according to the terms of the license and the Water Act.   it is difficult to determine whether the licenses are being used in the manner prescribed in the license or if the license is being used at all. In addition, the volume of water actually being used by the license holder is not usually measured or monitored in any way.

British Columbia continues to be the only province in Canada with unregulated use of groundwater. As a result of the over-allocation of surface water, many human needs for water are being satisfied through groundwater extraction due to its lack of regulation. Many shallow withdrawals are also effectively unlicensed surface water withdrawals.

Programs

In response to conflicts around water use for its power generating facilities, BC Hydro has initiated a multi-stakeholder Water Use Planning process for its facilities. A Water Use Plan is a document that defines how water control facilities will be operated. The purpose of a Water Use Planning process is to develop recommendations defining a preferred operating strategy using a public participatory process (BC Hydro 2003). In November 2003, it is expected that the full set of Water Use Plans should be ready for review for BC Hydro’s 23 facilities. A focus of each Plan is for the participating parties to reach agreement or compromise to satisfy all their water use needs – including consideration for some aspects of biodiversity (fish and wildlife). For example, the Jordan River Water Use Plan returns some water to the Jordan River year-round to help sustain fish populations and establishes minimum permitted levels for the reservoirs.

Watershed-based Fish Sustainability Planning (WFSP – Department of Fisheries and Oceans 2003) may be helpful to resolving conflicts over freshwater demand because it promotes better cooperation, coordination, and consistency among the federal and provincial governments and the various groups with an interest in fish conservation. In WFSP, biophysical and sociopolitical profiles are developed for priority watershed planning units so as to achieve fish sustainability.

In 2003, the Ministry of Sustainable Resource Management initiated the development of a Water Management Plan for the Trepanier Landscape Unit. In this work, water supply and water demand are being assessed in light of land use and multi-stakeholder discussions to build a Water Management Plan that can be incorporated into an Official Community Plan.

Lastly, there exists a number of active local stewardship groups such as the Salmon River Roundtable (Karen Rothe personal communication).

Key impact/ threat issues that need resolution

Ecosystem-based assessments are needed to identify the basic water needs of freshwater systems for the maintenance of their biodiversity. While the need is urgent in semi-arid areas, it is also significant in more humid areas that are experiencing high population growth or where there is high probability of drying climate change. Specifically, minimum required low flows and maximum allowable water temperatures for the maintenance of livable stream habitats need to be determined, especially for fish. Requirements for flushing flows and peak flows also need to be specified for the maintenance of channel integrity.

A companion analysis is needed which identifies current licensed demands and provides a ranking of their relative priority. Such assessments would benefit from a review of associated land-use activities in each stream system of interest so that current changes to the natural hydrograph can be described.

An integrated basin planning process is the preferred instrument for assembling information and data sources. This process would assemble and interpret existing scientific understanding relevant to the basin of interest and would identify monitoring needs including a strategy for addressing gaps. Groundwater withdrawals should be included in any analyses. The process would be tasked to initiate basin-specific cumulative effects studies and would take the lead on integrating all data and information sources to draw up preferred land-use zonation and practices. A technically-oriented multi-stakeholder process would be appropriate to discuss recommendations and seek compromise. The entire process can likely be effective only if it is in some way legally binding.

Ultimately, with these assessments and plans in place, future licensing requests should be framed against the incremental water available above and beyond ecosystem requirements. A licensing system is also needed for groundwater withdrawals, supported by a parallel assessment providing demand limitations based on ecosystem requirements. In addition, these biophysical assessments should take into account the potential impact of climate change in modifying water availability/distribution. Any international trade in water should be resolved on an ecosystem basis before the withdrawals are licensed.

There are three main obstacles to achieving these goals. The jurisdictional cooperation required would challenging particularly if it demands a reworking of legislation away from traditional disciplinary lines. Second, in some parts of the province, reductions would likely be required in irrigation and human consumption. Water conservation proposals may be met with mixed reception unless legislated. Water metering may be required despite its expense. Lastly, the dramatic reductions through the 1990s in the scope of water monitoring carried out by the Water Survey of Canada has resulted in a loss of important data concerning flow regimes.

Information Gaps

The tools and baseline knowledge required to achieve the outcomes given above are only partially available. Key information gaps include:

- The freshwater needs of individual stream systems of concern – particularly the low flow and maximum temperature requirements.
- The size, recharge times, and current condition of important water-supply aquifers.
- Current water use distribution of existing licenses including demand monitoring where information is unavailable. Logbooks kept by farmers could provide important information on irrigation demand.
- Streamflow monitoring (where currently unavailable).

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SECTION 7B. COMMERCIAL FISHING METHODS IN BC.

Threat Description

Commercial fishing in British Columbia can be broken down into a number of categories:

- Trawling or dragging gear along the bottom for groundfish, shrimp or scallops
- Setting out traps on the bottom for prawns, sablefish or crabs
- Hanging fixed nests in the water for salmon
- Dragging (seine) nets through the surface water for salmon or herring
- Using a hook and line dragged behind the vessel (salmon trolling, tuna) or laid along the bottom (halibut, rockfish)
- Hand picking invertebrates from the bottom (sea cucumbers, urchins, gooseneck barnacles, abalone)
- Digging in the substrate for geoducks (using hoses) or clams (using rakes or shovels)
- Hand harvesting seaweeds (kelps, nori)
- Harvesting spawn deposited on kelp strung on lines for that purpose

General Impacts of Commercial Fishing

All marine harvesting has the potential to impact marine ecosystem processes, if fishing mortality is high enough to cause a sharp decline in recruitment equilibrium. In such cases the population may take decades to recover, or not recover at all. Deciding when recruitment fishing is occurring (i.e. fishing is amplifying a population decline) is difficult, and currently relies on the best judgment of fishery managers.

Some gear types, for example trawl gear, catch a significant number of non-targeted species. This is referred to as “bycatch”. A problem with bycatch is that it is not carefully monitored, and as it is largely composed of non-commercial species or life stages, it goes unrecorded. This impact is especially important when the species in the bycatch are already threatened, for example the bycatch of eulachons in the shrimp trawl fishery (Olsen et al. 2000). Bycatch has also been a problem in the groundfish long-line fishery. It causes mortality of birds and turtles when they take the baited hooks as they are being deployed. Ghost fishing – the phenomena where gear that has been deployed but lost or abandoned at sea may continue to attract and destroy fish – is a problem with net and trap fisheries.

Impacts Specific to Benthic Habitat Modification from mobile fishing gear

Two basic types of trawling, or mobile bottom fishing gear that is dragged along the seabed are used in the BC groundfish fishery; otter trawls and beam trawls. In BC Beam trawls are used only in the shrimp trawl fishery; the groundfish trawl fishery exclusively uses otter trawls. Otter trawls have two boards, each weighting tens to thousands of kilograms, that hold the trawl mouth open. The bottom of the trawl mouth is a ground rope weighted to keep it on the sea floor. The ground rope on some trawlers may also be fitted with rollers to help them ride over uneven ground. It is rumoured that some trawlers “clean” the grounds of debris and non-targeted sessile invertebrates with a chain, before they actively start trawling with their nets (Glen Jamieson pers. comm. 2003). The end of the net, or “cod end” fills up with the targeted fish as well as bycatch, rocks and other debris and may weigh tens to thousands of Kilograms when full. The combined gear – doors, ground rope, rollers and cod – gets dragged over the bottom and can impact on the seabed and associated benthos.

The majority of bottom trawling occurs in waters of less than 100 m. The areas most intensively fished by bottom trawls include the banks off the west coast of Vancouver Island, Hecate Strait and Queen Charlotte Sound. Bottom trawling has been compared to terrestrial clearcutting as a threat to the biodiversity of marine benthic communities (Watling and Norse 1998). Unlike clearcutting, the impacts of bottom trawling are largely hidden from view and are difficult to study. The assessment of the impacts caused by trawling is difficult to separate from that caused by natural disturbance. In depths of < 100 m, there are a number of natural disturbances such as seasonal storms, scouring by tidal currents, as well as smaller scale disturbances caused by predator feeding activities (Kaiser 1998). As a result the detection of long-term benthic community changes that are attributable to fishing activity has been problematic except for the most obvious cases (Riesen and Reise 1982; Jamieson and Chew 2002).

In general, large epibenthic species on soft bottom are most at risk from impacts of trawling. In the Wadden Sea, the disappearance of reefs of the tubiculous polychaete *Sabellaria spinulosa* was attributed to intense trawling (Riesen and Reise 1982). In certain areas of the BC coast, the globally unique sponge reefs in have been subject to damage by seafloor trawling in the past decade, and are possibly still being impacted by groundfish trawl gear (Jamieson and Chew 2002).

These epibenthic species themselves, even those that reach only a few centimetres into the water column, form habitats for other organisms, including the post-settlement stages of a number of commercially fished species. The sponge reefs form mounds up to 18 m in height and are extensive, forming complexes covering an area of up to 300 km^2 (DFO 2000). The surface of these sponges is estimated to be 100-150 years old, and they probably have continuously occupied these sites since shortly after the end of the last glaciation (8500-9000 years, DFO 2000). The importance of the sponge reefs to the ecology of the continental shelf is largely unknown. Qualitative submersible observations suggest that species of crab, shrimp, prawns and rockfish utilise interstices within and between the sponges as refugia. The timeframe of recovery of a destroyed sponge reef is probably in the order of 100-200 years (DFO 2000).

Another potential impact of bottom trawling is the continual re-suspension of bottom sediments on both fauna and on regional nutrient budgets (Pilskaln et al. 1997). The extent to which trawling-induced bottom sediment re-suspension occurs is unknown, but has potential implications on the regional nitrogen and silica budgets. Nutrients re-suspended by trawling are sent up in a large pulse rather than by the usual slower and more steady mechanisms (Pilskaln et al. 1997)

Current Approach to protection or mitigation

All groundfish trawlers have a mandatory observer on board to document each trawler’s catch and bycatch. Areas and times of fishing are restricted, primarily to conserve stocks. A voluntary closure of areas where sponge reefs are known to be present was instigated in 2002, and made enforceable in 2003 when it was found the voluntary closure was not uniformly being adhered to.

There are no regulations in place to protect non-commercial epibenthic species other than the sponge reefs. Due to the lack of taxonomic expertise of the observers and the poor state of specimens that come up from trawls, there is no monitoring of the damage being done to epibenthos in British Columbia by the groundfish trawl fishery.

Key threat/ impact issues that need resolution

Actions to protect areas with sensitive epibenthos need to be developed[12]. These actions could include:

- The closure of areas with sensitive epibenthos to trawling using MPAs or local groundfish trawl closures.
- Modifications to trawl gear to minimise impacts on epibenthos.
- The use of alternate gear such as hook and line gear.

Information Gaps

- Monitoring of the damage being done to epibenthos in British Columbia. Observers with better taxonomic expertise are needed to collect information on the extent of epibenthic by-catch in the groundfish trawl fishery.
- Mapping of sensitive epibenthos using submersibles, side scan sonar, and/or other means
- Assessment of sensitive epibenthos is needed to determine the ecological value of these habitats to other species.

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[12] Note these are not intended to be an exhaustive list of potential solutions, rather specific examples.

SECTION 7C. FORESTRY ON CROWN LAND: STAND STRUCTURE MANAGEMENT

This overview of the effects of forest harvesting on stand-level habitat focuses on the two most important classes of habitat elements currently considered to be threatened by forest management: wildlife trees (particularly snags) and coarse woody debris.

Threat description

Highly extensive: Threats of forest harvesting to stand level biodiversity are a concern throughout the timber harvesting landbase in all forested biogeoclimatic zones in BC. Areas with high percent area of operable forest are particularly at risk.

Forest harvest and its impact on stand structure is highly variable across the province. Forest harvesting involves different silviculture systems (e.g., clearcut, shelterwood, group selection) and harvesting methods (e.g., ground-based, cable yarding, helicopter logging); however, the focal habitat elements described here are subject to some level of reduction, irrespective of the silviculture system and harvesting methods used. For example, clearcut harvest generally removes all standing trees from within the cutblock, and may result in coarse woody debris being piled and burnt to facilitate silviculture activities. Retention or partial harvest may also result in significant removal of, at minimum, standing dead trees, as safety rules from Workers Compensation Board are invoked. The specific threat is created because stand structural elements are reduced as an increasing proportion of the land base is harvested initially and again in future rotations. With relatively short rotations (e.g., 80-120 years), there is no opportunity for large-diameter wildlife trees or coarse woody debris to develop. Retention of these attributes currently must therefore be sufficient to maintain biodiversity now and into future rotations.

In general, wildlife trees, snags and coarse woody debris may be removed in proportion to the extent of harvest. However, standing dead trees in particular may be removed at an additional rate because of a combination of worker safety rules and firewood cutting which tends to remove significant percentages of wildlife trees adjacent to forestry roads and from cutblock boundaries and retention patch boundaries.

Impact description

Ecological Importance

Numerous vertebrate species are dependent on stand-level habitat elements (e.g., 57 species require tree cavities for nesting, denning, roosting and shelter) and, in addition, of 70 wildlife tree-dependent species (Machmer & Steeger 2003), 20 are listed by the BC Conservation Data Centre (11 are listed by COSEWIC, and 17 are being considered for inclusion in Volume II of the IWMS). The retention of ecologically functional snags, wildlife trees and coarse woody debris during harvesting is therefore a significant requirement to maintain stand-level biodiversity.

Wildlife trees are defined as "*any standing dead or live tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife*" (Province of BC 2001). Wildlife trees of special ecological value are standing dead trees (snags), which, together with fallen trees or coarse woody debris (CWD), have become an important forest management focus throughout the Pacific Northwest (review in Laudenslayer et al. 2002).

In a review of the ecological roles of CWD in BC forests, Stevens (1997) categorises these roles into four inter-related categories: productivity of forest trees, provision of wildlife habitat, geomorphology of streams and slopes, and long-term carbon storage. From a habitat perspective, CWD is essential for a wide variety of organisms, including 19 mammal, 2 bird, 7 herptile, and 5 vascular plant species. Hundreds of nonvascular plants, fungi, and lichen species are also considered *closely* associated with CWD (Stevens 1997).

Geographic Pattern of Impacts

Ecologically, stand management has the potential to be particularly significant in two types of areas: a) where gap dynamic disturbances are naturally predominant (e.g., wet coastal forests and wet interior cedar hemlock forests) since harvesting is different from natural disturbance regimes, and b) in areas where naturally large structural attributes would be relatively scarce (e.g., moderately productive SBS plateau forests).

Forested areas affected by disturbance events (e.g., wildfires, beetle or disease outbreaks, etc.) are often subject to salvage operations; these require higher conservation concern since many species are adapted to exploit the habitat created by such disturbances.

Evidence of Impacts

Wildlife trees and coarse woody debris are known to be highly important for maintaining natural species diversity and functioning since high numbers of species and processes require dead wood structures (Laudenslayer et al. 2002). However, there remains controversy around the extent of redundancy in this system. That is, it is currently unknown what percent of the natural abundance of dead wood is required to maintain the ecological functions associated with such structures.

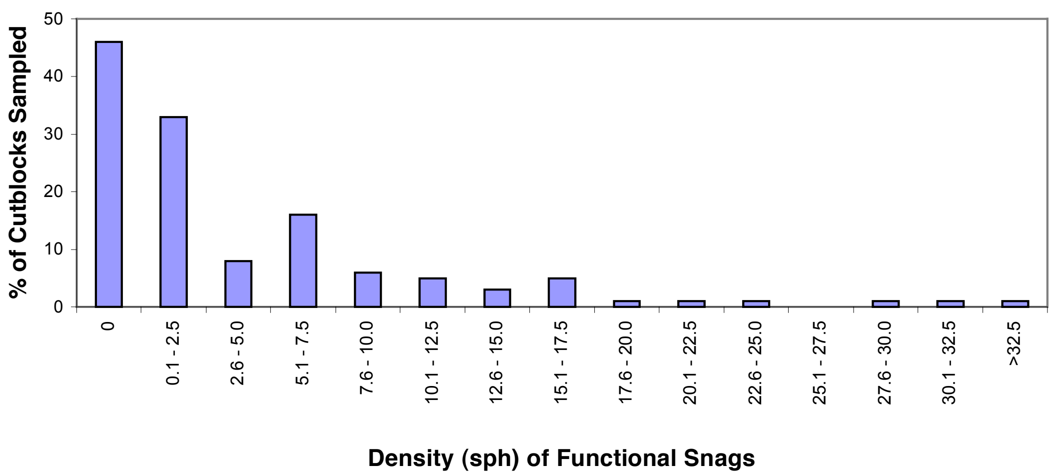

Figure 1. Frequency distribution showing % retention (sph) of functional snags (i.e., ≥20 cm dbh and ≥10 m height) in 128 cutblocks sampled for the WT Evaluation Project (from Machmer & Steeger 2003).

A recent project designed to specifically assess the biological effectiveness of wildlife tree retention in British Columbia (Machmer & Steeger 2003) summarised retention levels of functional wildlife trees (i.e., trees ≥20 cm dbh and ≥10 m height) during forest harvesting. This was done in order to compare retention levels to species requirements and supply of wildlife trees in unmanaged stands. This assessment indicates severe reductions of snags on sampled cutblocks compared with unmanaged stands (Table 1 and Figure 1). Retention of other types of wildlife trees was also extremely low: of 128 sampled cutblocks, 88% had no trees with mistletoe, 52% had no trees with internal decay indicators, 81% had no veteran trees, and no trees with cavities were retained on any of the cutblocks sampled. With few exceptions, those cutblocks with retention showed relatively low densities of functional wildlife trees (Machmer & Steeger 2003).

TABLE 1. Mean density (sph) of snags (≥10 m height) retained by BEC zone. Also shown are snag densities in unmanaged stands (BC Ministry of Forests 2001) for comparison.

BEC Zone	No. Blocks	Snags (>20 cm dbh) Retained	Snags (>20 cm dbh) Unmanaged[1]	Snags (>50 cm dbh) Retained	Snags (>50 cm dbh) Unmanaged[1]
BWBS	8	31.8	-	0.1	-
CWH	31	9.3	72.4	1.0	15.3
ESSF	30	7.1	143.2	0.4	6.4
ICH	30	8.1	65.0	1.5	6.1
IDF	14	4.2	27.9	0.2	2.6
SBPS	6	0.2	-	0.1	-
SBS	9	6.3	85.1	0.1	3.2

[1] Densities are mean snags/ha in mature and old (>100 years) stands averaged within all subzones, variants and site series for a given BEC zone, based on data from the Provincial Ecology Program (PEP; BC Min. of Forests 2001).

While it is evident that levels of snags are drastically reduced in managed stands, the effects these reductions in stand structural attributes have on biodiversity is less clear for British Columbia, but has been documented for European forests (review in Bunnell et al. 2002). However, one experimental study on the effects of harvest and/or burn treatments on cavity-nesting birds conducted in British Columbia (Machmer 2000) indicated that reproductive rates of birds breeding in untreated areas tended to be higher than those breeding in clearcuts with wildlife tree patches or in partial cut areas.

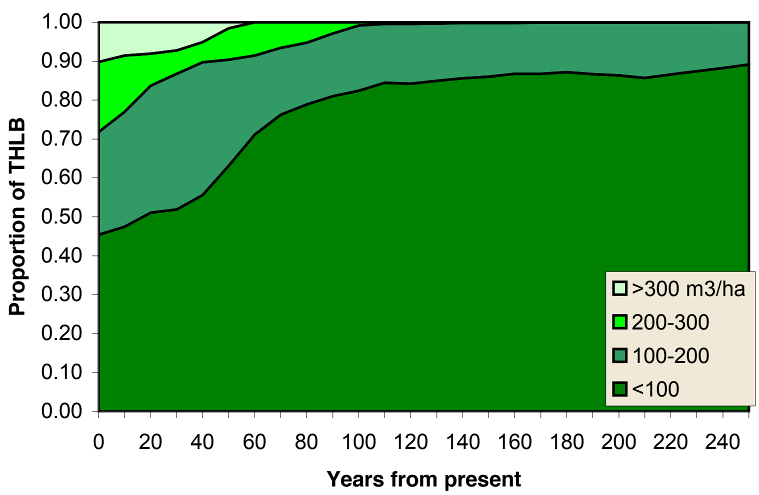

Fig. 2. Downed wood volumes (m^3/ha) on the timber harvesting land base of the Arrow Timber Supply Area. Volumes are projected from 10-250 years from present (from Wilson et al. 2003).

In general, very little information is available to document the relationship between different levels of CWD supply with patterns of biodiversity. What appears to be clear is that the supply of CWD has declined in managed forests; however less clear is what appropriate levels of CWD are in managed forests (Bunnell et al. 2002). Some evidence of declining CWD levels over time has been compiled for the Arrow IFPA as part of a habitat supply modeling project (Wilson et al. 2003). The trends in CWD supply (Fig. 1) are based in part on empirical data from several sources. As shown in Fig. 1, low and moderate CWD volumes (<100 and 100-200 m^3/ha) in managed stands increase substantially while the supply of high volumes (200-300 m^3/ha) and very high volumes (>300 m^3/ha) ceases by approx. year 100 and 60, respectively. Note that while the contribution of large pieces of CWD to any volume estimate is high and large pieces have higher habitat value and longevity than small pieces, it is those large pieces of CWD that are removed from forests during harvesting operations. The predicted reduction in CWD supply over time will therefore likely have detrimental effects on biodiversity.

Current Approach to Protection or Mitigation

Stand level management strategies are under provincial jurisdiction, and dealt with within legislation, regulations, policies and best management practices which are all currently under review.

Currently, the management of stand-level biodiversity in BC is based primarily on the provincial *Wildlife Tree Policy and Management Recommendations* (Province of BC 2000). This coarse-filter management policy addresses retention of stand structural habitat elements (*wildlife trees*) on cutblocks throughout BC. On a fine-filter scale, the Identified Wildlife Management Strategy (IWMS) promotes *General Wildlife Measures* and establishment of *Wildlife Habitat Areas* intended to protect specific stand-level habitats of animal and plant species and communities of special management concern. The Wildlife Tree Policy is intended to maintain habitat for over 80 vertebrate species known to be critically dependent on wildlife trees. The IWMS contains provisions for habitat protection of 38 vertebrate and 7 invertebrate species, as well as 1 plant species and 5 plant communities (Volume I and II).

The effectiveness of wildlife tree retention is reduced by

- the provincial Workers' Compensation Board (WCB) Occupational Health and Safety Regulations – WCB requires that all dangerous trees, most of which are snags, are removed in all forestry operations;
- major and small scale wood salvage initiatives – removal of dead and declining trees is encouraged and often required, primarily to minimise loss of merchantable timber and to prevent spread of tree-parasitic insects and diseases;
- standard rotation lengths – harvest rotations are generally too short (80-120 years) to allow development of ecologically valuable snags, CWD pieces, and large live trees; and
- firewood cutting – dead and dying trees that have been retained adjacent to roads, landings and trails but are accessible to firewood cutters are often removed, even if these trees were purposefully left as wildlife trees.

CWD is managed under an interim short-term management strategy (Parminter 2000). This strategy gives utilisation standards priority over retention of CWD, but provides general recommendations for the supply of CWD in managed stands. Meeting utilisation standards likely results in the largest, least decayed CWD pieces with greatest longevity and wildlife habitat value being systematically removed from managed stands.

Key threat/ impact issues that need resolution

- In general, maintenance of stand level habitat and associated species will likely require higher snag and CWD retention levels. Addressing the following may increase the adequacy of retention of important stand structure elements:
- retention requirements for wildlife trees should be expressed as stems per hectare values, in addition to the current area requirements;
- retention targets should reflect wildlife habitat requirements and should fall within the habitat elements' natural range of variability;
- retention targets should be developed by ecosystems and stand types (i.e., there are marked differences in natural snag supply among ecosystems; these differences must be reflected in management guidelines);
- only wildlife trees of functional size should count towards stems per hectare requirements;
- adequate retention of snags and green trees intended as future snags should be required explicitly;
- retention strategies should include adequate spatial distribution of dead wood, to avoid habitat fragmentation or isolation;

- direction is needed regarding retention of CWD in appropriate amounts, piece sizes, and decay stages.
- CWD and wildlife tree management should be integrated; many of the aforementioned recommended wildlife tree policy revisions would have direct impacts on CWD supply, and a single policy for both wildlife trees and CWD may be appropriate. Currently, large CWD pieces that are merchantable can only be retained within wildlife tree patches and this limits the distribution of these habitat elements.
- Since parks play increasingly important roles in habitat conservation, retention of wildlife trees and CWD needs to be emphasised within and adjacent to parks.

Information Gaps

Wildlife trees:

- while there is some information on the types of dead and live trees required by wildlife in selected BEC zones, there is no information on the density of functional snags required by wildlife populations;
- there is lack of information on differences in the supply of habitat elements in the timber harvesting landbase and the non-contributing landbase ;
- there is a need to collect snag data consistently (for use in habitat supply analysis coupled with timber supply analysis) to develop more accurate projections of supply over time;
- there is a need to establish ecosystem and stand type-specific densities, fall rates, and recruitment rates of snags, as well as ranges of natural variability;
- there is a need to establish new criteria for WCB regulations pertaining to hazard trees and to integrate these with timber and wildlife management objectives

Coarse Woody Debris:

- basic information for understanding CWD dynamics is needed, including input rates and rates of fragmentation and decay (Stevens 1997);
- finer resolution of information required includes decay rates of different wood components, decay under different moisture and temperature regimes, and the role of different decay organisms (Stevens 1997);
- as in the case of snags, CWD data need to be collected consistently (for use, in habitat and timber supply analysis for example) to develop more accurate projections over time.

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SECTION 7D. TERRESTRIAL OIL AND GAS DEVELOPMENT

General Description of Threat

Oil and gas developments include exploration, extraction and transportation activities that impact marine, freshwater and terrestrial biodiversity. This section only addresses terrestrial and freshwater oil and gas issues, but there are many threats and impacts associated with marine operations. For example, exploration and extraction activities disrupt communication, feeding and orientation of marine mammals, cause mortality of fish larveae, and create local disruptions to benthic communities. Transportation activities may cause the most significant damage to biodiversity through the oil spills, which cause mortality or reduced fecundity of vulnerable species, disruption of intertidal communities and damage to coastlines. With the recent lifting of the moratorium on offshore oil and gas exploration, marine threats and impacts are likely to increase.

The ecological footprint of oil and gas development is broad and diverse. In terrestrial environments, it is composed of linear developments such as roads, seismic lines, and pipeline right-of-ways; well sites; compressor stations; flaring stacks; and processing plants/refineries. The development of oil and gas involves 3 main processes: 1) exploration to identify oil and gas reservoirs, 2) access to and extraction of reservoirs via the drilling of wells, and 3) transportation of raw oil/gas from the well to a processing plant. Following development, there is constant need for the monitoring and maintenance of the infrastructure.

Seismic Exploration

Conventional seismic exploration in northern-forest systems requires seismic lines 6 to 8 m wide, typically cleared with a bulldozer. Once the line is cleared, drilling equipment mounted on trucks drill a series of holes into which dynamite charges are placed and fired. Depending on the locality, a seismic survey usually involves a series of parallel lines, 400 m or more apart. Advancements in seismic exploration have lead to the adoption of low-impact seismic, which employs lines averaging a 5-m width, and unlike conventional lines can meander, allowing for the avoidance of valuable stands of merchantable forest; enviro-drills mounted on all-terrain vehicles that only require 2-m wide lines; and heli-portable drills, which eliminate the need for seismic lines (Schneider 2002) (Note: the types of seismic listed are in order of increasing expense).

Well Drilling, Extraction, and Monitoring

The drilling of a well begins with the building of access roads for the transportation of drilling equipment, supplies, and workers. Once drilling has tapped the reservoir, the well casing is cemented into place and the well is capped to regulate flow. To maximise the volume of oil/gas extracted, depending on the property of the deposit, additional methods can be employed which include more wells drilled into the reservoir or the injection of water or natural gas into the well to maintain extraction pressure. As a result of technological advances, many natural gas wells can be monitored remotely and accessed via helicopter, without the need for roads. However, this is not possible for oil wells, which require all weather roads for regular monitoring and maintenance (Schneider 2002).

Transportation and Processing

Once a well is brought into production, it is tied into a pipeline. A pipeline right-of-way is a linear corridor of cleared forest, wider than conventional seismic lines. Small pipelines are approximately 16-40 m wide, but pipelines shared by multiple companies can exceed 90m in width. In constructing pipelines, the ground is trenched and the pipeline is buried. Regular aerial and ground monitoring requires limited re-growth of vegetation, which requires mechanical and/or chemical treatment along the pipeline right-of-way. Once connected to the pipeline, raw oil is transported to refineries, usually near major city centres. Natural gas is usually processed in plants near the production sites, in forested areas (Schneider 2002).

Ecological Impacts

In general, the ecological impacts of oil and gas development can be summarised as varying degrees of habitat loss, fragmentation, edge effects, barriers to movement, facilitation of movement, soil erosion and compaction, contamination of water, soil, and air, changes to drainage patterns, disruption of predator-prey dynamics, direct and indirect mortality, and increased access and human activity in formerly remote areas. Overall, scientific literature on the ecological impacts of oil and gas development is scant. Of the research done, linear developments have received the most attention, especially roads (but not necessarily in relation to oil and gas development).

Habitat Loss and Fragmentation

The clearing of forest for roads, seismic lines, pipeline rights-of-way, and well sites all contribute to the physical loss of habitat. In some areas of the mixedwood boreal forest (Alberta), the accumulative clearing of forest for various aspects of oil and gas development closely matches the quantity of timber extracted by forest companies, on a yearly basis (Schneider 2002). Some species avoid areas adjacent to an oil and gas disturbance, which leads to habitat loss, as well as the fragmentation of large, contiguous tracts of forest if full utilisation of the land by wildlife is prevented (Jalkotzy et al. 1997). Forest-interior wildlife species are most likely to be affected. A review by Jalkotzy et al. (1997) found that wildlife frequently avoided habitats near roads and other linear disturbances because of repeated disturbance along the right-of-way, with the degree of avoidance species-specific. In British Columbia, repeated disturbance would result from road vehicle, ATV, and snowmobile traffic. The avoidance of areas adjacent to seismic lines, well sites, and roads has been observed in the northern forests of Canada (e.g. woodland caribou observed to avoid seismic lines and well sites, Dyer et al. 2001; American marten observed to avoid roads, Robitaille and Aubry 2000).

Increased Habitat

Forest clearing creates habitat for species such as the coyote, American kestrel, great grey owl, and great-horned owl, which results in higher predation risk to some species living near edges. Species that benefit from increases in this type of habitat are usually generalist that do so to the detriment of habitat-specific species.

Contamination of Soil, Surface and Ground Water, and Air

The contamination of soil, water, and air occurs as a results of improper waste disposal, poor storage and handling, underground leaks from drilling, spills and leaks during regular operations, pipeline failures, the flaring of gas, and well blowouts, to name a few. Some of the contaminants include hydrocarbons, saline water, heavy metals, chemicals associated with drilling, industrial fluids (solvents, fuel, lubricants), sewage, garbage, benzene, carbon monoxide, sulphur dioxide, and nitrogen dioxide (Schneider 2002).

Damage to Soil

Because of damage to root systems, poor light penetration, competition with grass species, compaction and mixing of soil horizons by heavy machinery, and repeated use by ATVs, snowmobiles and vehicles, decommissioned well sites and seismic lines are slow to regenerate, prolonging the recovery of lost habitat (Schneider 2002). {Well sites, roads, and pipelines, are used for a long time (e.g. commonly 25 years for a well). Given their long use and slow regeneration, they are essentially permanent.}

Damage to Aquatics

Oil and gas development can damage aquatic systems through increase stream sedimentation, bank erosion, barriers to fish passage, destruction of aquatic habitats and alterations of drainage patterns.

The use of fresh ground water for enhanced oil recovery is extensive (230 billion L in 2001 in Alberta), and has the potential to impact levels of water bodies and jeopardise the supply of freshwater required by humans (Schneider 2002). In particular, in situ projects tend to divert large volumes of water to meet project needs. Road, seismic and pipeling crossings also increase sedimentation during the building phase and without adequate planning, culverts or diversion projects can create considerable barriers for fish.

Movement

Linear development (seismic lines, pipeline rights-of-way, roads) can function as a filter or barrier to movement. The impact of linear disturbance on the movement of wildlife has been poorly studied; however, there is evidence suggesting that linear disturbances can affect movement, and consequently the distribution and population dynamics of some species (Jalkotzy et al. 1997). There are at least 3 important ecological functions associated with movement that can be affected: 1) access to resources, e.g. food and den sites; 2) dispersal, which reduces competition and helps maintain genetic diversity; and 3) gene dispersal during the mating season when males may travel large distances to breed. If movements for these purposes, and possibly others, are inhibited, the viability of a population may be compromised.

Linear development can also enhance the movement of wildlife by providing routes of easy travel across the landscape. The disadvantage is that the facilitation of movement can increase the hunting efficiency of some predators (eg. wolves, James and Stuart-Smith 2000) to the detriment of prey species. For example, wildlife may be unwilling to cross rights-of-way because of increased risk of predation, and American marten avoid openings. Evidence showing that linear disturbances can affect the movements of small- and medium-sized mammals is presented in Oxley et al. 1974, Schrieber and Graves 1977, Mader 1984, and Doucet and Brown 1997.

Direct and Indirect Mortality

Collisions with vehicles along roads would be the greatest source of direct wildlife mortality associated with oil and gas development. Two other sources of direct mortality would be exposure to hydrogen sulphide leaked from sour gas wells or pipelines, and the exposure of aerial wildlife (e.g bird, bats, insects) to toxic gases and flames from gas flaring. Indirect mortality may result from increases in poaching and hunting due to increased access to formerly remote areas, the disruption of ecological process, as well as the alteration of predator-prey dynamics (e.g. moose, deer, caribou, and wolves). Spraying of herbicides and chemical spills associated with well drilling also have detrimental effects on terrestrial and aquatic species.

Introduced species

Linear corridors are known vectors of exotic and invasive species that are spread accidentally (through transport along the corridor) or intentionally (through deliberate seeding during site reclamation). Pipeline, powerline and road construction also create disturbed soil conditions that are ideal for the spread of most invasive species. Once established, exotic and invasive species become aggressive weeds in forests.

Edge Effects

Increased predation of small and large mammals has been observed along edges and nest predation and parasitism (e.g. by brown headed cowbirds) is highly associated with forest edges.

Geographic Variation in Impact

Most oil and gas exploration occurs in the northeastern portion of the province, where the primary impacts are concentrated in streams, forests and muskeg environments.

Scientific Evidence

In the literature, studies are predominately on the rights-of-way of powerlines and roads, and have focused largely on bird communities, small mammals, and ungulates, primarily deer. Most of these studies examined distribution patterns and abundance, very few studied movement. In general, there is a paucity of literature with regard to the effects of linear disturbance on furbearers, and the study of amphibians, reptiles, and insects is appreciatively low. There is a growing body of literature demonstrating the negative effects of oil and gas development on wildlife. If the extrapolation of information from the studies of roads and powerline rights-of-way is acceptable, then there is greater evidence for large mammals to insects to be affected by oil and gas development.

Certainty of the effects of oil and gas development is relatively low for disturbances such as seismic lines, pipelines and well sites because of the paucity of literature based on these structures. Certainty of effects related to roads is much higher since greater attention has been given to the effects of major roadways such as highways on wildlife.

Current Approach to protection or mitigation

The Oil and Gas Commission regulates all exploration and development activities within BC. The OGC is part of the Ministry of Mines and Energy and is structured much like a crown corporation. Its mandate is to facilitate oil and gas development, and the commission reviews all projects within BC on an individual basis. Although some guidelines for conserving biodiversity exist (e.g. for protecting wildlife values and regulating stream crossings), they are difficult to enforce and are generally not effective. OGC staff claim that the regulations do not help them to protect biodiversity and that they meet strong opposition from oil and gas developers when they attempt to invoke regulations.

The largest overall impact from oil and gas development is related to seismic lines because these are the first impact on the landscape. Once seismic lines are in place, permits for pipelines and roads are easily obtained so long as they follow the existing lines. The OGC regulates seismic activity, but no environmental impact assessments are required. However, EIAs (through the EIA office in Victoria) are mandatory for pipelines over 38km long unless they follow existing seismic lines. Since seismic lines are generally well established before oil and gas are piped out of an area, assessments rarely occur. The Government of Canada requires EIAs for all cross-boundary (provincial or international) pipelines.

The ministries of Water, Air and Land Protection and Forests work with the OGC to conduct yearly audits of oil and gas operations. These generally consist of permit inspections as well as assessments of stream crossings. Audits only occur once per year and generally take place in the spring.

Key threat/ impact issues that need resolution

- Incorporate or maintain habitat structure along or across linear disturbances to encourage/facilitate movement over a variety of scales.
- Use lower impact seismic – the current limitation is the cost to the company, and better technology is more expensive.
- Regeneration of seismic lines and well sites – more aggressive intervention is required; incorporate silviculture, accelerate reclamation, and prescribe native vegetation species (i.e. restore sites so they can develop into pre-disturbance vegetation complexes)
- Better access management – Limit access or prohibit movement along seismic lines, roads and pipelines. For example, trees cleared for seismic lines are usually piled along the edge of the line, but should be rolled back onto the line once seismic testing is finished to prevent ATV or snowmobile use. Gated access and legislation that limits access are also required.
- Cumulative impacts assessment – The area of forest cleared for oil and gas development needs to be incorporated into the annual allowable cut – landuse planners must take into account the cumulative impact of oil and gas development on timber harvesting. Cumulative impact assessments should also include assessments of the amount of linear corridors per hectare within an area (and should be assessed in relation to natural disturbance patterns - e.g. amount of mature seral lost due

to exploration and development), as well as assessments of how fragmentation, alteration and loss of ecosystems relate to biodiversity.

- Zonation – exploration and development should occur in zones where risks to biodiversity are lower.
- Regulations and Environmental Impact Assessments - Stronger, enforceable regulations are necessary. Current regulations facilitate development, and generally fail to protect biodiversity needs. Environmental impact assessments should apply to seismic activities and to more permanent developments that follow existing seismic lines (e.g. roads and pipelines).
- Increased monitoring and adaptive management – More enforcement, monitoring and inspection of permits by the Ministry of Water, Air and Land Protection are necessary and Conservation Officers and ecosystem specialists should do more field inspections. Adaptive management should focus on selecting appropriate fine filters (like cornerstone species), ensuring the maintenance of large unfragmented patches, and assessing seral stage distributions that fall within the range of natural variability.

Information Gaps

Very little research has been done on the impacts of oil and gas developments on wildlife. The majority of research relating to linear disturbance has been on powerlines, railways, and roads, with virtually nothing on seismic and pipeline rights-of-way. The only seismic and pipeline studies published relate to woodland caribou.

There are few post-construction studies on the impacts of pipeline rights-of-way. Prior to the construction of pipelines such as the Mackenzie Valley and Alaska Highway Gas Pipelines, several biological reports by consultants and government assessed the probably of impacts and provided baseline data (e.g. Artic Gas Biological Report Series). However, research during and following the construction of pipelines is largely restricted to the influence of the pipeline and associated disturbances on the movement patterns of migratory caribou herds and moose. In the published scientific literature, there is very little, and most is in the grey literature.

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Section 7E. Aquaculture - Intertidal bottom culture of Manila clams

Background

Manila clams (*Venerupis japonica*) were inadvertently introduced into British Columbia from Japan with seed of the Pacific oyster (*Crassostrea gigas*) in the early 1900s (Bourne 1982). The first specimens were found in Ladysmith Harbour in 1936 and quickly spread throughout Georgia Strait. After introduction into Barkley Sound, they also spread up the west coast of Vancouver Island (Quayle 1964). Intentional introductions to the North Coast and Queen Charlotte Islands failed to produce sustainable populations (Gillespie and Bourne 1998), and recruitment into the Central Coast is likely from pelagic larvae from northern Vancouver Island, perhaps Quatsino Sound (Bourne 1982). Manila clams achieved significant economic importance as a fishery on the South Coast in the 1980s and are currently the most important commercial wild-harvested clam species in BC.

The Manila clam culture began in an experimental manner in British Columbia in 1969, and continued as such until the early 1990's (Heath *et al.* 1992). Since 1990, commercial culture of Manila clams has been conducted in a relatively small area in B.C., mainly in those areas that were tenured for oyster culture prior to 1990 (Caine and Dickson 1992). Baynes Sound has become the leading growing area for Manila clams in BC, with licensed tenures covering about 492 ha, or 32% of the intertidal area by 2001 (Emmett 2002).

Threat description and potential impacts

The threats to the environment associated with intertidal clam culture arise primarily from a number of site treatments used to increase the production of Manila clams. These include modifications to substrate type, beach contours, wave exposure, predation levels, and clam densities. Additional impacts arise from competition with indigenous species, harvesting of the clams and the possible introduction of pests and disease during stocking.

Substrate type and modification

The ideal substrate for Manila clam growth and survival is a stable, loosely packed substrate consisting of gravel, sand, mud and shell. If intertidal shellfish tenure lacks adequate natural substrate to support Manila clams, there are methods for substrate modification that may be applied under appropriate circumstances, with permission from government agencies (Land & Water BC, DFO). Substrate modification generally involves placing gravel, or a combination of gravel and crushed oyster shell onto a soft (mud or mud-sand) or hard (packed cobble) beach area to create a substrate that approaches the ideal substrate for Manila clams (Thompson 1995). Other forms of substrate modification include the removal of wood debris and/or rocks that will interfere with fanning techniques.

There have been no direct studies on the impacts of substrate modification, however by examining comparisons of impacted sites with adjacent or nearby "reference" sites, it appears that graveling beaches probably affects the structure of benthic interstitial communities. These communities shift from those dominated by glycerid, sabellid and nereid polychaetes to ones dominated by bivalves and nemerteans (Simenstad and Fresh 1995). For epibenthic meiofauna, effects were related to the extent of natural substrate replacement by gravel. If gravel was completely replaced, biodiversity was depressed, but if there was not a total loss of sand and mud, an increase in habitat complexity occurred (Simenstad and Fresh 1995).

Beach Modification

In unstable areas or areas exposed to storm waves, the matrix of sediment fines that hold the gravel and sand together may wash away, leaving only an unsuitable, loose deposit of sand and gravel. Substrate stability can be enhanced by use of predator-exclusion netting and berms to lower wave energy. Vexar© fences are often used to hold oysters and protective netting may be used to assist in stabilizing substrate. Low boulder berms are sometimes placed 50-100m seaward of the clam plots (at or near zero tide level) to protect them from storm damage. Creation of such "improvements" requires approval within the tenure's Shellfish Development Plan by Land & Water BC. Other practices employed to stabilize the growing area are contouring the intertidal and the channelizing streams that flow through the plots; the latter practice is discouraged and requires prior DFO approval.

The construction of berms, placement of Vexar© fences, use of predator (car cover) netting, beach clearing and stream channelization all may alter the natural patterns of waves and currents resulting in impacts on the natural patterns of erosion and sedimentation in the intertidal zone (Spencer et al. 1997, Goulletquer and Trut 1999).

Predator control

To reduce clam seed predation by a variety of predators, such as bottom fish, crabs, starfish and sea birds, panels of light-weight, 1.25 cm (0.5") mesh plastic netting (car cover) or old seine or fish farm smolt-pen netting are placed over the seeded substrates. As with other improvements the use of protective netting requires approval within the tenure's Shellfish Development Plan by Lands & Water BC. Other forms of predator control involves the killing of animals such as birds, moonsnails and starfish, and requires a licence.

Predator exclusion netting and the removal and destruction of predator species such as birds, snails, crabs, and sea stars can have both a direct and indirect impact on the intertidal community structure. The removal and destruction/exclusion of predator species (e.g. snails, crabs, etc.) may shift the intertidal community from one dominated primarily by epibenthos species to that comprised primarily of clams (Bendell-Young and Ydenberg 2001). Surf scoters have been identified as a potential keystone species in these ecosystems, based on their role of removing large quantities of mussels, and thereby providing space for other species of intertidal invertebrates (Lacroix 2001). The removal of scoters as predators by the use of exclusion netting may therefore reduce biological diversity in intertidal habitats.

Population Levels and Competition: Planting Clam Seed

Since natural recruitment of clam seed into netted plots is variable, farmers spread hatchery seed to ensure a desired set. While Manila clams may occur naturally in the area, stocking will usually be from a different genetic stock than the “wild” clams. Clam seed used in the BC aquaculture industry comes from hatcheries based in California, Washington and BC.

The dispersal of large quantities of cultured Manila clam seed could have potential negative impacts on wild populations by modifying gene pools, increasing the risk of disease transmission, introductions of non-indigenous species that might alter food webs, and increasing competition for ecological niches (Kaiser *et al.* 1998).

Maintenance

Because tidal flats are not always accessible by boat, terrestrial vehicles are sometimes used to access lease areas. While the use of vehicles is discouraged, permission is granted for activities such as spreading gravel on beaches, moving materials into place, or retrieving bags of clams or materials. There is also significant human activity on the beach during periods of site preparation, seeding and harvesting. Maintenance using lights may take place during the night in winter due to the timing of the low tides.

Vehicle use in the intertidal will compact the substrate and can alter the drainage and surficial sediment matrix (DeGrave *et al.* 1998). This can impact on the intertidal vegetation and delicate infauna such as small-bodied crustaceans and shallow, fragile burrowing bivalves (Emmett 2002, DeGrave *et al.* 1998). As well, accidental discharge of oil and gasoline from vehicles poses a potential contamination threat to fish and fish habitat in the intertidal zone. Maintenance of leases by boats also has the potential to impact eelgrass beds by propeller wash, direct cutting action of propellers, and by boat hulls being dragging over vegetated bottoms (Short and Wyllie-Echeverria 1996).

Human activity at the site can disrupt nesting, roosting or foraging activities of coastal birds (Axys *et al.* 2000). This is a short-term local effect, but could be significant if the number and density of sites is high.

Harvesting

Clam harvesting is currently done exclusively by hand raking, with sediments being turned over to a depth of a few inches. Most harvesting occurs at night from October to March because of the occurrence of high tides during daylight hours.

Certain finfish species in BC spawn in the intertidal areas of beaches. These include smelt, herring, sandlance and rock sole. Harvesting activity during the period when these species are spawning or their eggs are incubating, could impact on their spawning success (Emmett 2002). Human activity on the beach may disturb birds and reduce their foraging time.

Clam harvesting can also disrupt the sediments – locally increasing sediment in the water, burying epibenthic species and exposing anaerobic communities ((Emmett 2002). Studies on hand raking of cockles indicate that effects may be significant for a year, but are unlikely to persist beyond this time-scale unless there are larger long-lived species present within the community (Kaiser et al. 2001).

Current Approach to Protection or Mitigation

Activity	Current Guidelines or Practices or Regulations	Agency(s)
Site selection	The issue of siting of shellfish farms will be dealt with in the Shellfish Development Plan. The Shellfish Development Plan contains the type and level of information to ensure shellfish farms are appropriately positioned relative to a number of factors: habitats, species, other uses or areas of high ecological value.	DFO Land & Water BC MAFF
Seeding	Appropriate relay permits and certification are obtained prior to moving shellfish.	MAFF
Vehicles on beach	Vehicle use in intertidal may only be allowable on substrate sufficient to support their use without damaging infauna or the substrate itself, and vehicles may not be used on designated sensitive intertidal areas. A DFO letter of advice or authorization may be required.	DFO
Predator netting; Vexar© fences	Can be installed at most sites subject to permission from Land & Water BC; in Baynes Sound predator nets will be 5/8" mesh (or less), and held taut by use of weights or anchors.	Land & Water BC
Beach gravelling, boulder cobble removal	Beach/foreshore modification requires an Authorization under Section 35(2) of the Federal Fisheries Act.	DFP
Stream channelization	Shellfish culture shall not be conducted within the braided intertidal channels of the Creek. No channelization or structure, which alters the naturally meandering nature of the Creek, is permitted.	DFO
Use of pesticides or antibiotics	Pesticides not permitted in B.C.; antibiotics are not used by the shellfish industry in BC.	DFO MWLAP
Predator removal	Lethal methods of predator control are not normally acceptable, and depending on species, may either be prohibited or require prior approval from DFO.	DFO CWS
Disturbance	Construction activities will be timed to ensure no impacts on plants/animals/fish occur (e.g. avoiding main herring spawning windows	DFO
Harvesting	All intertidal clam harvesting is done by hand in B.C.	DFO

Key Impact/ Threats that need Resolution

- The high concentration of clam leases in areas such as Baynes Sound could disrupt the natural ecosystem processes by changing sedimentation processes, removing or excluding molluscan predators, and through substrate modification (Jamieson *et al.* 2001).
- Changes to benthic epifauna or vegetation from modification of substrate or sedimentation processes may impact on focal species especially herring or chum salmon.
- Waterfowl (scoters, harlequin ducks and goldeneye) and shorebirds are at especially high risk from activities associated with clam culture (Axys *et al.* 2000). They are most effected by human disturbance, exclusion from foraging areas by predator netting, changes in the intertidal prey arising from predator removal, substrate modification and predator netting. In areas of waterfowl and shorebird abundance human activity should be limited during times when the species are concentrated and the use of predator nets limited.
- In areas such as small estuaries, clam culture could be impacting sensitive and high value marine ecosystem components. While clam culture is excluded from areas of eelgrass, it is possible that changes in the local sediment regime could impact on the productivity and health of nearby eelgrass beds. Buffers should be placed around beds of eelgrass and other coastal rooted vegetation. Use of vehicles on the beach should be limited (and eliminated where possible) especially in areas where there is rooted vegetation.

Information Gaps

At present, studies on the impacts of intertidal culture of Manila clams on the environment are relatively few. Much of what has been written is speculative, and there is a definite need for rigorous studies and evaluations. Additionally, there is poor understanding of the cumulative effect of many contiguous tenures combined with other secondary impacts such as changes in water quality, other alien species, and climate change. Studies are needed to better understand the threats that have been identified as being of potentially high impact, but for which there is inadequate knowledge. Key issues include:

- The effects of predator netting on feeding of waterfowl and shorebirds.
- The effects of predator netting on the sediment regime and the intertidal benthic communities.
- The effects of predator removal the intertidal benthic communities.
- The impact of vehicles on sediments and communities in various beach types.
- The cumulative effects of high densities of clam culture sites on the local benthic communities and associated wildlife.

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8.0 DISCUSSION

The objective of this work was to provide insight into the threats to biodiversity in BC, and the associated gaps in conservation instruments that allow those threats to translate into impacts on biodiversity. To meet this goal we have produced a number of primary and interim products that are summarised in the previous sections and various appendices. This section discusses some of the implications and limitations of the results, while the next section (Section 9.0) provides recommendations for updating and verification of this project, as well as suggestions for follow-up phases.

8.1. Assessment and Ranking of Threats and Impacts to Biodiversity

A primary outcome from this project is the ranked summaries of Threat Activities and Threat Categories based on their associated impacts in the Terrestrial, Marine and Freshwater Aquatic realms. If, based on available data and expert opinion, a particular activity is considered to have significant ecological impacts, then we assume that there must be a significant gap in terms of biodiversity protection in relation to that activity. As a result, the key activities for which protection instruments are lacking or ineffective are those that ranked highest within each realm.

The ranking of threats and impacts incorporated a number of approaches, including ranking based on the magnitude of the impact, on the extent of the impact, and on a combination of the two. Activities that ranked highest overall, also ranked high for both magnitude and extent. However, note that many activities rank high for either magnitude or extent, but not both. That is, they have severe impacts in a limited area, or the impacts are less severe but pervasive across extensive areas. Clearly, the activities that rank at the top for both magnitude and extent should be a priority for action, however this should not preclude action for specific impacts that are either severe and localised, or less severe and pervasive.

This report is intended to provide information at a strategic level. As such, an extensive approach to the task was taken, yet we maintained sufficient detail to ensure a credible basis for our conclusions. The core of the threats analysis is based on Assessment Tables, which were compiled using the maximum available information within the timeframe available: primarily expert opinion and a number of key datasets that informed expert opinion (Section 3.0 Step 3). The Assessment Tables provide a relative rating of the impacts of Threat Activities across ecological scales, and are appropriately rolled up into provincial or regional summaries. However, the Assessment Tables are not intended to provide detailed assessment of all impacts of all Threat Activities for every locale in the province. Rather the work we present here should be viewed as a framework that can be rolled up to show provincial and regional *patterns*. Using the framework for analysis at a finer scale would require detailed review and verification at regional and local levels, and likely a definition of a finer basic assessment unit, potentially at both the ecological unit level and the geographic scale (see Section 9.0 for recommendations on potential follow-up work).

In developing the Assessment Tables, we ranked Threat Activities based on the severity, reversibility and extent of their impacts. We gamed with a variety of approaches to ranking, including using weighted criteria (e.g. giving higher level ecosystem impacts such as ecosystem processes an increased weight in the ranking over lower level impacts such as individual habitat elements), or weighting only impacts greater than a specific level (e.g. values > 4), to give additional weight to 'severe' impacts. However, for a final approach we used an additive non-weighted ranking procedure because we found that impacts at higher ecological levels generally had cascading impacts recorded at lower levels, and therefore did not require weighting to be ranked higher. We noted in trials of different permutations of ranking procedures that in fact, major differences in ranking results were not seen as a result of different ranking procedures; although some threat activities did change their individual ranking order, the group of activities in the top portion of the ranking generally did not change significantly. Although we believe that, in general, negative impacts on processes are more likely to have long-term cascading impacts on habitat elements, species and genes, we did not want to overly downplay the significance of impacts primarily acting at these lower levels.

The ranking process did not directly employ the Persistence of Threat Activities, nor the Strength of Evidence linking the activities to the impacts. Instead we use these as accessory characteristics to inform the user of the broader issues related to each of the activities. These attributes were not considered to be as significant as the primary criteria related directly to the significance of the impacts themselves.

Across all three realms, there is a general dearth of information regarding genetic impacts from particular activities, except for a few notable exceptions (e.g. the potential genetic impacts of aquaculture employing non-native species and/or stocks). Genetic impacts have the potential for serious ecological impacts. For example, can fragmented populations of species retain sufficient genetic diversity to remain robust and adapt to rapidly changing landscapes? In recent studies in the Pacific Northwest, northern flying squirrel populations inhabiting highly fragmented forested landscapes had lower genetic diversity than those in a forested landscape with few barriers to squirrel movement, and a population decline caused by commercial thinning resulted in a 1/3rd reduction in genetic diversity for an individual population (Carey 2000; PNW 2003). For this species, which is highly vagile and also promiscuous, the gene pool is fast to rebound (USDA 2003), but the potential impacts of such changes on less mobile or K-selected species over the long-term could be cause for significant conservation concern. Although genetics are likely a key factor in maintaining biodiversity through time, especially under climate change scenarios, we could not find sufficient data to adequately assess the impacts on genetic code and as such this area currently constitutes a significant gap in our work to date.

8.1.1. How significant are threats to biodiversity?

Our results have presented relative rankings of Threat Activities and their impacts on biodiversity in three realms in BC. But do we know that these impacts are real and significant, and that they are in fact negatively impacting biodiversity in this province?

To answer this question, we assessed data from the BC Conservation Data Centre (CDC 2002) on red- and blue-listed vertebrates, plant species and ecosystems. We examined and reclassified the rationale for listings into one of the 18 Threat Categories used in our report. In reviewing the available rationales, we noted that many species listed (and most plants) do not have an identified cause of decline, and only a small percentage are actually listed as having an *unknown* cause for decline (4 vertebrates and 2 plant species; Table 13). Of those with a stated decline agent the largest number of species are primarily impacted by agriculture, forestry, urban (and some rural development – although it is difficult to differentiate), harvesting and non-native species. Of listed ecosystems identified in this dataset, the majority of stated causes are forestry related (83), grazing (20), rural / urban development (22) and non-native species (15).

Table 13. Summary of rationale for listing by CDC. (CDC 2002).

Threat Class	Birds	Mammals	Amphibians	Reptiles	Freshwater Fish	Plants	Ecosystems	Total
AG	32	19	3	7	3		6	64
AQ	2							2
CC	4	1	1					6
DA	2	3	1		10	6	2	22
FC	32	22	5	1	2	1	83	63
FP	4							4
GR	13	5	2		1		20	21
HA	15	14	1	6	4	14		54
IN	10	5	1		2			18
ME	2	6			3			11
NS	17	5	3	3	9	3	15	40
OG	24	2			1			27
RD	3	6	1	2	2	10	2	24
RE	5	20		1		9	6	35
TC	6	10	3	4	2	3		28
UD	28	16	3	6	7	2	19	62
Unstated, or unknown	12	16	1	2	21	580	151	632
Total # Listed	104	69	9	11	48	625	263	866

Although this is an incomplete list (given the lack of identified Threat Activities) it provides substantiation that the Threat Activities we identified as ranking high are in fact having severe impacts on species and ecosystems, even given the relatively recent state of industrial development in BC.

Similar (or complementary) approaches to assess the status and needs for conservation have also been used by many others in North America and globally. In a Status of Biodiversity for the United States, the Association for Biodiversity Information, and the Nature Conservancy have collaboratively compiled an impressive array of information on biodiversity values and the potential impacts caused by a variety of human activities (Stein et al. 2000). In this report they identify the geographic patterns of diversity, rarity and endemism within the US, and comment on the leading threats to imperilment.

Using broad categories of threats – habitat destruction, overharvest, pollution (including siltation), alien species, and disease, this group assessed nearly 2500 imperiled and federally listed species to determine how each one is impacted by each category. They note that formalised information was difficult to obtain, so they made their assessments based on a combination of the Federal Register (which summarises known information for listed species), and also used interviews with experts across the country. They succeeded in assigning a threat group to approximately 75% of the species originally listed, with success rates ranging from 97% for mammals and birds down to 54% for dragonflies. Threat information was available for 71% of plant species included. Their results (in general agreement with those obtained in our study) identify habitat destruction and degradation from a variety of causes as being the predominant threat to US species, and contributing to the endangerment of 85% of species assessed. Impacts of alien species (predation by, or competition with) ranked second highest, impacting 49% of all species. This was followed by 24%, 17% and 3% impacted respectively by pollution, overexploitation and disease (Fig. 12).

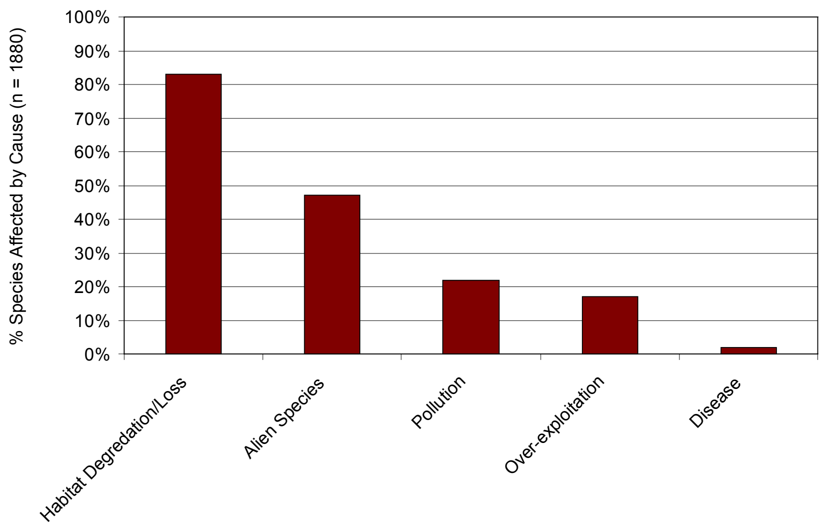

Figure 12. Major threats to biodiversity in the US (taken from Stein et al. 2000).

Stein et al.'s assessment also identified variability across and within realms as to the impacts of threats – for example, habitat degradation and loss impacted all groups equally, although alien species predominantly impacted plants (57% compared with 39% of animals) and island animal species (on Hawaii in particular) were disproportionately impacted by alien species. Marine / freshwater aquatic species were highly impacted by pollution (which included siltation in this analysis). Due to the high impact of habitat loss impacts, Stein et al. (2000) further separated the effects within habitats – creating groups that largely mirror those in this study. Of eleven groups (see below), agriculture affected the largest number of species, followed by land conversion for commercial development, water development, outdoor recreation (particularly offroad vehicles) and livestock grazing (see Fig. 13).

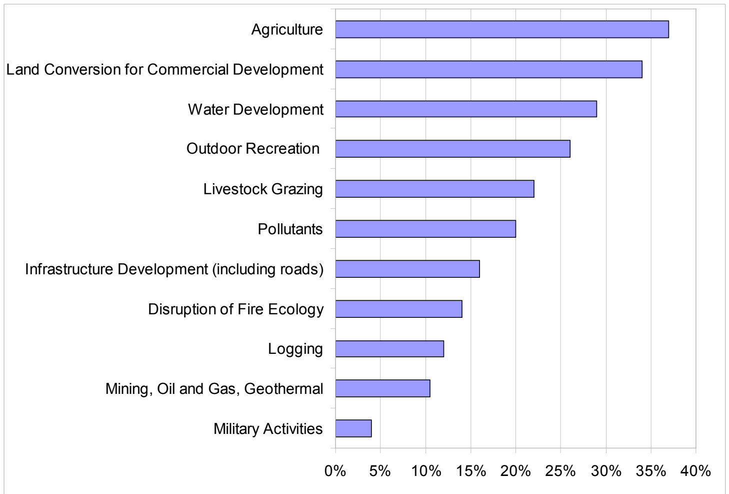

Figure 13. Importance of various forms of habitat degradation to biodiversity loss (taken from Stein et al. 2000).

A slightly different approach was taken in a summary of Endangered Ecosystems in America where Noss and Peters (1995) summarised the ecosystems of North America that were the most rare, contained the most endangered species, and were considered most ‘at risk’ from future human activity. From this assessment, they summarised the 21 most endangered ecosystems in the US, developed from a combination of a risk index and a development index. Ecosystems rank high on this list if they have greatly reduced in size since European settlement, have many threatened species, or if the probability of continuing loss is high – such an example would be the California coastal sage scrub which has been heavily impacted by urban and rural development. In summarising endangered ecosystems, they also emphasise that 117 million ha of wetlands (50% of the original prior to European settlement), 25% of Northwest old forest (90% of the original), and almost all the original grasslands have disappeared. They note that 27 ecosystem types have lost more than 98% of their original area, and for these and many others, what remains is being further degraded by a combination of threats, such as the pressures on grassland ecosystems by fire suppression and livestock grazing.

They note that global climate change will likely become the largest future threat, but has not yet had its major impacts. The largest current threats to ecosystems are summarised as habitat destruction (responsible in part for 95% of listed species), introduction of non-native species, fire suppression, recreation and environmental toxins. They also point out that hunting pressure has the potential to be a large threat, but in fact is currently sufficiently well regulated that it is not a significant threat. Under habitat destruction, agricultural development and urban development have the highest impacts, and in less developed areas of the US grazing and forestry activities also contribute significantly to direct habitat loss and species extinctions.

In our work, we took a somewhat different approach to the single species approaches outlined above. It is recognised that single species information is often lacking, and in a province where intensive development has occurred for a shorter time period, there are opportunities for preventing the general species extinctions that have already occurred in many countries with a longer history of industrial development. Hence our attempt to incorporate the potential impacts of broader scale process changes of individual threats, assuming trickle down effects through ecosystems.

8.2. Instruments for Protection of Biodiversity

Section 6.0 summarises our compilation of the regulatory and non-regulatory instruments presently in use or potentially available for the conservation of biodiversity. The following two subsections discuss the results and some of their limitations and implications.

8.2.1. Regulatory Instruments

We specifically assessed regulations and statutes in effect in as of December 2001, since the regulatory framework of many activities in BC is currently in flux. However, it was still difficult to assess the impacts resulting from changes made to the regulatory framework as recently as the late 1990s, because it can take as many as 5 years for some elements to be fully implemented, and as many years for the impacts of particular activities to become obvious. With the many ongoing changes to legislation and regulation now in progress, it is very difficult to predict their future effectiveness at controlling activities detrimental to biodiversity.

Although Section 6.0 provides a relatively robust compilation of available regulatory instruments for the conservation of biodiversity, the presence of legislation or regulations does not ensure biodiversity protection, and many of the regulatory instruments have only peripheral impacts. Even where the emphasis of an act or regulation is on biodiversity, the degree of effectiveness can vary greatly, depending on policy direction, enforcement resources and other practicalities.

It was agreed with MWLAP that a thorough assessment of effectiveness of all potential biodiversity protection instruments was outside the purview of this project; however, the summary of instruments itself identifies some initial issues. Biodiversity protection from a legal perspective is dealt with in a piecemeal fashion, and often as a by-product of general legislation regulating a particular activity or industry. As a result, there is no coordinated approach – which is clearly a problem given the linkages between elements of biodiversity. Section 9.0 provides suggestions regarding an approach for a more detailed assessment of the effectiveness of various conservation instruments.

8.2.2. Non-regulatory Instruments

One of the primary concerns with non-regulatory measures is their uneven distribution, not only geographically, but also across sectors, and most importantly among the various components of biodiversity. Because many non-regulatory instruments depend on public support, they tend to emphasise issues and biodiversity elements that are important to people economically, as public health or safety issues, or affect them emotionally. These types of issues often do not correspond to the priority issues for the conservation of biodiversity in general. The level of public support at any given moment is also dependent on how the public rates biodiversity conservation issues relative to other issues that may be affecting them at that time, whereas many conservation issues demand long-term programs with ongoing commitment.

The most extensive non-regulatory programs in British Columbia relate to crown forested lands where numerous certification schemes, education, advocacy and research initiatives apply. Education and advocacy are closely linked to park proposals, but silvicultural systems, riparian issues, road networks, and stand structural modification have also received considerable attention. Land trust organisations and some environmental groups have targeted private forestry, and considerable research occurs on private lands where large forest companies invest in their own properties. Stewardship groups, land trusts, municipalities, and regional districts are generally only peripherally involved in threats related to forestry on crown lands. Many non-regulatory programs relating to forestry focus on the public opinion realm.

Oil and gas development, mining, hunting, recreation, transportation and other linear corridors, aquaculture, and agriculture receive the least attention from non-regulatory programs. Individual mining, road building, recreation or hunting issues occasionally garner widespread attention, but there are no programs covering the full extent of the province or these threats. Within the agriculture sector, pesticide use has received considerable attention, and environmental education and advocacy groups (such as the David Suzuki Foundation) have recently taken a strong interest in aquaculture. Dams are poorly addressed outside of the Columbia Basin and Peace-Williston Fish and Wildlife Compensation Programs (which are a partnership between BC Hydro and the provincial government). Rural and urban development are also poorly addressed by non-legislative programs, although most municipalities and regional districts have a policy and planning framework in place.

Local stewardship groups have the potential for positive impacts on biodiversity, although there are several limitations to their success. Community capacity and the geographic distribution of projects are the most limiting factors for successful implementation of stewardship programs for biodiversity in British Columbia. A study of biodiversity initiatives in the Greater Vancouver Regional District (AXYS Environmental Consulting 2002), reported the following challenges facing stewardship groups: 1) urban/rural development is proceeding faster than conservation initiatives, 2) there is not enough funding for grassroots initiatives, 3) political will towards conserving biodiversity is lacking in local governments, 4) bylaws and regulations are lacking or not enforced, and 5) private landowners are difficult to work with, uncaring and/or uninformed. While these general issues face most stewardship groups, biodiversity needs, community initiative, and financial resources differ across the province and are related to social, economic, and environmental conditions.

Most of the stewardship groups listed in Harper's (2002) annotated catalogue are located in the Lower Mainland, southern Vancouver Island or other highly populated areas. Outside of these cities, many communities lack people with the skills necessary to organise, fundraise and implement projects for biodiversity enhancement. Stewardship groups depend on volunteer labour, as well as donated supplies, machinery, etc., but not all communities have equal access to these resources and socio-economic factors play an important role in the distribution of local stewardship projects. Because stewardship groups are volunteer-driven, they rely heavily on personal interest and their success is often linked to personalities and an ability to work as a team. Difficulties are encountered where there is no skilled leadership or where community members do not want to work with those instigating the project (i.e. they are motivated and skilled, but difficult to work with).

Even where capacity is not a problem, stewardship programs may fail to enhance biodiversity values because of their focus. Most projects are based on people's interests, not necessarily on biodiversity needs. Many projects undertaken at a local level relate to recreation or 'charismatic megafauna' (attractive fish and wildlife) and may not be scientifically defensible. Projects such as removing debris from creeks (while increasing kayaking values), stocking mountain lakes with non-native fish species, or re-vegetating lands with exotic species may be initiated with good intentions, but result in further damage to biodiversity. Education is required to increase the level of participation and concern regarding local stewardship projects as well as the nature of the projects.

The type of project, as well as the capacity to complete it will vary, but in general all projects are more likely to be undertaken if they are close to or within communities, even if the most pressing biodiversity issues are more distant. This is particularly important in the BC context since the vast majority of the province is sparsely populated and biodiversity needs outside of major centres are less likely to be addressed by stewardship groups.

According to AXYS Environmental Consulting (2002), partnerships between NGOs, business and government are generally the most successful because they combine skilled and knowledgeable project direction with volunteer involvement and local 'ownership' and continuity. First Nations involvement in stewardship programs is also very important. Some partnerships exist between First Nations and NGOs or governments, but there is no record (to our knowledge) of where, how many, or how successful these are. Schools are another important target group for partnerships (as identified by AXYS Environmental Consulting 2002), but are likely to impact small areas close to their facilities (i.e. butterfly gardens, garbage pick-up, some stream projects, etc). The potential for partnerships between industry and the Ministry of Water, Air and Land Protection through the Forest Investment Initiative (FII) were recently assessed (Ackhurst Group 2003). Such corporate partnerships may address some biodiversity needs, but are likely to emphasise a given company's operating area and will fail to address biodiversity needs where the mandate between industry and MWALP differs.

9.0 RECOMMENDATIONS

9.1. Project Next Steps

9.1.1. Assessing and Ranking of Threats to Biodiversity

As a result of our insights gained while compiling and assessing information, and as a result of feedback from Ministry staff after presentation of methodology and preliminary results, we have the following suggestions as this project moves into future phases.

- Our approach provides a framework for ranking threat activities in terms of their impacts, at provincial and regional scales. It was based on available data sets and expert opinion. We recommend gathering additional information for verification and updating of Threat Activities and impact information from regional staff, specialists and other stakeholders through a series of targeted interviews, invited written reviews, and/or a series of regional workshops.

- We suggest that the framework be reviewed in light of internal comments garnered from MWLAP staff, other specialists and stakeholders. Specific areas to consider include the structure of the Threat Categories and the Threat Activities (e.g. Non-native species, riparian/ wetland disturbance, access-related issues, independent power production projects), as well as the geographic groups and ecological units used for assessments.
- Potential future threats and impacts were not well accounted for in our assessment. For example, oil and gas tanker routes received a low ranking in the marine realm because there has not yet been a large-scale spill on the BC coast. However, the potential impacts of a large-scale spill may have extremely significant ramifications and should be included in this assessment. Additionally, because many policies and regulations are currently under review, the scope and extent of many activities that impact biodiversity are currently changing – for instance there has recently been a large increase in the number of proposals for Independent Power Production projects. Because they have not been approved, they are difficult to assess as potential impacts, although they may have large impacts to biodiversity in the future. Again, these are not adequately incorporated into our analysis. We recommend an update to our assessment system that specifically identifies potential future threats and their potential impacts.
- As future reviews and input by regional and local specialists are received it may be advisable to add another ‘tag’ for each row in the Assessment Tables – one that identifies our certainty that the information in that row is correct. This would be helpful to future users to clearly identify areas where the information is of varying reliability.
- We have provided a few examples of how to present the results of our assessment. However, the basic assessment data, as well as the ranking outputs could be rolled-up in various ways to meet the needs of a variety of users. For example, we decided to focus on identifying threat activities and their impacts in different ecosystems, rather than organising by ecosystem or ecosystem element and identifying which combination of threats acts there. It would be possible to present results in these alternative formats – e.g. to take a particular ecosystem (e.g. the intertidal in the marine, or wetlands in the freshwater aquatic, or a particular biogeoclimatic variant in the terrestrial) and number and rank the threat activities occurring there (see Fig. 14 for example).

Top Ranked Threat Activities Impacting Wetlands

CC Climate change
NS Non-native species
AG Cultivation
RE Motorised terrestrial
UD Habitat conversion
RE Motorised aquatic
AG Hydrologic feature modification
TC Highways
RD Habitat conversion
GR Soil modification

Figure 14. Repackaging the results in alternative formats. An example of threat activities impacting wetlands

- Additionally, it would be possible to reorganise our Threat Activities into different categories or groups. For example, the Threat Activities could be repackaged into different classes – for example, all roads or trail information would be compiled and analysed as ‘access’. Simply a different way of viewing our results.
- Having NS non-native species as a specific Threat Activities is somewhat of a misnomer. Generally in our analysis we attributed invasion of non-native species to their associated activities – for example, use of motorised off-road vehicles in the grasslands had a relatively high impact because they provide a conduit for movement of non-native species. However, we also had an additional category of non-native species because many non-native species can no longer be attributed to a particular activity, yet are still invading and impacting habitats (e.g. gorse on Vancouver Island, or marsh plume thistle invading wetlands in the interior cedar hemlock forests of the central interior). Although we attempted to avoid any ‘double-counting’ of impacts, it is possible that some impacts were attributed twice. The more detailed assessment of invasive species (Rankin in prep.) should provide sufficient detail to allow a further drilling down into this issue in future.
- Impacts resulting from Threat Activities and Threat Activities themselves could also be characterised in relation to how they relate to society’s expectations to better link them to regulatory and non-regulatory instruments. For example some activities have focussed, direct and intentional impacts on species and populations (e.g. hunting, fishing, commercial harvest, pest control), while others have similar direct and intentional impacts on ecosystems and habitat elements (e.g. forest harvesting, agricultural clearing, urban development). These impacts are in fact supported by many in society, and not likely to be eliminated, but they can be regulated with regard to location, geographic extent and intensity. Some of the other impacts are essentially considered to be collateral damage, or the “cost of doing business” (e.g. fishing “by-catch”, snag falling, migratory fish loss due to dams, regulated pollution). These types of impacts also are unlikely to disappear, but can be effectively reduced through better regulation of the activities, or more robust cost-benefit analyses and mitigation. Lastly, there are the accidental or unintended impacts (e.g. oil and other pollution spills, some non-native species introductions). In theory these are less controversial to control, and they can be significantly reduced through better planning, tougher regulation and enforcement.

9.1.2. Further Assessment of Conservation Instruments

Section 6.0 summarises our compilation of the regulatory and non-regulatory instruments presently in use or potentially available for the conservation of biodiversity. However, the presence of regulatory and non-regulatory instruments alone does not ensure biodiversity conservation. Section 7.0 provides a series of examples of the analyses required to identify and define specific gaps in our toolbox of conservation instruments. Once specific high priority gaps have been characterised based on an in-depth analysis of their impacts and causal threat activities, then there is a need to assess the various instruments cross-referenced to those threats and to evaluate both their potential and their actual effectiveness in meeting biodiversity conservation needs. Additional analyses could also assess instruments that are effective. The results of these analyses will help frame the discussion around finding solutions to filling the gaps. A start to this was undertaken previously (D. Romaine pers. comm.) and is available to jump-start this process.

A detailed assessment of regulatory and non-regulatory instruments is beyond the scope of this project, however, we provide the following comments on a possible approach to this work in a subsequent phase of this program. A credible and more detailed assessment will require input from persons with a range of expertise, including:

- persons with legal expertise to examine legislation and regulations with regard to their scope, limitations, and the legal history of their success in actual applications;
- specialists in ecology, ecosystem processes, conservation biology and various related aspects of terrestrial, marine and freshwater biology to evaluate the significance of impacts and the key factors essential to conserving biodiversity in a particular situation; and
- regional and local planners, managers, enforcement staff and stakeholders to comment on the success and failures of actually using specific legislation or regulations in on-the-ground efforts

to conserve biodiversity.

We would recommend gathering information from regional staff and stakeholders through a series of targeted, invited written reviews, and/or a series of regional workshops. This process would be combined with the interviews, review and/or workshops described in Section 9.1.1for verification and updating of impact information.

To explore an approach to such an assessment, we examined the effectiveness of provincial forestry legislation and regulations (see Table 14). We caution that is was a brief overview based on expert opinion and is only intended as a preliminary example of a possible *approach*. Using this approach, overall effectiveness was evaluated in the initial step, where legislation is given one of the following ratings for each Threat Activity: effective, ineffective, questionable, or unknown. If a more detailed assessment of conservation instruments is to proceed, we recommend a two-tiered approach, assessing both the overall effectiveness of the instrument and, in the case of ineffective instruments, attempting to describe the root cause of the ineffectiveness.

The following are an example of criteria for the instrument effectiveness portion of the assessment:

Class	Characteristics
Fully Effective	Instrument ensures that Threat Activity results in no significant impacts (may be rare in this assessment, as essentially no impacts would be found).
Partly Effective	Instrument significantly reduces potential impacts of Threat Activity, but a few significant impacts still occur.
Minimally Effective	Instrument has some positive effects, but many significant impacts still occur.
Ineffective	Instrument has some potential, but has little or no effect on reducing impacts.
Unknown	Instrument has some potential, but not enough information is available to assess its effectiveness.

The following are an example of criteria for the description of causal factors related to ineffectiveness:

1. Instrument has no significant limitations
2. Legislation/regulation moderately strong - implementation and/or enforcement not consistent
3. Legislation/regulation strong, but a lack of implementation and/or enforcement
4. Legislation/regulation is weak - thresholds too low and/or requirements too vague
5. Legislation/regulation inappropriate - appears to be inconsistent with ecological principles
6. Legislation/regulation strong, but a lack of implementation and/or enforcement
7. Program has strong potential, but implementation is limited to only a few locations
8. Program is strong, but limited by lack of funding
9. Program is strong, but scope is very narrow
10. Program has strong potential, but implementation is limited to only a few locations
11. Program is limited by lack of buy-in by key stakeholders
12. Program has a complex set of problems that limit it from reaching full potential
13. Program is weak or too vague, with likely few tangible results
14. Insufficient information to evaluate cause of ineffectiveness

Table 14. Draft effectiveness rating of provincial forestry regulations based on professional opinion, as an example.

	FC	FC	FC	FC	FC	FC	FC	FP	FP	FP	FP
Provincial Forestry Legislation/ Regulations	fire control	landscape level modificn	ocean log handling	riparian disturbance/	roads	stand structure modificn	silviculture	landscape level modifications	riparian disturbance/	roads	stand structure modificn
Forest Act		1	4		4						
Cut Control Regulation		4									
Designated Areas Under Section 169 of the Act- Notice		3									
Innovative Forest Practices Regulation		4		1	4	1	1				
Log Salvage Regulation for the Vancouver Log Salvage District			2								
Forest Land Reserve Act		4									
Forest Land Reserve Procedure Regulation		4						4			
Forest Land Reserve Use Regulation		4						4			
Private Land Forest Practices Regulation								2	1	2	1
FPC Act		2		1		2	2			4	
Bark Beetle Regulation		4				4					
Community Forest Regulation		4		4				4			
Forest Fire Prevention and Suppression Regulation	1	4									
Forest Road Regulation		4			4						

	FC	FC	FC	FC	FC	FC	FC	FP	FP	FP	FP
Provincial Forestry Legislation/ Regulations	fire control	landscape level modifications	ocean log handling	riparian disturbance/ modification	roads	stand structure modifications	silviculture	landscape level modifications	riparian disturbance/ modification	roads	stand structure modifications
Forest Service Road Use Regulation					4						
Health, Safety and Reclamation Code for Mines (Part 11) Exemption Regulation					4						
Operational Planning Regulation		1		1	4	4	2				
Provincial Forest Use Regulation		4						4			
Range Practices Regulation				4							
Silvculture Practices Regulation				2		2	2				
Strategic Planning Regulation		3									
Timber Harvesting Practices Regulation				1	4	4					
Tree Cone, Seed and Vegetative Material Regulation						4	4				
Woodlot Licence Regulation		4		1		4	4				
Forest Stand Management Fund Act						3	4				

1: Leg/reg innappropriate - inconsistent with ecological principles
2: Leg/reg weak - low thresholds, weak requirements
3: Leg/reg strong -lack of implementation or enforcement
4: Insufficient info to assess effectiveness

9.2. Providing a foundation for a BC Biodiversity Strategy

Our work, in combination with that of others (e.g. Nicholson in prep.; Rankin in prep.), is intended to lay the goundwork for development of a Biodiversity Strategy for BC. The following discussion provides some context for development of a strategy and recommendations for approaches to strategy development, incorporating information from others similar to that produced in this project.

In light of Canada's participation in various international agreements that highlight biodiversity conservation, the Canadian Society of Zoologists undertook a process to identify key opportunities, issues and problems associated with biodiversity conservation (CSZ 2002). In particular, they identify the need to recognise:

- loss of biodiversity and habitat (local, regional and global),
- loss of biodiversity expertise,
- ignorance of the consequences of biodiversity loss,
- absence of dedicated funds for research on the factors that influence and maintain biodiversity,
- inadequate inventories of existing biodiversity,
- inadequate resources to maintain biodiversity information (collections and databases),
- lack of coordination among multiple, independent and inadequately funded single-focus biodiversity initiatives, and the
- absence of a national strategy to conserve habitat and prevent future reductions in biodiversity.

The Zoologists also identify a number of key challenges that need to be met if biodiversity conservation is to be successful:

- modelling: - predicting global change impacts on biodiversity (e.g., climate change, fragmentation, globalisation, human population growth and urbanisation);
- designing strategies to reduce biodiversity and habitat loss – developing sound, cutting edge science in aid of conserving and restoring biodiversity;
- ensuring inclusivity – adequately conserving all groups of organisms (functional and taxonomic) in both protected and working landscapes;
- coping with constitutional constraints – accommodating jurisdictional issues without compromising habitat protection;
- putting policy into action – ensuring that science is effectively applied, by linking scientists, managers and policy makers to help meet our national and international biodiversity obligations (CSZ 2002).

In writing a draft strategy to protect biodiversity in North America, the North American Commission for Environmental Cooperation (NACEC; 2001) premise their work on the knowledge that "a great deal of North American biodiversity is in peril ". They identify four broad categories for the major threats to biodiversity including those having to do with: major ecological impacts of human activity, constraints in decision making, lack of knowledge and ineffective conservation planning and resource management. Action plans within their strategy are prioritised basedon the biological urgency of issues, the possibility of taking advantage of unique opportunities, and the potential for concrete actions and results within a set time frame.

Preliminary recommendations from the NACEC strategy include:

- recognise the ecological seriousness of the problem and invest in applied research that looks at the key factors contributing to the problems;
- assess, evaluate and monitor the State of North American Biodiversity every 3-5 years;
- focus on habitat protection not single species needs;
- only focus on single species if they play keystone or umbrella roles;

- focus on a small set of ecoregions where the Commission for Environmental Cooperation could have great success;
- focus on invasive species;
- buffer and connect (through corridors) public and private lands surrounding biodiversity conservation core areas (i.e. parks/ protected areas);
- incorporate the unique perspective, knowledge and needs of aboriginal people;
- help develop appropriate incentives for biodiversity conservation; and,
- develop harmonised laws and regulations for biodiversity; develop and make available information for decision makers (NACEC 2001).

The products of this project mesh well with recommendations from the NACEC. Our results provide information regarding the identification of key factors contributing to biodiversity impacts, recognition of where ecosystem processes, habitat and species are the prime concerns, which geographic regions are most threatened and by what activities, the existing regulatory framework affecting biodiversity conservation and examples of how to present the information to decision-makers and managers.

9.2.1. Conclusions

This project has identified 84 threat activities that have had, are, or potentially will have significant detrimental impacts on biodiversity across the province. In addition we have identified specific parts of the province, the lower mainland, southern Vancouver Island and the Okanagan, where impacts are particularly severe due to increasing human population and concentrations of industrial and agricultural development. The biodiversity implications of expanding that scale of development over increasing parts of the province are visible in the US (e.g. Noss and Peters 1995). However, BC still has an opportunity to reverse these trends. Hopefully the results of this project will provide a basis for development and implementation of a biodiversity strategy that begins to seriously address the many impacts and gaps in biodiversity conservation highlighted here; a strategy that will ensure fulfilment of MWLAPs' goal to "maintain and restore the natural diversity of ecosystems, .. species and their habitats."

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