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Climate Change, Biodiversity And the Benefit of Healthy Ecosystems

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On behalf of the Canadian Parks and Wilderness Society - BC Chapter

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> *"There is no solution available, I assure you, to save Earth's biodiversity other than the preservation of natural environments in reserves large enough to maintain wild populations sustainably."* (E.O. Wilson, The Creation 2006)
>
> *Imagine the world's climate zones changing dramatically over your lifetime - so that [Victoria's] climate is more akin to that of [San Diego] - think what that will mean for the forests, birds and other animals of the region where you live… (Tim Flannery, The Weather Makers 2005)*

1.0 CONTEXT

The February 13, 2007 Speech from the Throne called for concerted provincial action on climate change in British Columbia. As a result, the provincial government is preparing a climate change action plan[ii].

We argue that any climate change action plan be comprehensive and (1) recognize the contribution of healthy marine and terrestrial ecosystems to human health and to protecting biodiversity, and (2) safeguard the stable functioning of global carbon cycling through the protection of natural carbon sinks, such as forests and marine environments. Climate change plans that focus only on altering human use of carbon for the purpose of reducing carbon emissions (mitigation) are missing an important element – adaptation (the reduction of impacts given climate change).

The most significant stressors of biodiversity in BC are urban development, agriculture, transport and utility corridors, forestry, over-extraction of marine resources, oil and gas activities, invasive and alien species and climate change. Of these, climate change is arguably the greatest long-term threat to biodiversity, yet the implications of climate change and the need for new conservation strategies have only just begun to be considered and much of the current knowledge about biodiversity is based on past experience, which is increasingly unreliable.

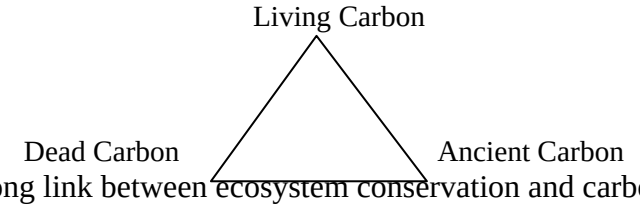
The purpose of this paper is to outline the benefit of healthy marine and terrestrial ecosystems to protecting biodiversity, in light of climate change. The paper is a compendium of information

from a variety of sources and is not intended to be a scientific or academic document on climate change. As a result it contains some generalizations.

2.0 BACKGROUND[iii]

- Biodiversity forms the foundation of the vast array of ecosystem services that are critical to human well-being. Ecosystems support all forms of life, moderate climates, filter water and air, conserve soil nutrients and control pests. Species provide people with food, building materials, energy and medicines. They also provide services such as pollination, waste assimilation, water filtration and distribution of seeds and nutrients free of charge. Retaining a variety of life permits adaptability in changing environments and a diversity of organisms maintains future ecological stability.
- Many people believe that all life forms have intrinsic value and that humans have a moral obligation to protect the environment for its own sake as well as for future human generations.
- Human response to climate change needs to have two aspects, mitigation and adaptation:
    1. Mitigation: doing something now and in the future to decrease the amount of greenhouse gas emissions being discharged into the atmosphere, primarily by adjusting how we generate and use energy, construct buildings and transport people.
    2. Adaptation: involves biological, behavioural or physical adjustments to reduce impacts of a given amount of climate change. Building resilience into ecological systems to prepare for and reduce the effects associated with climate change is essential. Healthy ecosystems are the cornerstone of the adaptive approach to protecting biodiversity.
- While mitigation initiatives have attracted attention globally, less attention has been paid to adaptation. When considering impacts on people and biodiversity, people have been prioritized and climate change strategies usually give little attention to impacts on biodiversity. In the case of impacts on biodiversity, strategies to reduce impacts on species viability through the maintenance of healthy ecosystems have received little attention[iv].
- No matter how successful mitigation is, the current mechanisms forcing climate change are so advanced that stabilization of ecosystems cannot be expected for over one hundred years[v]. To survive, most species will need to undergo major ecological or evolutionary changes. Their survival would be greatly facilitated by healthy planetary processes and reducing ecosystem stressors.
- Humans can influence that survival through our land, freshwater and marine planning. This paper is not meant to suggest that adaptation measures are more or less important than mitigation (it is not an either-or proposition), rather it is of concern that currently more thought and energy is being put toward mitigation efforts than recognizing the critical role of adaptation.

- A healthy-ecosystem approach is vital to both biodiversity and long-term carbon stewardship. There are three aspects of carbon that require consideration: living carbon (ecosystems that sustain life), dead carbon (organic matter, for example soils within healthy forests) and ancient carbon (held as fossil fuels) [vi].



- There is a strong link between ecosystem conservation and carbon stewardship. Keeping ecosystems healthy and connected conserves living carbon, which in turn generates and sequesters dead carbon through the indirect management of organic matter.[vii] Mitigation efforts largely focus on ancient carbon management - i.e. reducing the use of fossil fuels[viii]. Protecting living carbon and the dead carbon that supports it is as important as reducing the use of ancient carbon - it is our insurance against the negative impacts of change. Human effort can influence the future of biodiversity through adaptation mechanisms associated with keeping ecosystems healthy and connected.
- Species confronting rapid climate changes will be faced with a new form of stress. For the most part they have but two survival options: evolve (behaviourally or genetically), or migrate to adjacent suitable habitats. For many organisms, evolution will be unable to keep pace with the current rapid rate of climate change. We must therefore do what we can to build resilience into natural systems to reduce stressors, and to facilitate species movement through the protection of connected[ix] networks of large, healthy land and seascapes.
- Future protected area managers, in addition to the more traditional roles of protecting ecosystem functions, communicating with the public, and providing outdoor recreation opportunities will need to focus on: i) conserving climate refugia, ii) facilitating migration, iii) gathering climate change related baseline and monitoring data, and iv) maintaining critical ecological services.
- In the marine realm, the short life spans of many key organisms means that the effects of climate change are felt more quickly. This quick response time can be advantageous when recovering from disturbances, but only if critical resilience thresholds are not exceeded during the disturbance. A highly disturbed population with little resilience may not be able to recover at all.

3.0 BRITISH COLUMBIA'S ECOSYSTEMS[x]

- British Columbia is a large climatically variable and biologically diverse province including parts of three of the four terrestrial ecoregions in North America, and is influenced by a long coastline on the Pacific Ocean. It is topographically complex with 5 major mountain ranges (Coast, Rocky, Columbia, Cassiar-Omineca, and Cariboo). This complexity of ecoregional influences and topography provides for the diversity of habitats that has spawned the biodiversity that makes British Columbia so famous.
- Terrestrially, the rugged topography works to limit human influences and has therefore left much of the environment relatively intact. The same steep mountains that have limited

human development have however led to degradation in the aquatic realm as most of the major river valleys have been logged at least once and many have been dammed to provide hydroelectric energy and irrigation.

- BC's coastal waters have been classified into five regions (Hecate Strait, West Queen Charlotte Islands, Queen Charlotte Sound, West Vancouver Island Shelf, Strait of Georgia). It has been difficult to translate our well-established approaches for protection in terrestrial environments to the marine context. The complexity is further compounded by the multiple, overlapping legislation at the federal level for marine protected area (MPA) establishment, with three federal agencies holding that mandate (Parks Canada, Fisheries and Oceans and Environment Canada).
- Many of the marine fisheries are overexploited (globally, half of all fish stocks are overexploited and 90% of predatory fish have been removed), and large amounts of nutrient inputs from terrestrial runoff from agriculture, industry, and other human activities have led to degradation and reduced functioning of coastal ecosystems.

4.0 CLIMATE CHANGE IMPLICATIONS

- Climate change will have significant implications for the stability of ecosystems. The changing climate will stimulate species-level changes in range and abundance, life cycle and behaviour and, over time, genetic evolution. This has already been seen in BC with the rapid spread of the mountain pine beetle infestation. There is evidence[xi] that some species are already evolving (adapting genetically), or expanding their range pole-wards or upwards in elevation (or in the water column), or adjusting migration or breeding times as a response to climate warming.
- Some specific terrestrially-related climate change predictions are:
    - An increase of 1 C° will 'force' a shift of biomes or ecosystem zones a predicted 300m up in elevation and 150 km north. The prediction is a minimum increase of 2-5 C° in 70-100 years, translating to 600m-1500m in elevation and 300km-750km in distance.
    - This projected 'ecological zone shift' is estimated to be at a rate of 40 km per decade --- the 'average' plant/animal/insect can shift habitats at a maximum of 6 km per decade[xii]. The rate that appropriate conditions shift will therefore be so fast that many species will be unable to compensate through dispersal.
    - Over 50% of the alpine tundra ecosystems will disappear as forests shift up in elevation and forest composition will change significantly in most regions of BC. Expect reduction of moist forests and expansion of dry forests in the southern portion of the province; moister warmer forests will probably expand in the north. Western red cedar could disappear from the southern lowlands. As a result of decreased forest health, drought stress, more frequent, larger and more intense wildfires will occur. There will be an increase in grassland-montane landscapes[xiii].
    - 40-60% of the glaciers in BC will disappear and others will diminish greatly. Beyond the effects on biodiversity, the resultant effects on provincial water systems and watershed management will have substantial consequences on industrial and community water supply, hydro production, fisheries, tourism, agriculture and forest management.

- Freshwater fish populations will be affected dramatically. For example, there is evidence that anadromous salmon may be unable to migrate through the Fraser River due to overly warm waters.

- Through the steep climate gradients of BC's mountains, ecosystems are highly sensitive to climate fluctuations. Mountain systems offer the greatest opportunities for biodiversity conservation - beyond the typical north-south and east-west opportunities for biodiversity migration, mountains also offer up-down altitudinal and 'contouring around the mountain' avenues for species migration.
- The implications of climate warming for freshwater biodiversity are not certain, with strong variation expected among watersheds - but clearly wetland and riverine ecosystems will change. Beyond the changes in the timing and amount of the spring melt, warming is also expected to accelerate the water cycle (increasing rates at which water enters the atmosphere and rains down again) – The effects of this on hydrology, fish and invertebrate populations remains to be seen. Freshwater species have few migration options as their habitat is within the stream system.
- Some specific marine-related climate change predictions include[xiv]:
  - Warmer air and sea temperatures caused by climate change have led to thermal expansion of warmed water and melting of glaciers, sea ice and ice shelves[xv]. As a result sea level has been rising at an average rate of 2-3mm/year. Higher sea levels will require humans and marine animals alike to adapt to altered or lost habitat including submerged lands, altered distribution of habitats and increased wind and storm intensity with associated frequent flooding. This may result in the extirpation of a number of coastal freshwater plants, habitat loss for migrating shorebirds, destructive storm surges and an altered marine food chain.
  - 20-30% of marine plant and animal species are at risk of extinction if global temperatures increase by an additional 1.5-2.5 C°.
  - There is increasing concern based on studies in Atlantic regions that large ocean currents - responsible for exchanging massive volumes of water between higher and lower latitudes, and vital to climate and habitat regulation, species' migratory movements, and general ocean productivity - may be severely affected by global warming. Scientists predict that climate change could lead to a weakening, or in an extreme case, a complete cessation of large-scale ocean circulation with dire consequences to all biodiversity.
  - The oceans are one of the planet's most important carbon sinks. Roughly half of the CO_2 released by humans between 1900 and 1994 is now stored in the oceans, and about 30% of modern CO_2 continues to be stored by the sea. The chemical reaction of this massive volume of CO_2 has led to an alarming acidification of the world's oceans. A continuation of current trends is predicted to lead to a level of acidification unprecedented in the last several million years, which could be irreversible for millennia and will have severe negative consequences for marine ecosystems.
  - The effects of the rapid rate of climate change, combined with overfishing and pollution, is likely to exceed the adaptive capacity and resilience of many species over the next century leading to unpredictable, negative responses.

- Climate change will act synergistically with many of the biggest existing impacts to biodiversity: i.e. each individual impact will have a total greater cumulative effect leading to drastic unpredictable changes to the current web-of-life.
- These changes will occur during a single century, rather than over a period of several thousand years and lead to temperatures unseen for millions of years. Many species will simply be unable to adapt to these rapid changes[xvi].
- This future pressure on species has been termed the Big Squeeze or Bottleneck[xvii], with the most harmful time forecast to be 70-150 years from now. This period will be quite an unstable time for species and their habitats. The challenge for the future of biodiversity is to get as many species as possible through this Big Squeeze into the different habitats and hydrological cycles that will emerge in the future.
- It is highly probable that species richness will diminish over the next few decades - some specialized creatures will disappear and many coarse species will expand their range[xviii]. It is this loss of genetic diversity (including whole species) that will be the most difficult, and sometimes not possible, loss to recoup[xix].
- Loss of diversity will lead to loss of resilience of ecosystems and wide-ranging ecological disruption. The best management approach is to conserve large ecosystems with associated migration connectivity[xx]. Such an approach will build resiliency into natural systems, increase their adaptive capacity and enable as many species as possible to survive the Big Squeeze - thus reducing the negative effects of climate change on biodiversity and human health.

5.0 HEALTHY ECOSYSTEMS AND CONNECTIVITY

5.1 Terrestrial

- To support the maintenance of biological diversity and help as many species as possible adapt to climate change, a management regime that secures large landscapes with appropriate connecting ecological corridors is essential. Given that migration will occur over the course of many generations (not within a generation), migrating organisms will need much **wider corridors** than have typically been included in conservation plans. Without this, the benefits of parks as centres for biodiversity will be greatly compromised.
- Such a planning framework increases the opportunity for maintaining population resiliency and species survival.
- There is evidence that a protected area size of at least 270,000 hectares[xxi] is necessary for core refugia[xxii]. Following are examples (Figure 1) of such large areas in British Columbia:
    - There are seven protected area complexes in the province that meet this size criterion: Garibaldi, Kitlope-Tweedsmuir, Wells Gray, Spatsizi, Dune Za Keyih, Northern Rocky Mountains and Tatshenshini.
    - If one includes protected areas directly adjacent to large transboundary complexes Manning, Yoho-Kootenay-Alberta Rockies and Mount Robson can be added.

- Terrestrial protected area complexes with large marine components such as Clayoquot Sound, Broughton Archipelago, Hakai and Gwaii Haanas could also be considered.

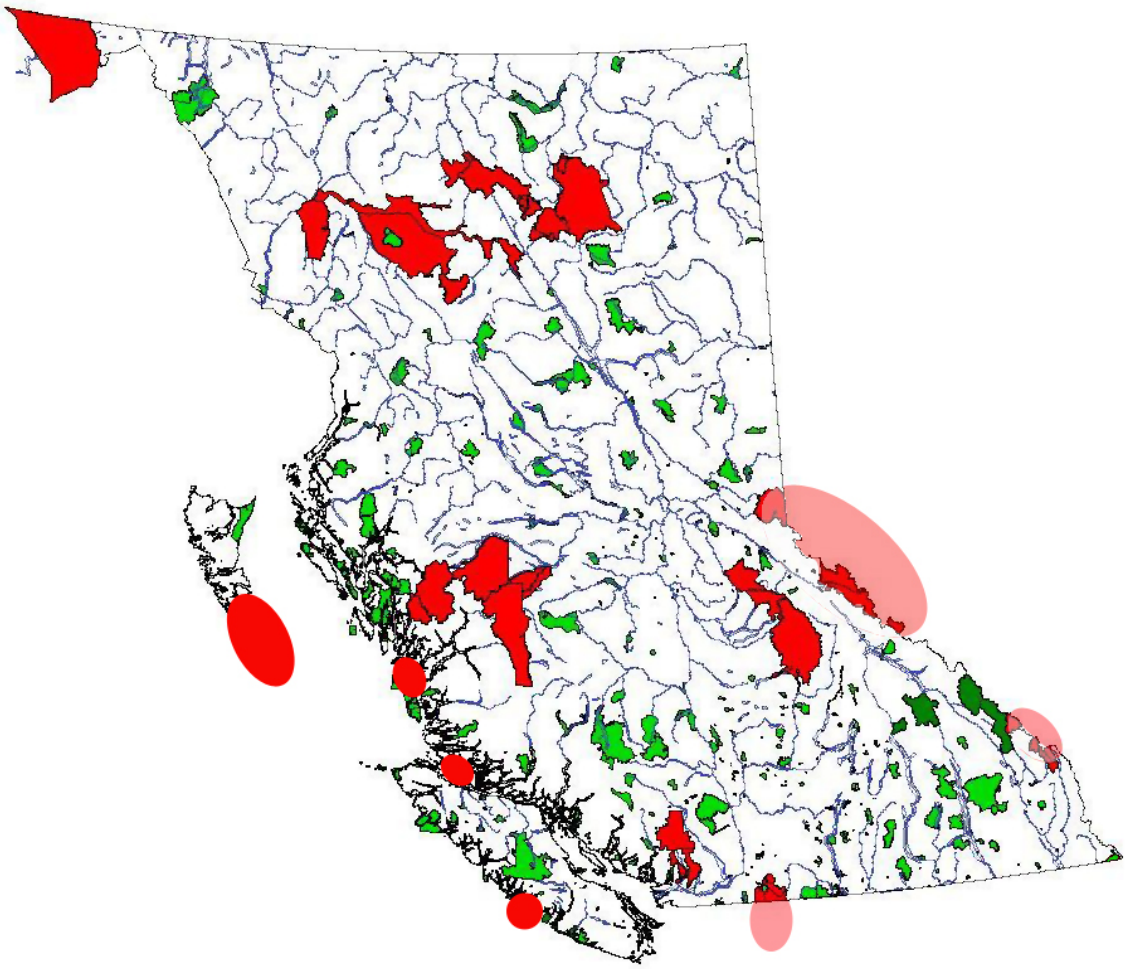


Figure 1

Large protected area complexes in BC that may act as core refugia for species and ecosystems during changing climates

- Funds for conservation are insufficient to save every species and habitat. To optimize the allocation of resources and save the maximum amount of habitat and species, one approach being put forward is the concept of intact ecosystem conservation areas. This approach is in contrast to focused single species management. Multi-species conservation areas support the core-corridor approach[xxiii].
- Climate change challenges the basic assumptions upon which traditional land, freshwater and marine planning has been based, such as protecting representative ecosystems. Current management needs to be based on modeling the future conditions and 'back casting' from those conditions, not making decisions by forecasting from today's situation[xxiv].

- The Muskwa-Kechika Management Area and Great Bear Rainforests, with their focus on management of the non-reserve, non-corridor areas, provide great models for protecting biodiversity in the face of climate change – they will enable the kind of migration-over-generations that we discuss above.

5.2 Marine

- BC has one of the world's longest coastlines and more ocean territory than many federal-level governments.
- Healthy oceans play a key role in the carbon, climate and water cycles of the planet: covering two-thirds of the earth's surface, oceans initially take up the greater part of incoming solar heat, thus determining the climate system. Similarly, the global water cycle is driven by evaporation from the oceans, which also take up and cycle a large proportion of atmospheric carbon dioxide.
- Climate change impacts have been described for all levels of marine ecosystems, from the essential base of the food chain, all the way up to sharks and other large predators.
- Scientists have recognized that well-managed and adequately funded marine protected area networks are vitally important conservation tools as marine systems and organisms struggle to survive and adapt to climate change. On average, the establishment of a marine reserve will double the density, triple the biomass and increase the size and diversity of organisms present by 20-30%.
- Healthy populations are more likely to be resilient to climate-related disturbances such as storms, or warmed or acidified waters. To support ecosystem resilience, we must reduce the number of simultaneous threats faced by that ecosystem. By reducing human impacts within marine protected areas, we can manage our oceans to minimize risks of population collapses, community disruption, and biodiversity loss.
- Due to the fluid, three-dimensional nature of the marine environment, marine processes such as upwelling and ocean circulation, and the specific life histories of many marine organisms (ex. those with pelagic larval phases, and long-range migratory movements), it is critical to consider ecological connectivity when designing comprehensive systems of marine protected areas.

6.0 BC'S PROTECTED AREA SYSTEM

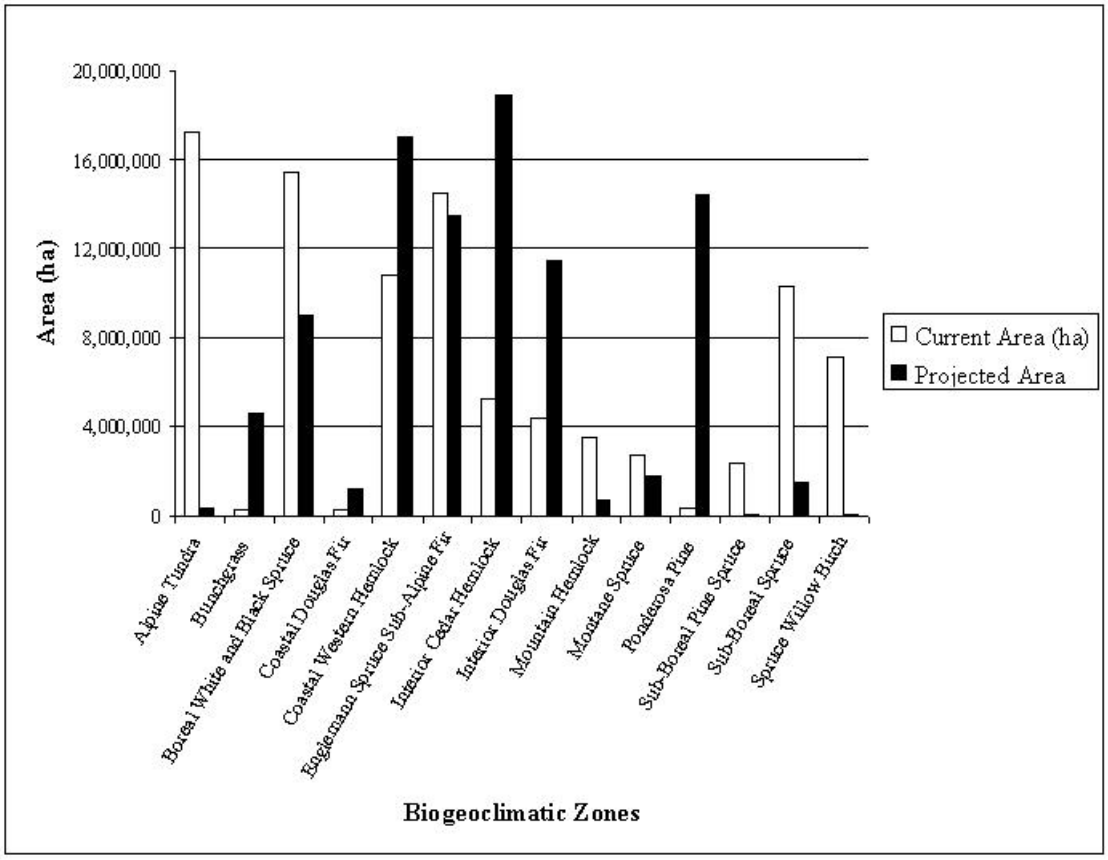
6.1 Terrestrial

- The protected area system (PAS) has been growing since Strathcona Provincial Park was first established in 1911. Today roughly 14% of the province is protected (federal, provincial, regional and private).
- One of the main purposes of the current terrestrial system has been to proportionately represent the variety of life and habitats throughout British Columbia. Although the PAS is not fully complete those areas that are set aside do a reasonable job of representing the biogeoclimatic zones of the province; and using roadlessness as a surrogate for intactness, the protected area system is approximately 60% intact.

- As a result of climate change the current BEC zone representation within the existing protected areas will shift quite significantly by the turn of the century (Figure 2) [xxv] However, due to the many levels and huge magnitude of uncertainty, the resulting ecosystems are entirely unpredictable.
- Figure 2 illustrates how the biogeoclimatic zones change dramatically over time due to climate change - thus stressing the importance of a landscape approach to management that provides core protection and connectivity between protected areas.

Figure 2

Biogeoclimatic Zones in Protected Areas: Current (2007) and Possible Projections (2085) [xxvi]



- It is crucial to ensure that connectivity for species migration is maintained between protected areas. A strategy of protected areas connected by narrow strands will not work - species will be lost - a broader landscape conservation approach is required. It is very uncertain to predict 'core landscape shifts'; it is much less risky to work at the species level. The provincial protected areas strategy needs to plan for these migration shifts now and plan according to the 'new' landscape, not today's representation.
- We need to maintain our current parks and protected areas system, build on that using traditional methods such as private land conservation, and employ a wide array of new or

established methods to maintain healthy ecosystems such as minimizing linear disturbance, managing access by ATV's and snowmobiles, placing limits on recreational hunting and fishing, and adjusting rates of forest harvest.

- Protected areas cannot halt climate change but they can provide the healthy landscapes required to afford the natural world the opportunity to adapt to climate changes, until mitigation measures take effect. Among other things, the ecosystems they protect within their boundaries support all forms of life, moderate climates, filter water and air, conserve soil nutrients, and control pests.
- Through appropriate public programming, protected areas also have an increasingly important role in educating society at large about the causes and consequences of climate change.

6.2 Marine: the urgent need for MPAs in light of climate change

- The condition of our coastal waters and fisheries is declining rapidly. Decisive action needs to be taken to protect remaining healthy ecosystems, to promote the recovery of degraded areas and to build resilience and adaptive capacity into all marine systems. This can be accomplished through the legislated protection of large networks of marine protected areas.
- Immediate, extensive, and precautionary protection is immediately required for our coastal waters to guard against further known and unpredictable climate-change related impacts to the already overly disturbed and highly threatened marine ecosystems.
- There is a tremendous opportunity for the BC government to move forward on the protection of Canada's biodiversity in the marine environment as a result of increased awareness, and knowledge. Canada has agreed to establish a representative network of MPAs in national waters by 2012.
- Global best practices dictate that to protect marine diversity a minimum of 20-30% of our marine ecosystems need to be fully protected in representative networks of marine protected areas. Yet less than 1% of the marine environment is currently protected by legislation.
- While there is some limited protection of some BC waters, it is essential to establish a representative system of marine reserves in British Columbia that include 'no-take' zones to protect marine biodiversity, align ourselves with global standards and meet our international commitments. This is especially important for highly productive marine areas. The effectiveness of MPAs has long been recognized at the highest levels[xxvii].
- Marine reserves pose a tremendous opportunity as benchmarks for assessing the state of the marine environment on an ongoing basis. Marine managers can move forward on a marine protection plan that reflects current and future climate conditions and sets aside marine areas with provisions for 'no take' (full protection) areas and connection between these areas.
- Marine reserves must be designed to maintain ecological processes. To ensure that such processes and functions are maintained, it is essential to protect not only adequate, but also appropriate marine spaces to ensure the representation of key functional groups, and rare and important species and habitats.

7.0 CONCLUSIONS

To reduce the effect of climate change on biodiversity including those things that are uniquely British Columbian (grizzly bears, salmon, giant trees, whales, glaciers and grasslands), well configured, healthy land and seascapes are essential. Retaining these images can be our legacy.

The benefits of protecting large land and seascapes to maintain and promote the health of BC's lands and marine waters cannot be overstated, with benefits undoubtedly well beyond what we are able to predict. It seems wise therefore to apply the precautionary principle, acknowledging and acting to safeguard not only the known, but also the unknown benefits to us, to future generations, and for the health of natural systems.

1. **Climate Change Action Plan**. The British Columbia climate change action plan be comprehensive and include both pillars of a good response to climate change - mitigation and adaptation. No matter how successful mitigation efforts are the current mechanisms forcing climate change are so advanced that any stabilization of ecosystems cannot be expected for over one hundred years.

2. **Management Approach.** Under a changing climate, BC can expect major transformation in biodiversity across all systems (terrestrial, freshwater and marine) and across all levels (genetic, species and ecosystems). Maintaining ecosystem resilience and adaptive capacity needs to be the management priority. Effective land and seascape management needs to be based on 'back casting' from the future, not forecasting from the current environment in which we live. This goal can best be accomplished through a management approach that minimizes habitat fragmentation, secures core refugia and provides functional migration corridors. Funding for conservation is insufficient to save every species and habitat. To optimize the allocation of resources a multi-species conservation approach is recommended over single species management. Training for all pertinent ministry staff on the implications of climate change on biodiversity and management approaches is critical

3. **Contribution of Protected Areas.** The fundamental integration of climate change into protected areas planning is not yet a reality. BC's climate change action plans must acknowledge both marine and terrestrial protected areas as some of the most important management instruments for biodiversity conservation. The potential for major long-term ecosystem shifts under changing climactic conditions suggests a need to fully articulate the role that protected areas play in facilitating adaptation by species and ecosystems under altered conditions. Protected areas are an excellent place to monitor and research the impacts of climate change and engage the citizens of British Columbia. In this regard, British Columbia has the opportunity to be a world leader.

4. **Research.** There is a need for long-term base-line assessment and monitoring of biodiversity under changing climates. Research capacity should be strengthened to model the responses of species and ecosystems to varying climate change scenarios, and management measures should focus on biodiversity and the contribution of healthy ecosystems to maintaining and bolstering species and ecosystem resilience.

5. **Public Education.** Climate change provides an opportunity to educate the public about the effect of carbon use on biodiversity and healthy ecosystems and the need for effective land, freshwater and marine planning. Interpretive and educational programming can describe why it is so crucial for the survival of biodiversity and human health that we have protected areas, and how essential it is that we switch to alternative energy technology, thus reducing the amount of ancient carbon used by humans.

6. **Pilot Programs.** 'Pilot' protected areas could be selected for high profile climate change programming and research. There are certain protected areas that clearly illustrate the connection between climate change and ecosystem impacts, for example: Mount Robson (glaciers disappearing), Tweedsmuir (mountain pine beetle), Cypress-Garibaldi (alpine vegetation), Muskwa-Kechika (a working model), Manning (forest vegetation changes), Miracle Beach (coastal marine) and Clayoquot Sound (marine systems).

7. **Financial Implications.** Seriously addressing the adaptation issues associated with climate change will have both positive and negative financial implications for the province. By protecting adequate and appropriate land and seascapes, BC has the opportunity to position itself as a leader within the environmental industry, and leverage increased public and private dollars as a result. Managing conscientiously for the effects of climate change is likely to have specific potentially negative impacts on resource industries, such as fisheries and forestry; but these impacts will be balanced by the many positive opportunities for communities and business around the province.

8. **Community Partnerships.** Communities could quite easily become engaged in monitoring the effects of climate change with the encouragement of government. Depending on the community location it will experience climate change differently and its residents will respond to climate change accordingly. Maps from modeling exercises are useful to help 'picture' the impending changes. Particularly important are water management and connectivity. For example: 1) working with NGOs, service groups, business, First Nations and local government to create the necessary social conditions so that climate change can be used as a 'positive force' for community land and water use planning - with the goal to reduce the causes and consequences of climate change (mitigate) and plan for the changes that are coming (adapt); 2) fostering training and providing monitoring kits to enable various volunteer groups, youth, service clubs, ecoreserve wardens and young naturalists to collect data at local monitoring stations, whether coastal or inland.

9. **Public Messaging.** It is important to inform the public about climate change, however the message should not be too strong or negative, and instead be realistic. Some basic message suggestions are:
    - Large ecosystem conservation initiatives are a positive approach to preparing for climate change.
    - It is important to maintain as much of the present wildlife, fisheries and coastal habitat as possible to help minimize the effects of climate change, and to help as many species as possible survive. These conservation efforts will act as insurance against the negative effects of high risk transformations.

- With good public response, especially related to land and water allocation, it is possible to minimize some climate-related changes so that the consequences to wildlife will be less significant.
- Maintaining and bolstering the resilience of native ecosystems will minimize the opportunity for the invasion and establishment of harmful exotic species and the outbreak of native species (e.g., mountain pine beetle).
- Wildlife must be able to migrate (emphasizing the importance of cores and connectivity) and climate change will make that more difficult for many species. Messages should include the importance of community planning based on 'back casting' from the future, not on forecasting from the current situation.
- Mitigation alone is not the solution.

GLOSSARY

Biodiversity: the variety of species and ecosystems on Earth and the ecological processes of which they are a part - including ecosystem, species and genetic diversity components.

Climate change and global warming: Greenhouse gases are a class of gases, which can trap heat near the Earth's surface. As they increase in the atmosphere, the extra heat they trap leads to global warming. This warming in turn places pressure on Earth's climate system, and can lead to climate change.

Coastal marine ecosystems: tidal zones, estuaries and coastal wetlands and the species that utilize them.

Corridors and connectivity: We use the corridor and connectivity concepts throughout this paper in the broadest sense of the words. Connectivity and corridors do not imply just linear spaces between two spaces. Rather in this context they can be three dimensional, especially in the marine environment. They can be a series of stop overs such as important feeding areas along a migration route. They may be seasonal or otherwise temporally constrained.

Protected Area: includes parks, protected areas, ecological reserves, conservation lands, etc.

Sequestration: refers to the processes that remove carbon from the atmosphere and store it. Natural carbon sequestration processes include plant growth. A variety of means of artificially capturing and storing carbon, as well as enhancing natural sequestration processes are being explored.

Weather, climate and climate change: Weather is what we experience each day. Climate is the sum of all weathers over a certain period, for a region or for the planet as a whole. The variables generally measured are temperature, precipitation and wind. While climate has changed continually since the earth was formed, the changes have usually occurred over long periods of time measured in thousand and millions of years. At present, the scientific community agrees that the Earth is undergoing rapid climate change in response to human activities that have increased the amount of greenhouse gases (primarily CO2) in the atmosphere to the point that the global average surface temperature is rising. The United Nations Intergovernmental Panel on Climate Change reports that the average global surface temperature has increased by 1°C over the past century and is likely to rise by another 1.4-5.8°C over the century.

ENDNOTES

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[ii] The Government of British Columbia and the Ministry of Environment have published a number of climate change reports. Two such reports are: Indicators of Climate Change for BC, 2002 and Weather, Climate and the Future: BC's Plan, 2004

[iii] An Assessment of Climate Change Impacts on Biodiversity Management in BC by Compass Resource Management Ltd and the (draft) Status of Biodiversity in British Columbia prepared for Biodiversity BC, were useful references during the preparation of this document.

[iv] Most climate change plans are weighted toward mitigation with little specific mention of actions to proactively address potential biodiversity impacts through adaptation. In BC, like most other jurisdictions, the emphasis has been on mitigation and public knowledge with little focused effort on mechanisms related to adaptation.

[v] There is evidence that marine environments may respond more quickly, perhaps in the range of a few decades.

[vi] This concept is based on a conversation with Dr. Richard Hebda.

[vii] Compared to many part of the world BC is endowed with exceptional ecological richness - that richness is central in an adaptation strategy for climate change. British Columbia is a relatively minor CO2 producer, within the world context.

[viii] Some authors are expressing an increasing caution about artificial sequestration as a positive mechanism, due to energy and transportation concerns. It is preferable to retain as much living and dead carbon as possible, and reduce as much as possible the amount of ancient carbon that is used by humans.

[ix] The term connected or connectivity throughout the paper does not only refer to linear corridors connecting two or more places. Connectivity includes other things such as temporal, seasonal, process and other kinds of connections that are important to species and ecosystems.

[x] BC has a relatively short post-glaciation history and the mountainous terrain has limited the amount of impact in the province overall. However BC has the highest number of species at risk of any province or territory as assessed by Committee on Endangered Status of Wildlife in Canada. The province has 2 of the 4 most endangered ecosystems in Canada, the Garry Oak ecosystem and the Antelope Brush Grasslands ecosystem.

[xi] Parmesan, Camille. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology and Systematics 37: 637-669.

[xii] Larger mammals may be able to shift habitats at a faster rate.

[xiii] A number of illustrative maps are available at www.pacificclimate.org.

[xiv] Climate change impacts on already overly impacted coastal waters will be significant and the situation will become increasingly critical and urgent. Eighty million metric tonnes of food are taken from the sea every year. Accordingly half of all fish stocks are fully exploited and one quarter have already collapsed from overexploitation. Globally ocean ecosystems are so eroded from targeted and bycatch over fishing that more than 90% of large predatory fish have been fished out of the seas, and many other species have been reduced to vulnerable remnant populations. If current trends continue warmer temperatures and increased atmospheric CO2 concentrations are predicted to lead to significant sea level rise, altered ocean circulation patterns, increased storm severity and frequency, staggering species extinctions, unprecedented ocean acidification, and changes in the behavior, interactions, location, and genetics of marine species that do survive.

[xv] Sea level rise comes from the expansion of the oceans, for warm water occupies more space than cold. Only the land ice, as it melts and runs into the sea, adds to sea levels - not melting glaciers and ice caps.

[xvi] Some predictions are up to half of all species will be gone or fated for early extinction by the end of this century.
[xvii] E.O. Wilson originally published these terms. To illustrate his concept think of an egg timer -)(- with the goal to have as many species as possible 'squeeze through the next few decades' and emerge into the future habitats of that time.
[xviii] It is ironic to think that decades from now coarse species and invasive aliens might well be fulfilling the ecological role presently being undertaken by some of our current native species.
[xix] Regardless of our effort during this time period species richness will diminish, many special niche creatures will disappear and most coarse species will expand their range.
[xx] This point is not to negate the important contributions of restoration, seed collection and storage, DNA storage, etc.
[xxi] 2700 sq.km, 648,000 acres, 1000 sq.mi
[xxii] This concept is based on a conversation with Dr. Tory Stevens.
[xxiii] The Muskwa-Kechika Management Area, at 6.4 million hectares, is a classic multi-species conservation area model, with core refugia and corridors.
[xxiv] This future landscape may be hard to define but present day modeling has increasingly accurate predictive validity. BC is fortunate to have access to the professional assistance of the Pacific Climate Impacts Consortium (PCIC) at the University of Victoria.
[xxv] Note the area in the hectares column and compare how it shifts from current to 2085 - that shift illustrates the direct effect of climate change on biogeography.
[xxvi] Based on predictive modeling by Dr. Andreas Hamann, University of Alberta.
[xxvii] The World Summit on Sustainable Development, the IUCN's World Commission on Protected Areas, the Convention on Biological Diversity, and the G8 Group of Nations have all called for establishing a global system of MPA networks by 2012.