



**TECHNICAL SUBCOMMITTEE
COMPONENT REPORT**

MAJOR IMPACTS TO BIODIVERSITY IN BRITISH COLUMBIA (EXCLUDING CLIMATE CHANGE)

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FOR: THE BIODIVERSITY BC TECHNICAL SUBCOMMITTEE
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MAJOR IMPACTS TO BIODIVERSITY IN BRITISH COLUMBIA

(excluding climate change)

A REPORT TO THE CONSERVATION PLANNING TOOLS
COMMITTEE

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1.0 INTRODUCTION

As we rounded the south point of the tiny island, what I thought were lumpy black rocks turned out to be a fine herd of massive California sea lions. The air above us was now thick with glaucous-winged gulls, harlequin ducks, surf scoters, ravens and crows. Gawky double-breasted cormorants festooned the rocks, and bonded pairs of oystercatchers picked delicately along the shoreline. An eagle passed overhead, and as it did so, hundreds of nesting birds swarmed, herding the predator away from their rocky nursery. As we steered our boat in toward a small bay at the north end of the island, we passed a clutch of fat harbour seals. The astounding biological abundance continued as we stepped ashore. Drifts of pink sea-blush, interspersed with yellow monkey flower and blue camas, were strewn artistically across the rocky slopes. In depressions where soil and water accumulate, there were tiger and chocolate lilies, alumroot, saxifrage, brodiaea, Saskatoon and Pacific sanicle. The dry rock basins harboured prickly pear, whose fragile yellow blooms contrasted with their aggressive spines.

These notes are from a brief visit to Mitlenatch, an uninhabited islet in the Gulf Islands group, near Campbell River. They describe a mere sampling of the incredible diversity of the islet's lifeforms. To do justice to the flora and fauna of Mitlenatch I would need a few weeks, armed with skin-diving gear, binocular microscope and field glasses. Even then the result would still be a partial catalogue.

Mitlenatch is just one example of the biological abundance which our Province contains. British Columbians are becoming aware of that unique richness, and at the same time are realizing their stewardship responsibilities. A key element of stewardship, and a fundamental measure of biological richness and ecosystem health, is a concept called *biodiversity*. Biodiversity, and its impacts, is the subject of this Report.

The Report was commissioned by the Conservation Planning Tools Committee¹, a consortium of Ministries and ENGO's with a conservation mandate. This Report will become part of the larger Biodiversity Status Report, which will be used as a basis for the development of a Biodiversity Action Plan. It is important to note that climate change impacts on biodiversity is addressed in a separate background report, and is not addressed directly in these pages.

Biodiversity is not only a challenge to maintain, it is a challenging concept to define. First coined in 1980, we have been in almost daily contact with the word for over twenty-five years. Yet it remains a vague concept for the average person, and even among scientists, there are widely differing interpretations.

The working definition of biodiversity used in this Report is "the variety of species and ecosystems and the ecological processes of which they are a part—including ecosystem, species and genetic diversity components." The highest conceptual level of biodiversity is the number of different ecosystems within a given area. Next is the number of species

¹ Also known as the Biodiversity BC Steering Committee

within a specific ecosystem or site (this level is also known as alpha diversity), and the lowest level of biodiversity is the amount of genetic diversity within a population of a single species. These three categories or levels are somewhat arbitrary—we could just as easily come up with two or twelve—but they are useful for describing and managing biodiversity. The individual levels of biodiversity are like Russian dolls: one level is nested within the next one above it, and so on.

The term biodiversity itself is not spatially specific; it can be used to describe the biological characteristics of a pond, or of a continent. Biodiversity can also be described not by genes, species and ecosystems, but on the basis of functional types. For example, moose and caribou are separate species, but their ecological function—large herbivores—is the same. Functional biodiversity is a less common approach, but has the advantage of focussing on ecological processes—herbivory, nitrogen fixation, predation, etc—rather than cataloguing genes, species and ecosystems. However, this Report will confine itself to the conventional approach.

Although the results are often visually obvious, there is a paucity of quantitative data linking various environmental impacts to permanent, or even temporary, decreases in biodiversity. Loss of habitat through land conversion presents a clear, quantifiable case, but linking less dramatic impacts—for example connecting pesticide use or invasive plants to biodiversity losses—is much more challenging.

One crude method of monitoring biodiversity loss is to track fluctuations in the number of species on the Federal and Provincial species at risk lists. However, species additions to the various lists often occur as a result of recent monitoring or research rather than as a result of actual declines in population size or range. So it is not an entirely accurate barometer.

2.0 DESCRIBING IMPACTS ON BIODIVERSITY

In my review of the literature and discussions with biodiversity practitioners, it became clear that cataloguing the impacts on biodiversity in British Columbia could be approached in several different ways. The basis for this difference lies in the concepts of “proximate cause” (the specific biophysical event that causes the loss of genetic, species or ecosystem diversity) “intermediate cause” (the human act that triggers the biophysical event) and “ultimate cause” (the underlying economic, social or policy reason motivating the human act). For example, the proximate cause for the decline in a particular fish population might be excessive siltation of gravel beds where they customarily spawn. The intermediate cause of the decline could be a hydroelectric dam upstream of the spawning bed, which has reduced the volume and velocity of the spring freshet that normally flushes silt out of the gravel. The ultimate cause, in this same instance, is the human demand for electrical energy. Much of our current attention is focussed on proximate and intermediate causes.

Impacts on biodiversity are also a matter of degree. Stepping on an ant is theoretically an impact on biodiversity, but we deem it to be insignificant. At the other end of the scale, there is general agreement that we have severely damaged the life of the Columbia River with an excessive number of dams on its main stem and tributaries. Somewhere between these two extremes lies the notion of sustainability—that ecosystems and biological processes are able to tolerate and absorb certain thresholds of human activity, but above those thresholds, biodiversity inevitably declines.

And finally, social priority and level of knowledge affects our understanding of biodiversity. As little as two decades ago, British Columbians generally saw the Western Rattlesnake as a dangerous pest, to be killed on sight. Now it is listed as Threatened by COSEWIC, Blue-Listed by the Provincial Government, and the subject of public education programs. This rapid change is symptomatic of a larger shift in social attitudes toward nature, a shift that proceeds apace. If the trend continues, one may assume that previously ignored aspects of our biodiversity will gain in importance. For instance, insects are a functional part of our biota, yet except for a handful of forest insect pests, we commonly ignore that component when describing and managing ecosystems, mainly because we know so little about them. The cataloguing of British Columbia’s insects--including those that are rare and even new to science--proceeds very slowly since only a handful of entomologists are available to work on it. However, it is quite possible that in a few decades insects and other invertebrates will play a major role in our biodiversity measures.

In the Section that follows, I have made an attempt to identify and document the major impacts on biodiversity in British Columbia (excluding climate change). An initial attempt was made to develop quantitative criteria for selecting “major” impacts, but the impacts themselves are so diverse and multifaceted, that they almost defy quantitative comparison. In the final analysis, the criteria used for selecting major impacts was expert opinion, research, and my own judgment. It is worthy of note that the major impacts

selected for this Report are similar to those selected by The Nature Conservancy of BC in their Okanagan Ecoregional Assessment (Pryce et al, 2006)

There are positive human impacts on biodiversity, as well as negative ones. The creation of protected areas, for instance, can slow the loss of biodiversity. Although positive impacts are mentioned tangentially in the various Discussion sections of each impact, this Report confines itself to negative impacts.

The impacts selected for the Report are generally intermediate and ultimate causes, as described above. "Habitat loss" is obviously a major source of biodiversity impact, but I have avoided this catch-all term, opting instead to identify the major drivers of habitat loss. Proximate causes tend to be amenable to technical solutions; ultimate causes generally require major economic, political and/or cultural solutions. At the conclusion of the Report, I speculate on ultimate causes and their potential solutions.

3.0 MAJOR BIODIVERSITY IMPACTS

Thirteen impact categories have been selected, based on research and consultation. They are:

- Urban Sprawl
- Aquatic, Terrestrial and Atmospheric Pollution
- Fresh Water Use
- Waterbody Alteration and Impoundment
- Energy Use
- Introduced Invasive Species
- Forest Harvesting
- Roads, Transmission Lines, Pipelines, Seismic Lines
- Mineral, Gravel, Oil, Coal and Gas Extraction
- Agriculture
- Fire Suppression
- Back Country Recreation
- Fishing and Fish Farming

No order of importance is implied by the sequence of impacts on the list.

3.1 Major Impact: Urban Sprawl

Definition: an increase in the areal extent of the developed portions of a city, town, village or subdivision.

The majority of British Columbia's population is concentrated in coastal areas of gentle terrain, and along our low-elevation river valleys. These same areas have high alpha and beta biodiversity, so conversion from a native ecosystem to a developed urban one implies a dramatic loss of biodiversity, the size of B.C.'s "urban ecological footprint" is an important issue. Sprawl creates direct loss of species and habitat as well as indirect losses from increased vehicular air pollution, habitat fragmentation, predation by domestic animals, roadkill, disruption of surface water flow, etc.

Methods of Assessment: The simplest measure of urban sprawl is population density. It is important to distinguish simple population statistics from population density: the metric for this is population per hectare. High numbers of people per hectare generally implies dense, compact urban aggregations. Population density numbers must be treated with some caution though, since they also reflect the geographical makeup of the census unit. For instance, a compact urban area situated within a municipality that includes a large amount of undeveloped or agricultural land would produce an unrealistically low density figure. The reverse would be true for a sprawling, low-density urban area that has little or no undeveloped land within its boundaries. For this reason, relative values—the

change in population density at one location over time—provide a more accurate assessment than comparisons between locations.

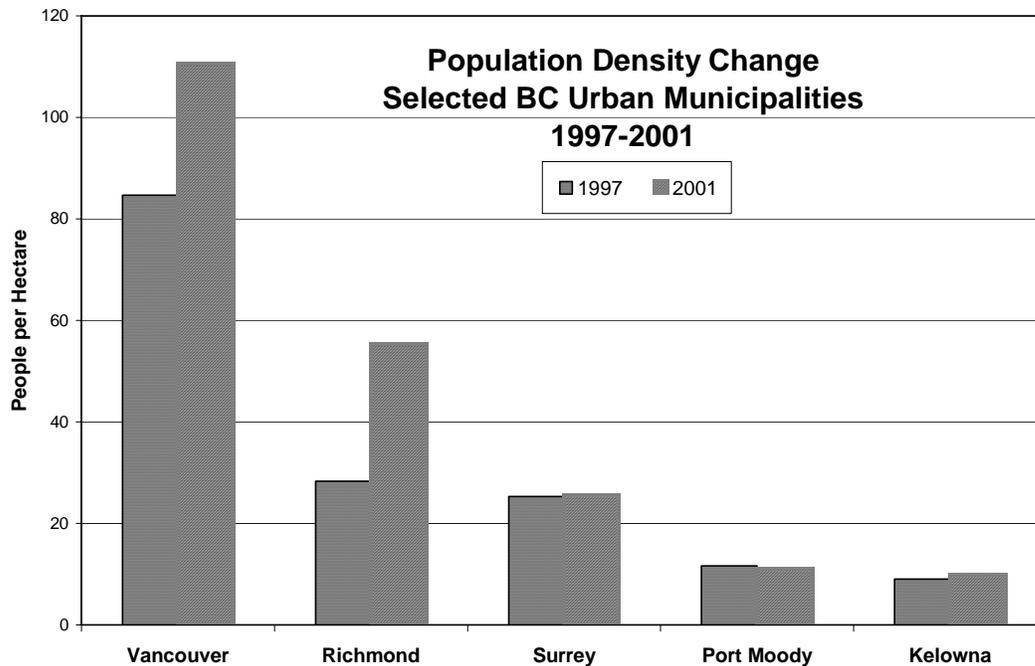


Fig. 1. Density changes over a four year period in five selected urban municipalities (Smart Growth BC, 2004).

Another important measure is the amount of impermeable surface, ie, buildings, paved streets and paved parking lots. Impermeable surfaces prevent the normal slow infiltration of rainwater and snowmelt into the ground, concentrate surface runoff, and create destructive excess waterflow events in adjacent creeks and streams. The impermeable surface area of the City of Prince George was recently calculated at 46% of its total area (Stanton-Kennedy, 2005).

Discussion: Vancouver’s average population density is higher than that of Seattle or Portland, but lower than San Francisco (City of Vancouver, 2003). Vancouver’s West End is often cited as a successful example of high urban density. At over 200 people per hectare, it rivals Manhattan and the highly developed cities of Japan, Hong Kong and Taiwan. In spite of the density (or perhaps because of it), the West End is seen as a desirable place to live, with plenty of green space, a vibrant commercial district, and relatively low crime rates. Many West Enders see car ownership as a liability (on-street parking is nearly impossible to find) and choose mass transit instead. As population growth continues to concentrate in British Columbia’s large urban centers, successful high-density areas like the West End may provide clues and signposts for reducing urban sprawl and its biodiversity consequences.

British Columbia has a growth-based economy: in other words, we see our economy as being sustained by continued population growth (a combination of natural population increase and in-migration) and by continued growth of our Gross Domestic Product (GDP). Both the population and GDP growth expectations contain inherent risks to biodiversity. However, since it is highly unlikely that our economic model will change substantially in the future, it is incumbent on us to create policies and regulations that reduce growth-related impacts on biodiversity.

Population growth is commonly thought of as a driver of urban sprawl. However, most of the impact of population growth has already occurred, as the Province went from 32,000 souls in 1867 to 4.3 million in 2006. Typical annual growth rates in the 1890's were eight to ten percent; in the current decade they hover around one percent. The rate of natural increase (births minus deaths) is declining, and is projected to "zero out" by 2021. Interprovincial and international in-migration is now providing the bulk of BC's population gain but it too is expected to level out by 2012 (BC Stats, 2006). Our British Columbia population growth impacts are far overshadowed by the growth in consumption and the ecological footprint of the existing population, a topic that will be discussed in the Conclusion.

Population growth in other parts of the world, and the resulting increase in both demand for our natural resources and in global pollution output, will certainly affect British Columbia's biodiversity indirectly.

There are a number of options for additional mitigation:

1. Municipal Community plans can have a substantial effect on sprawl if the community and its elected officials develop an informed consensus. One vehicle for building this consensus is the development principles and practices advocated by Smart Growth BC. This organization can provide technical and educational support to communities that wish to move in the direction of controlling sprawl.

2. Tax-related initiatives: various municipalities have attempted to direct growth by offering a "density bonus," or reduced property taxes for higher density housing, urban infill housing, conversion of underutilized commercial buildings to housing, creation of secondary suites, etc.

3. Development cost charges (DCC's): municipalities typically assess a DCC to new residential construction to cover the cost to the municipality in servicing that residence with roads, sewage and other municipal infrastructure. DCCs that reflect the full costs of servicing distant subdivisions in effect become incentives for infill housing in urban areas with services already in place, and for higher density housing where the DCC is amortized across more than one unit.

4. Transportation initiatives: urban sprawl is intimately tied to the private automobile. A number of disincentives have been used to discourage long commutes to distant suburbs and, conversely, incentives for the use of mass transit in the urban core.

5. Measures to reduce impermeable surfaces: selective elimination of curbs, the conversion of paved parking lots to semi-permeable or “porous pavement” and increasing urban green spaces are practical measures.

3.2 MAJOR IMPACT: AQUATIC, TERRESTRIAL AND ATMOSPHERIC POLLUTION

Definition: anthropogenic discharge of substances that have deleterious biophysical effects. Examples are toxic biochemicals and heavy metals; excess nutrients such as nitrogen or phosphorous released into aquatic environments; particulates released into air or water; pharmaceuticals released in sewage effluent that affect life processes. Metals such as mercury and lead, and persistent organochlorines such as DDT are often “legacy pollution” from past mining, manufacturing and agricultural practices which are no longer allowed.

Methods of Assessment: the Ministry of Environment regularly monitors ground level ozone as well as airborne fine particulate matter less than 10 microns in diameter (PM₁₀) in various airsheds around the Province. PM₁₀ consists of soot, smoke, liquid droplets and other particles emitted by vehicles, factories, power plants etc. (Ministry of Environment, 2002). The Ministry also monitors surface water quality, and periodically monitors bioaccumulated mercury in specific affected waterbodies, as well as the application of contract lawn and garden pesticides in the Lower Mainland.

Pulp mills are sources of both aquatic and atmospheric pollution, producing adsorbable organic halides (AOX) from the use of chlorine, sulphur compounds from the Kraft process, as well as dioxins and furans.

Some 60 decommissioned mines in British Columbia present pollution issues of toxic metal leaching (copper, zinc and cadmium are typical examples) and acid rock drainage into the environment. Some monitoring is done at these sites but more is required.

An emerging pollution issue, with potentially profound consequences, is the impact of anthropogenic chemicals on salmonid reproduction. A number of persistent pharmaceuticals, as well as compounds produced by kraft-based pulp mills, are known to affect salmonid reproductive development when released into the aquatic environment (Afonso, 2002). The explosive population growth along our major salmon-bearing water bodies, together with the other threats to salmonid survival, dictates a proactive research, monitoring and public education program to reduce the impact of these compounds on our aquatic biodiversity.

The Canadian Wildlife Service has done periodic monitoring of polychlorinated biphenols (PCBs) and DDT in heron eggs since 1977. Both of these banned substances are persistent, toxic and accumulate in the food chain. Fortunately, the sampling shows a slow downward trend in the concentration of these chemicals.

The application of agricultural pesticides is tightly regulated and monitored. The application of lawn and garden pesticides by licensed landscapes is recorded, and is

analyzed periodically. However, that represents only a component of the overall use of pesticides in non-agricultural situations: purchase and use of these chemicals by private individuals is unrecorded, and is likely increasing.

Results: the relevant federal and provincial agencies appear to be doing a satisfactory job of monitoring and controlling the production and release of the standard environmental contaminants, and slow progress is being made on some of the “legacy” contaminated sites. Progress has also been achieved with pulp mills, particularly in regard to dioxins and furans, but substantial amounts of AOX and sulphur compounds are still being emitted.

Overall pesticide use is declining, as seen in the figure below.

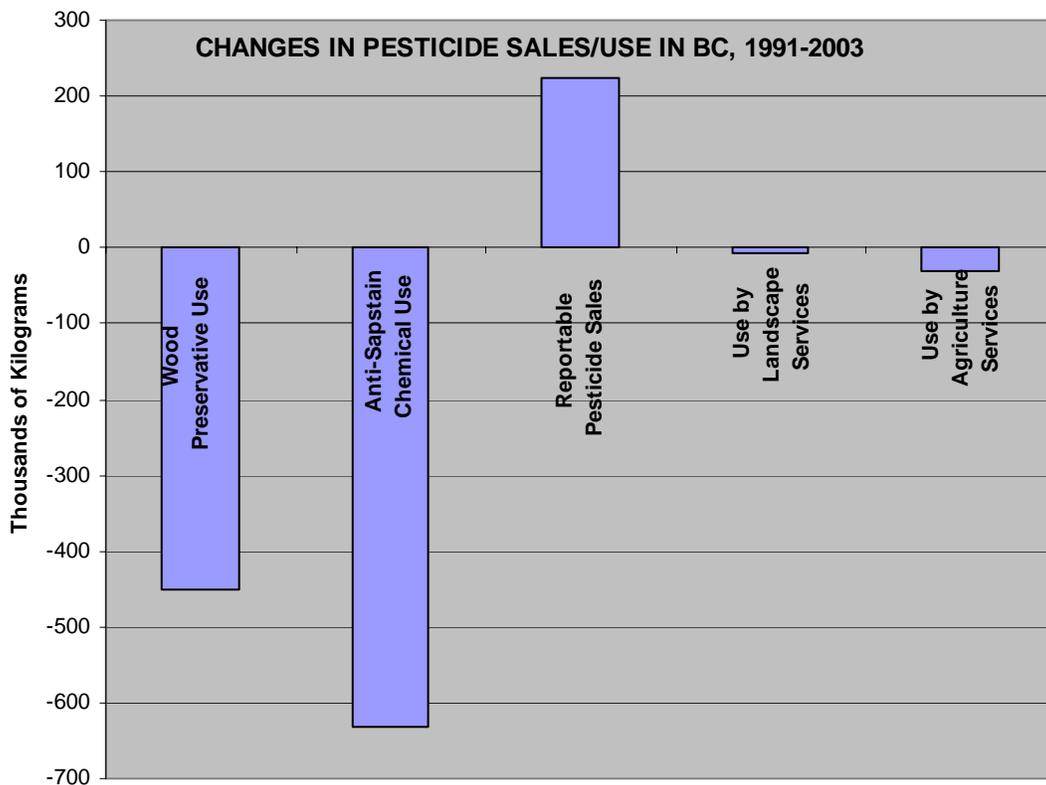


Fig. 2 Trends in pesticide use in BC (adapted from Ministry of Environment, 2003)

Notes on Figure 2:

- From 1991 to 2003 the quantity of Reportable pesticides sold increased by about 24%. However, 92% of the increase is attributable to increased sales of mineral oil (insecticidal or adjuvant), various strains of the biological insecticide *Bacillus thuringiensis* and insecticidal soap. These pesticides are “less toxic” alternatives to traditional pesticides.

- Sales of federally-labelled Restricted pesticides decreased by 63% between 1991 and 2003. This class of pesticides includes products that have high toxicity or are associated with other environmental concerns.
- Sales of veterinary flea control pesticides decreased by 83%. These pesticides have largely been replaced by products registered as drugs, which are administered orally or by injection or applied to one spot on the skin.
- Anti-sapstain chemical use by lumber mills declined by over 79%, and the decrease was statistically significant at the 1% level. There was no overall change in province-wide lumber production that could account for the decline, although a decrease in lumber production by coastal mills between 2001 and 2003 may have contributed to the change from 1999 use levels.
- The use of pesticides by landscape services in the Lower Mainland decreased by 50%. Linear regression analysis shows this trend to be significant at the 5% Level (Ministry of Environment, *ibid*).

Discussion:

Ensure that adequate funding is directed toward environmental toxicology research in British Columbia, particularly with reference to anthropogenic compounds that can cause reproductive impacts in salmonids.

Begin monitoring, and restricting, individual use of lawn and garden pesticides, with an eventual goal of banning their use in British Columbia. Exceptions would of course be made for the non-toxic and biodegradable products, such as insecticidal soaps, biocontrol products, pheromone traps etc.

3.3 MAJOR IMPACT: FRESH WATER CONSUMPTION

Definition: the rate of use of surface and groundwater by all phases of society, including individual, industrial, agricultural and institutional consumption.

Direct impacts to biodiversity include excessive drawdown of surface water sources, with consequent disruption of aquatic and riparian habitat. Impacts of excessive groundwater drawdown are longer term and harder to quantify. Indirect impacts are the proliferation and enlargement of municipal water storage reservoirs to meet growing demand, resulting in impacts described under Waterbody Alteration and Impoundment Section.

Methods of Assessment: A host of monitoring techniques inform us on the status of water consumption:

- Some 800 aquifers have been mapped and classified in British Columbia. The Groundwater Section of the Ministry of Environment tracks water levels in 160 active observation wells. The total number of aquifers that these observation wells monitor is not yet known. Well drilling and installation are regulated by Part 5 of the Water Act. The amount of water withdrawn from wells is currently not regulated.
- The Provincial and Federal governments jointly operate hydrometric stations on the major rivers in BC, to gauge flows. The Province allocates and licenses surface

water use. Allocations are tied to water availability in the particular drainage or waterbody.

- Municipalities also monitor water consumption.

Results: According to Environment Canada statistics, British Columbia sits in a middle position in terms of per capita fresh water consumption. Of the Provinces and Territories, the Northwest Territories had the lowest liters per capita (lpc) consumption, at 214; British Columbia sat in a middle position at 651, and New Brunswick was the highest at 1314 lpc (Environment Canada, 2004)². The Fraser Basin Council reported average water use in the Thompson Region at 1013 liters per person per day (presumably this is the same statistic as lpc), compared to the Canadian average of 343 liters. The Region showed a 15% increase in per capita water consumption between 2000 and 2003 (Fraser Basin Council, 2005).

Pulp mills, mines and smelters are major freshwater users, and their wastewater is often returned to the source waterbody with contaminants (see Aquatic, Terrestrial and Atmospheric pollution section).

The Ministry of Environment reports a decrease in the number of groundwater observation wells with declining water levels. Those wells still showing declining water levels due to human activity are concentrated in the high growth areas of the Okanagan, Lower Mainland, southeast Vancouver Island and the Gulf Islands (MWLAP 2001).

Between half and two-thirds of the available surface water in the populated regions of BC has been allocated. Surface water use restrictions have increased substantially in the last three decades. Close to 30% of licensed stream length in BC now have use restrictions in place. The majority of those restrictions are in the southern Interior.

Discussion: as with most resources, the most effective water conservation tool is price. Research has shown that water metering and consumption charges will trigger a 50% decrease in municipal water consumption (Campbell, 2004). Applying use charges to water consumption will drive a broader adoption of available water conservation technologies, from low-flow toilets to xeriscaping to agricultural drip and micro-irrigation. British Columbia does charge surface water licensing fees; the government should ensure those fees in some way reflect the cost of operating water licensing body, and the ongoing water level monitoring. Groundwater removal should also become subject to licensing and fees. Cost effective water metering is the first step towards user-pay charges and conservation. Indeed, some municipal jurisdictions have experienced decreases in domestic water consumption simply as a result of installing the meters and not assessing any use charges.

² These figures are derived from reporting municipalities, and include residential, business, industrial and other uses.

The vast majority of surface water licensing and use is for hydroelectric power. Moderating electrical demand has the dual benefit of reducing the need for new dams, as well as freeing up fresh water supplies.

3.4 MAJOR IMPACT: WATERBODY ALTERATION AND IMPOUNDMENT

Definition: damming, diking, channelizing or culverting lakes, rivers or streams, for the purposes of hydroelectric power, flood control, transportation crossings, irrigation, livestock watering, land development etc.

Dams extirpate riparian and valley bottom habitats, which typically support high levels of biodiversity. They hamper movement of migratory and anadromous fish species and reduce the transfer of marine derived nutrients into interior ecosystems; change turbidity and sediment levels to which species and ecosystems are adapted; trap nutrients which normally deposit in estuaries and deltas downstream; disrupt normal processes of river channel scouring and silt deposition; prevent normal downstream movement of coarse woody debris; change water temperature and oxygen conditions; provide habitat for exotic species, and create unstable, low-seral shorelines (McAllister et al, 2001).

Methods of Assessment: records are kept within various ministries of impoundment structures.

Results: there are 2200 registered dams in British Columbia.

The Canadian portion of the Okanagan River system (excluding the four lakes) was approximately 80 river kilometres long prior to channelization; now because of channel straightening, this river, which passes through one of the acknowledged “biodiversity hotspots” of the South Okanagan, is now less than 40 river kilometres. Only seven percent of the BC river portion remains unchannelized.

Discussion:

Since the primary purpose of water impoundment is hydroelectric power generation, the obvious biodiversity impact reduction measure is electrical energy demand reduction, coupled with the development of alternative energy sources. This will allow existing dams to spill more water to replicate seasonal peak flow events, and reduce the demand for new dams. Another measure is to retrofit existing “drone” (non-energy producing) dams to produce power. BC Hydro has a “Power Smart” program, aimed at more efficient use of electrical energy.

The removal of smaller dams that are ecologically inappropriate or no longer needed should also be made a priority. British Columbia Institute of Technology maintains a website documenting dams which are candidates for removal.

The Province is currently encouraging private development of new energy sources, such as micro-hydro power generation. This program should be scrutinized carefully for its potential impact on biodiversity.

Our traditional approach to flood control, through damming, diking and channelization, has allowed society to develop commercial and residential infrastructure in riparian areas immediately adjacent to rivers and streams. Through good community planning, public education, and political realignment, this type of development can be stopped—and in some cases even reversed—over time. Hand in hand with this is the development and adoption of new environmentally sensitive engineering and bioengineering techniques that still achieve flood control objectives but have less impact on biodiversity.

A bold new initiative that is being tried out in various locations in BC is river and stream “remeandering,” where the stream channel is made wider by moving the dikes farther apart. The river or stream is then freed to recreate its natural sinuosities, gravel bars and riffles, but the flood control aspect is still maintained. A good example of this is the Okanagan River Restoration Initiative (ORRI) which has initiated the re-meandering process on a short section of the Okanagan River just north of Oliver.

Many road and railroad culverts around the Province create barriers to fish movement and spawning. As stream water enters a culvert, its velocity increases, exceeding the “burst speed” of fish attempting to swim upstream. A simple retrofit is possible in many cases, by adding small baffles to the bottom surface of the culvert or spillway, to create pockets of slack water where ascending fish can rest.

3.5 MAJOR IMPACT: ENERGY USE

Definition: the consumption of fossil fuel and hydroelectric energy, for industry, transportation, space heating and other uses.

Energy consumption has profound and wide ranging consequences to biodiversity: the hydroelectric impacts described above; marine fuel and oil spills; roads, seismic lines, water use and water pollution associated with oil and natural gas drilling; pipeline and transmission corridors; physical extirpation of ecosystems and habitats from open pit coal mining; fouling of soil and fresh water through oil and fuel spills and leaks, and finally, the atmospheric emissions from vehicles propelled by fossil fuel combustion.

Methods of Assessment: Statistics Canada tracks “final demand” by Province. Final demand represents the sum of energy use by mining, manufacturing, forestry, construction, transportation, agriculture, residential, public administration and commercial and other institutional uses. Neither BC Stats nor the Ministry of Energy and Mines appear to maintain any statistics on energy consumption. Statistics Canada also records Provincial data on car sales by year.

Results: Our 2003-2004 increase in final demand outstripped the rest of the country (see fig. 3). In terms of total energy consumption per capita, BC is the second lowest in the country, behind Manitoba (Alberta has the highest rate). Per capita demand in the Province actually dropped between 1990 and 2003 (Menard, 2005). This does not imply an overall reduction in total energy use: the decrease is due to the fact that the rate of population growth currently exceeds the rate of energy consumption growth.

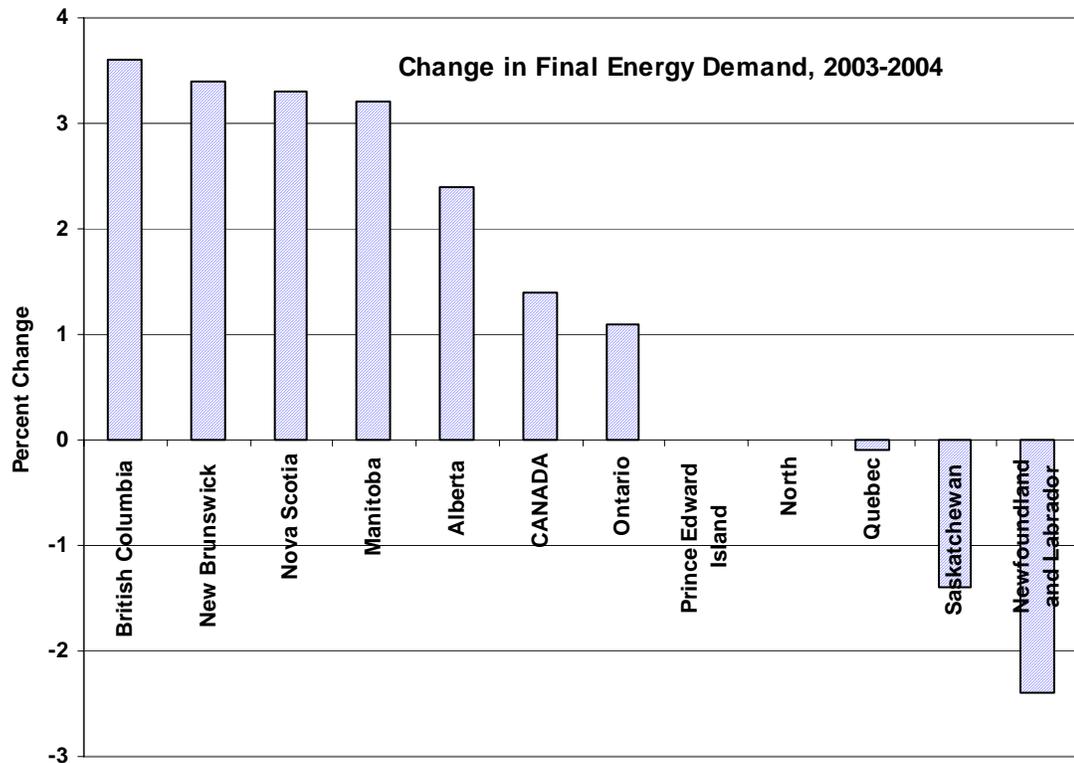


Figure 3. Change in Final Energy Demand in Canada, 2003-2004 (Statistics Canada, 2005)

Demand for electricity in B.C. is expected to increase by 1.7 per cent a year for the next 10 years. The need will be greatest in the Lower Mainland and Vancouver Island regions, which consume about 70 per cent of the province’s electricity (Ministry of Energy, Mines and Petroleum, 2006).

Discussion: Energy consumption is a fundamental cause of many of our negative impacts on biodiversity. A number of voluntary government programs exist to help consumers reduce energy consumption, but they have been largely ineffective. Industry, the biggest consumer of energy, has not been particularly responsive to voluntary energy conservation programs and incentives.

The Province has recently declared that BC will become self-sufficient in electrical energy production by 2016, and that production will have zero net carbon emissions by the same date (Government of British Columbia, 2007). This is laudable, but unless something is done to address our steadily increasing demand for electricity, the policy is likely to result in more environmentally intrusive hydro projects and perhaps an entry into nuclear electric generation, which would bring on a new set of biodiversity impacts.

3.6 MAJOR IMPACT: INTRODUCED INVASIVE SPECIES

Definition: species not native to British Columbia that have invaded and established themselves in our terrestrial and aquatic ecosystems. There are several terms to describe these organisms: alien, non-native, exotic or introduced (denoting foreign origin); invasive (generally an introduced species, capable of invading native ecosystems) noxious (applied to introduced weeds that are on the Provincial Noxious Weed List). “Weed” implies invasive qualities, generally in agricultural situations, but is an imprecise term, since there are a few native “weeds” or pioneer species.

There are some instances of direct predation, but the biggest impact of invasives is the displacement or competitive exclusion of native species, by occupying habitats and capturing resources. There are also many documented examples of invasives interfering with native species reproduction (Ciruna et al, 2003). Invasive herbaceous plants exhibit the greatest variety and extent, followed by birds, marine invertebrates, and insects. There are several major examples of invasives dramatically changing the nature and function of ecosystems. British Columbia examples are the black-tailed deer on Haida Gwaii; scotch broom in the Garry Oak ecosystems of southern Vancouver Island; purple loosestrife in the estuaries of the Fraser River; cheatgrass, Kentucky bluegrass and knapweed in the native grasslands of the Southern Interior; the American bullfrog in the Lower Mainland and Southern Vancouver Island; goldfish and other exotic fish in ponds and small lakes in southern BC; the suite of exotic marine species associated with the introduction of the Pacific Oyster to the BC coast, and the introduction of the mysid shrimp into the Kootenay, Arrow and Okanagan Lakes.

The stocking of lakes with rainbow trout (*Oncorhynchus mykiss*) warrants separate mention. Although rainbow trout is native to British Columbia, many small lakes were trout-free until purposely stocked for recreational fishery opportunities (Hirner, 2006). Several studies have confirmed the introduction of rainbow trout into previously fishless lakes triggers a decrease in amphibian and large invertebrate populations (Hirner, *ibid*, Knapp et al, 2000).

Methods of Assessment: The federal Ministry of Agriculture monitors imports of plant materials (Plant Protection Act), and sets standards for seed purity (Seeds Act). The Ministry of Agriculture and Lands maintains a Noxious Weed List, as part of the Noxious Weeds Act. The BC Conservation Data Centre maintains a list of all species in British Columbia, and identifies those that are introduced. The Ministry of Forests, the Ministry of Agriculture and Lands, together with the local and regional Invasive Plant Councils, track the introduction and spread of new invasive plants. A multisectoral BC Invasive Plant Strategy, representing Provincial and Municipal governments, First Nations, and the Fraser Basin Council, has recently been created. The Federal Ecological Monitoring and Assessment Network (EMAN) has developed a standardized protocol for monitoring invasive plants.

Results: Individual local and regional invasive plant councils do track the spread of noxious weeds, but there are no formal processes for monitoring trends in invasive

species. The Invasive Plant Council is urging various groups and organizations to commit to a set of operating principles that will help stem the invasion of weeds.

This author, in a study of the vegetation on seventeen grazed Crown grassland sites in southeastern BC, found that the percent cover of non-natives ranged from 0 to 84 percent, with an average of 35 percent (Gayton, 2004).

Discussion: invasives have a substantial and growing influence on biodiversity in British Columbia, due to a number of factors. Growing international trade and travel; high levels of soil disturbance; inappropriate disposal of exotic pets and plant materials; commercial fish farming, and weakened native plant communities unable to repel invaders, are some of the factors. Many ecosystem restoration projects across the Province are stymied because of the presence of invasive plants or their propagules.

Increased levels of monitoring are certainly appropriate, but a key element in controlling the impact of invasives on biodiversity is public education. The general public is blissfully ignorant, and uncaring, about the crisis precipitated by invasive species. Gaining public awareness and support is a prerequisite for any concerted action against invasive species.

There is a school of thought which suggests that invasive plants are not the true causative agents of biodiversity decline, rather they are simply “passengers” of the actual driver of biodiversity loss, which is anthropogenic disturbance of ecosystems and ecosystem processes (Didham, 2005). However, removal of introduced trout from small lakes has resulted in rebounds of amphibian and invertebrate populations (Knapp et al, *ibid*; Vredenburg, 2004), suggesting a direct correlation between alien introduction and biodiversity decline, at least in the case of a top predator.

3.7 Major Impact: Forest Harvesting

Definition: the removal of forest trees for timber or pulp, plus associated ground disturbance (roads and landings are covered under the Roads, Transmission Lines and Pipelines Section).

Impact on Biodiversity: forest harvesting has an array of landscape, stand and species level impacts, including:

- Fragmentation of habitat and disruption of movement corridors
- Alteration of seral stage distribution, with an emphasis on early and mid-seral communities
- Alteration of age-class distribution, tree species distribution and stand structure
- Loss of key habitat elements such as veteran trees, snags and downed trees

It should be noted that forest harvesting can in some cases be used to increase biodiversity, through ecosystem restoration harvesting techniques, and by creating diversity in even-aged stands.

Methods of Assessment: the wide variety of tenure systems, harvesting systems and forest types in BC make the assessment of harvesting levels very complex. The standard province-wide metrics are the Annual Allowable Cut--the rate at which timber is made available for harvesting in response to social, economic and environmental considerations—and the timber harvest—the amount of wood actually cut in a year.

Results: As can be seen from the graph below, both timber harvest and AAC fluctuate substantially. Timber harvest in both the Coast and the Interior, after peaking in the late 1980's, have since reached a plateau.

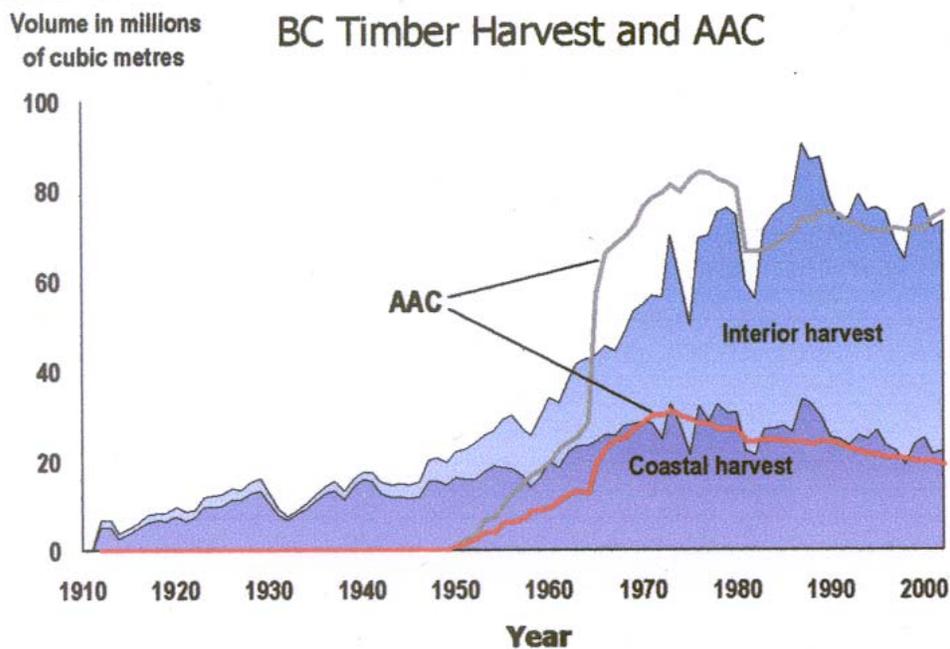


Fig. 4. The British Columbia AAC and the timber harvest (Pedersen, 2003).

Discussion: past and future “beetle uplifts”--temporary spikes in AAC and harvesting of beetle-killed wood—make interpretation of province-wide data difficult. Regional Timber Supply Reviews provide a more appropriate scale for assessing the rates of timber harvesting over time.

A linkage between bryophyte diversity and forest harvesting has been identified: in coastal western hemlock and interior cedar hemlock forests, bryophyte biodiversity is highest in older, first growth forests, and lowest in younger, second-growth stands (Newmaster et al, 2003)

Location, timing and method of harvesting can be of equal or greater importance to biodiversity as the actual rate of timber harvest. The amount of forest in older age classes is a central biodiversity measurement, as an extensive suite of avian and terrestrial fauna rely on both individual veteran trees as well as ancient forests. Although the amount of old forest in protected areas has increased, the Province-wide trend in the amount of old growth is downward due to forest harvesting. For example, in the East Vancouver Island

and Gulf Islands region, the area occupied by old (>100 years) forests is estimated at four percent of the area occupied 150 years ago (McPhee, 2000). Similarly, old forests are assumed to have previously dominated the central Okanagan; currently they represent 0.5% of the study area, in fragmented patches of less than 3 ha each (Iverson and Cadrin, 2003).³ The State of the Forests Report provides Province-wide data by predominant tree species and predominant age for the year 2000 (Ministry of Forests, 2004). It would be appropriate to turn this snapshot into a trendline, by backcasting from previous data, and ensuring that future data is collected in such a way that it can add to the trendline.

3.8 Major Impact: Roads, Transmission Lines, Pipelines and Seismic Lines

Definition: highways, secondary roads, logging and access roads, high voltage electrical transmission lines, natural gas pipelines and seismic exploration lines⁴ can fragment habitat; impede the movement of native species; facilitate the invasion of alien species; disrupt surface and subsurface waterflow, alter predator-prey relationships and cause direct mortality through collisions with vehicles.

Methods of Assessment: total (highway plus logging access) road density has been calculated for the Province by watershed, yielding a metric of kilometres of road per square kilometer. In addition, a calculation has been made of total road plus seismic line density. BC Hydro, by far the largest supplier of electricity in the Province, documents the extent of transmission lines.

Results: road density, as well as road plus seismic line density, varies widely across the Province, but generally being lowest in the northwest, and highest in the southern Interior, the Lower Mainland, southern Vancouver Island and the Peace River area. Total Provincial road length nearly doubled from 1988 to 1999. There are 110,000 kilometres of seismic lines in the Province, largely in the northeast. Although seismic lines are generally used once and then allowed to revert back to forest, the trend is upward: in 1999, 6,913 kilometres of lines were built in BC, and a year later, 10,632 km were built (West Coast Environmental Law, 2003).

Discussion: we are a relentlessly vehicular society, and it is a given that our road network will continue to expand. However, since three-quarters of the road kilometres in BC are forest access roads, we have the opportunity to temporarily or permanently decommission roads once forest harvesting and silvicultural operations are completed.

We as citizens have gotten used to the notion of having free and complete access to all forestry roads for recreational opportunities. This attitude will need to change over time, and it will take considerable public education to achieve that shift.

³ In both cases, old growth forests would have been lost to both timber harvesting and to urban/agricultural land development, but the proportions of each were not indicated.

⁴ Seismic lines are narrow (5-7 meter wide), linear clearings in forested areas that facilitate a method of oil and gas exploration which uses small explosive charges to create a pattern of shock waves. Geologists can interpret underground formations using the shock wave data.

Researchers have begun developing thresholds of road/seismic line density, above which certain species are negatively affected. For instance, grizzly bears are negatively impacted at road densities above 0.4 kilometers of road per square kilometer (BC Ministry Water Land and Air Protection, 2002). This type of research should be supported, and extended to other species.

3.9 Major Impact: Mineral, Gravel, Oil, Coal and Gas Extraction

- **Definition:** mining, gravel extraction and oil/gas extraction are lumped here since they create similar impacts of surface and subsurface soil disturbance, aquatic, terrestrial and atmospheric pollution, erosion and sedimentation from overburden and waste rock disposal. There is considerable overlap between this Impact and the following: Aquatic, Terrestrial and Atmospheric Pollution; Fresh Water Use; Energy Use, and Roads, Transmission Lines, Pipelines, Seismic Lines

Methods of Assessment: BC Stats maintains statistics on weight or volume and value of the following categories: metals, coal, industrial minerals, construction aggregates, mineral exploration, mineral refining and smelting, and downstream mineral processing. The statistics include production and value data. The Ministry of Energy, Mines and Petroleum Resources tracks mine safety and environmental inspections.

Results: Coal and petroleum resource extraction are growing in BC, as the graph of coal production will attest.

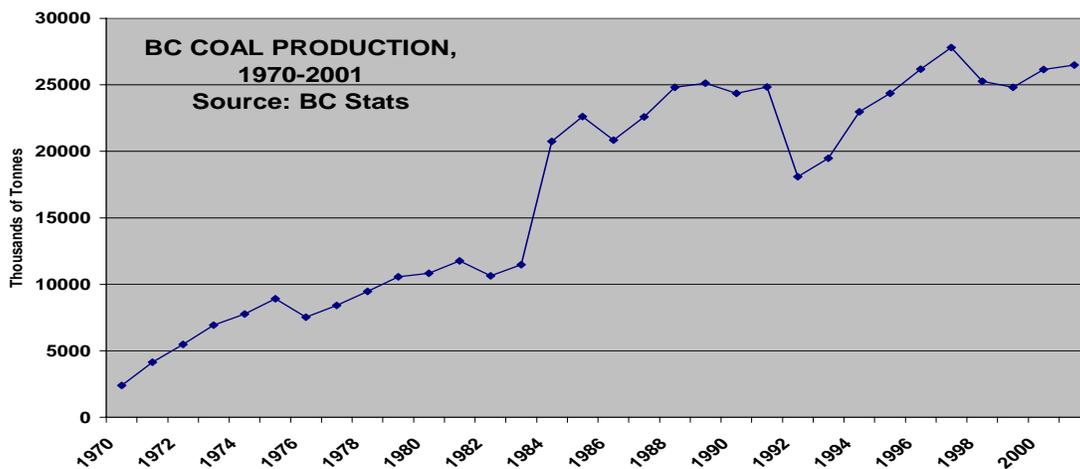


Fig. 5. Coal production in BC, 1970-2001 (BC Ministry of Energy Mines and Petroleum, 2006)

Gravel extraction has remained more or less constant over the last several years.

Discussion: the spectacular growth of petroleum extraction in Northeastern BC is likely to continue, and the multiple environmental effects (increased roading, seismic lines, chemical spills, CO2 release etc.) of that extraction should be monitored closely.

Coalbed methane (CBM) extraction is a relatively new energy source in BC, with most of the potential located in the Peace River and East Kootenay regions. Although CBM is thought to be more environmentally benign than conventional natural gas extraction, it does represent the potential for large areas of surface disturbance, in the form of wells, access roads, compressor stations, reservoirs etc. CBM extraction also uses large quantities of water which, depending on subsurface geology, may return to the surface carrying excess soluble salts or heavy metals (West Coast Environmental Law, 2003).

While current mining operations follow fairly strict environmental guidelines, the “legacy pollution” problem of old, decommissioned mines continues.

Gravel pits, while generally thought of as relatively benign, are perennial sources of noxious weed invasion. With their locations immediately adjacent to travel corridors, and the continuous movement of materials in and out, gravel pits are extremely effective incubators and vectors of noxious weed invasions.

3.10 Major Impact: Agriculture

Definition: impacts resulting from the cultivation of field crops, orchard crops, horticultural crops, vineyards, livestock ranching and feedlots. Impacts are habitat loss and fragmentation, pollution from animal waste, fertilizer and pesticides, grazing impacts on native plant communities, and noxious weed spread.

Methods of Assessment: The Ministry of Agriculture and BC Stats collect information on crop volume and value by category.

Various attempts have been made to assess the impacts of ranching—specifically livestock grazing on Crown rangelands. The largest of these initiatives was the Ministry of Forests’ Rangeland Reference Areas Program, which monitored grazing impacts on vegetation using permanent plots and grazing exclosures.

(<http://www.for.gov.bc.ca/hfp/range/rra/rra.htm>) The Program operated from 1995-1998 and then was cancelled, but the exclosures and monitoring plots remain. The Ministry of Environment has also undertaken occasional studies of livestock grazing impacts on wildlife (eg, Haddow and Muir, no date).

Pollution and subsequent eutrophication of surface water from agricultural runoff is a key component of agriculture’s impact on biodiversity. The Fraser Basin Council has coordinated with other agencies to create a nutrient management plan for the Fraser River (Fraser Basin Council, 2001)

Results: one area of substantial growth, as well as environmental concern, is the grape industry, which is largely concentrated in the very biodiverse and fragile ecosystems of the Okanagan Valley.

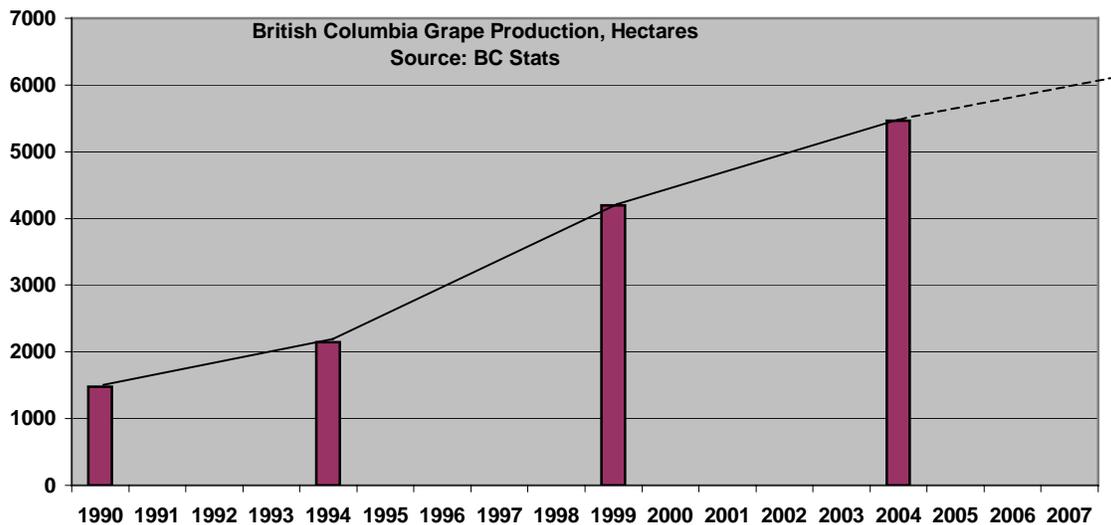


Fig. 6. Grape hectares in British Columbia, 1990-2004 (BC Stats).

Discussion: Because of its ecologically strategic location, grape production should be tracked more closely. The endangered antelope-brush community lies right at the epicentre of grape production in the South Okanagan, and industry expansion is putting that ecosystem at risk. Some of the expansion of the grape industry is through orchard conversion, and the statistics above do not distinguish between new land being brought under cultivation, and orchard conversion to vineyards.

Another area of concern are grazing impacts on Crown native grasslands and associated low elevation riparian areas. These grasslands and wetlands form a tiny portion of British Columbia's landbase, but have very high levels of biodiversity. Poor management and continuous grazing degrades the native plant community, reduces wildlife habitat, and in some cases totally extirpates riparian vegetation.

The Canada-British Columbia Environmental Farm Plan initiative (BCAC, 2006) is an important device designed to complement and enhance the environmental stewardship practices of farmers and ranchers. However, the Plans are simply that; there is no on-farm monitoring or follow up. Agriculture is a key sector for biodiversity, and it deserves a more substantial and long-term program.

3.11 Major Impact: Fire Suppression

Definition: the conversion of previously fire maintained grasslands and associated savanna forests to dense and/or closed forest communities, as a result of fire suppression. A correlated process of forest encroachment, where trees encroach on areas that were traditionally grassland, occurs for the same reason. The biodiversity impacts result from the reduction or elimination of herbaceous vegetation, together with the suite of fauna that rely on that vegetation.

Methods of Assessment: comparison of early (1940's-1950's) and contemporary aerial photographs gives an indication of recent change in forest cover and grassland extent. Rephotography of archival photographs, consulting old maps and survey notes is another source of information. Fire return intervals can be inferred from fire-scarred trees and dendrochronology.

Results: studies in the Chilcotin and the East Kootenays have documented substantial shifts in tree cover over time. In an assessment using 1952 and 1995 airphotos of some 250,000 hectares of low elevation Crown land in the Rocky Mountain Trench, this author (unpublished ms.) estimated 3000 hectares per year converted from grassland or open forest to closed forest.

Discussion: Some scattered attempts at fire-maintained ecosystem restoration are in progress in various parts of the southern Interior, but the magnitude of the ecosystem shift is far greater than the restoration effort.

Further documentation of fire histories, dry forest stand structure and ecosystem shifts will be useful in preparing goals and methods of fire maintained ecosystem restoration.

3.12 Major Impact: Back-Country Recreational Activities

Definition: the proliferation of back-country recreation, heli-skiing, ATV use, mountain biking, mud-bogging, rock climbing, lodge and cottage developments, etc. Primary biodiversity impact is in the form of human interference with normal animal behaviour; secondary impacts are habitat fragmentation, soil disturbance, erosion and the introduction of non-native species.

Methods of Assessment: this is a difficult category to monitor. Backcountry recreation tenures and permits are currently issued by the Ministry of Tourism, Sport and the Arts outside the protected areas system and the Ministry of Environment within the protected areas system. The Ministry of Environment controls back-country recreation, under the auspices of the Interim Guidelines for Back Country Recreation (Ministry of Environment, 2002). In addition, a new set, the Wildlife Guidelines for Commercial Back Country Recreation, were recently published (Ministry of Environment, 2006). Most other forms of back-country recreation are unlicensed and unmonitored.

Results: The government is currently promoting back country recreational tenures, and has speeded up the approval process. In 2003/2004, 1200 tenures were granted. The website of the Ministry of Tourism Sport and the Arts lists 744 current tenures, but the website indicates that not all tenures may be listed (British Columbia Ministry of Tourism, Sport and the Arts, 2006). Officials at the Ministry of Tourism Sport and the Arts informed me that recreational tenures were separated from other forms of commercial tenure in 2002 and thus could be tracked from that date. They did not have the information at hand, but indicated it could be available by making a request to Tantalus, a Web-based system supporting the administration of Crown land and the Crown land registry.

Discussion: The current expansion of back country activity is impacting locations and species that hitherto have had little or no exposure to human activity. It seems prudent to monitor these impacts closely.

3.13 Major Impact: Fishing and Fish Farming

Definition: commercial and recreational fisheries, including salmonids, groundfish, herring, shellfish, tuna and other species. Impacts are largely through overfishing, disruption of spawning, and pollution.

Methods of Assessment: control of marine fisheries is a joint responsibility of the Department of Fisheries and Oceans (DFO) and the Ministry of Agriculture and Lands (MAL). Statistics are available by each fish category, in some cases landings by region and by week. Commercial fish farm applications and operations are overseen by a consortium of provincial and federal agencies.

Results: catches of the various species vary widely every year based on spawning cycles and environmental factors, so it is difficult to pinpoint trends in this complex sector.

Discussion: there is general consensus that the Pacific salmon stocks are in serious decline, less consensus on the causes for the decline, and little consensus on what to do about it. This author has little background in fisheries issues, and within the scope of this contract, could not attempt more than a cursory review of biodiversity impacts.

The salmon lies at the very core of British Columbia's ecology, history, and identity. It is central to marine food webs, and is a fundamental link between terrestrial and marine environments. Extraordinary measures should be taken to ensure the survival of this wild species.

4.0 CONCLUSIONS

The concept of biodiversity has only been on our societal radar screen for about three decades. Few concrete, quantifiable examples of anthropogenic impacts leading to biodiversity loss are available. That inability to identify quantifiable links is one of the major shortcomings of this paper, and of our efforts to maintain biodiversity. We would do well to begin developing these linkages, starting with relatively “easy” examples, say amphibians or butterflies which have very restricted and defined ranges and habitats, and quantifying our anthropogenic disturbances upon them. This would help move our understanding forward, and give us the confidence to tackle wider-ranging species or habitats.

Even the very short list of impacts on biodiversity presented here opens up a bewildering array of separate and overlapping monitoring requirements, action plans and actions. To avoid the stasis inherent in overly complex programs, administrative and reporting structures, it seems logical to focus efforts as much as possible on the root, or ultimate, causes of negative biodiversity impact.

In the author’s considered opinion, the ultimate causes of biodiversity impact are growth-based economics, excessive personal consumption and associated waste, and excessive per capita energy use. These are obviously very challenging, controversial and non-traditional areas, far outside the normal purview of the agencies and entities involved in biodiversity conservation. However, if we as a society do not come to terms with these ultimate causes, then a great deal of energy will be expended in stopgap and bandaid solutions to proximate causes, winning a few biodiversity battles here and there, but losing the war.

Ecological Tax Reform is one avenue for addressing those key consumption areas—such as energy use, water use and solid waste disposal—that directly or indirectly harm the environment (Taylor, 1999). Although widely unpopular measures, consumption taxes and tariffs are effective in changing consumer behaviour. A small but classic example is British Columbia’s Beverage Container Stewardship Program, which placed a tariff on beverage containers, aimed at reducing waste and littering. Since it’s introduction ten years ago, the Program now is virtually invisible and self-regulating. No one questions the legitimacy of the Program, and it is extremely effective. I believe British Columbians (by that I mean the citizens, the ENGO’s, the Universities, local governments and the Province) could research, develop and consensually implement many other small, incremental and effective measures, like the Container Stewardship Program, which target the ultimate causes of biodiversity impact.

In researching this Report, the author was struck by the number of existing plans, action plans, accords, frameworks, logic models, agreements and treaties for the preservation of biodiversity. This redundancy in planning (which this Report could be logically accused of as well) speaks to a hesitancy, or an unwillingness, to commit to concrete action to preserve biodiversity. It seems high time to move beyond the planning and background report stage.

A great obstacle to any work in biodiversity preservation is the general lack of concern by the public. In truth, any significant project to protect biodiversity must either have the support of the public, or else the coercive force of the law.

Many in the conservation community, myself included, have spent years and decades doing public outreach and extension. In general, we have simply relied on handing out information, in the naïve assumption that if people were just able to access data about the spadefoot toad, or the endangered mountain caribou, or the evils of purple loosestrife, they would suddenly begin to care, and adjust their lifestyles to accommodate threatened species and ecosystems. This approach only engages a small fraction of the population, and generally preaches to the already converted. I believe we, the conservation community, have been spectacular failures in conveying ecosystem and species information, partly because of our unwillingness to “package” that information, to give it a cultural or spiritual or mythological context.

We must begin building a culture of nature, to move species and ecosystems from the distant periphery to the very center of the human stage. Only then will biodiversity cease to be an esoteric notion discussed by a select few, and become a living, breathing presence that the average British Columbian can believe in, and make sacrifices for.

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