Species at Risk from Climate Change: Adapting to Climate Variation and Change in Canada

MARK R.S. JOHANNES

Fisheries Sector, Canadian Climate Impacts and Adaptation Research Network, Pacific Biological Station, Fisheries and Oceans Canada, 3190 Hammond Bay Road, Nanaimo, BC, V9T 6N7, Canada, email mark@fishclimate.ca

Abstract: There is increasing evidence that species at risk, ecosystem integrity, and biodiversity in Canada are impacted by global climate change and warming. Future assessment, conservation, and protection activities to preserve biodiversity and threatened species will require more effort and greater refinement of climate predictions to improve our understanding of climate change 'impacts'. As an immediate response to species at risk and biodiversity conservation issues, an 'adaptation' approach should be used to prepare for impacts of climate change on natural systems. Such an approach will help define vulnerabilities of species at risk to climate change and help develop adaptive management and conservation actions for sensitive habitats and important plants, animals, and ecosystems in Canada. Adaptation to climate variability and change can be used to modify human and social practices (e.g., water use practices), processes such as land use planning, management of such things as parks, and statutory and legal systems (e.g., acts, regulations, agencies) based on projected changes in climate. Adaptation to climate change can be used to create awareness and alter resource use expectations to help conserve and protect sensitive habitats, ecosystems, and biodiversity.

Key Words: climate change, species at risk, biodiversity, habitat, impacts, adaptation, Canada

Introduction

Recent weather events across Canada, such as hurricanes in Atlantic Canada, floods in Manitoba, and drought and fire in British Columbia, have demonstrated the dramatic influence that daily and annual shifts in weather can have on our lives and communities, and on the animals and plants which comprise the natural ecosystems on which we depend. Climate differs from weather. Climate is the average condition experienced across a specific set of variables such as temperature, salinity, precipitation, ocean current, and wind. Long-term climate is not stable; it changes over extended periods of centuries to tens of thousands of years or more, and can include such things as short-term El Niño events or very long-term changes between glacial and warming periods. The Third Assessment Report of the Intergovernmental Panel of Climate Change concludes that surface temperatures across the earth are warming at unprecedented rates and are associated with burning of fossil fuels, forest harvesting, and urban, rural, and industrial development over the past two centuries (McCarthy et al. 2001). The accelerated warming rate correlates with an increased frequency of extreme climate events (e.g., storms, hurricanes) at

levels not observed in the historic records. Human industrial development, resource extraction, and land use have modified the earth's surface and have led to increased concentrations of atmospheric greenhouse gases such that global surface temperatures have increased on average 0.6 ± 0.2°C within the last century (Hengeveld 2000; Houghton et al. 2001). Global Climate Models predict that relative to 1990, surface air temperatures will increase on average 1.3–5.8ºC by 2100, and sea levels will rise 0.09–0.88 m across the globe (Houghton et al. 2001). The Canadian Global Climate Model predicts that some Arctic areas of Canada may experience > 5ºC change in average annual temperatures, while southern regions of the country will experience average temperature increases of 3–4ºC (Fig. 1).

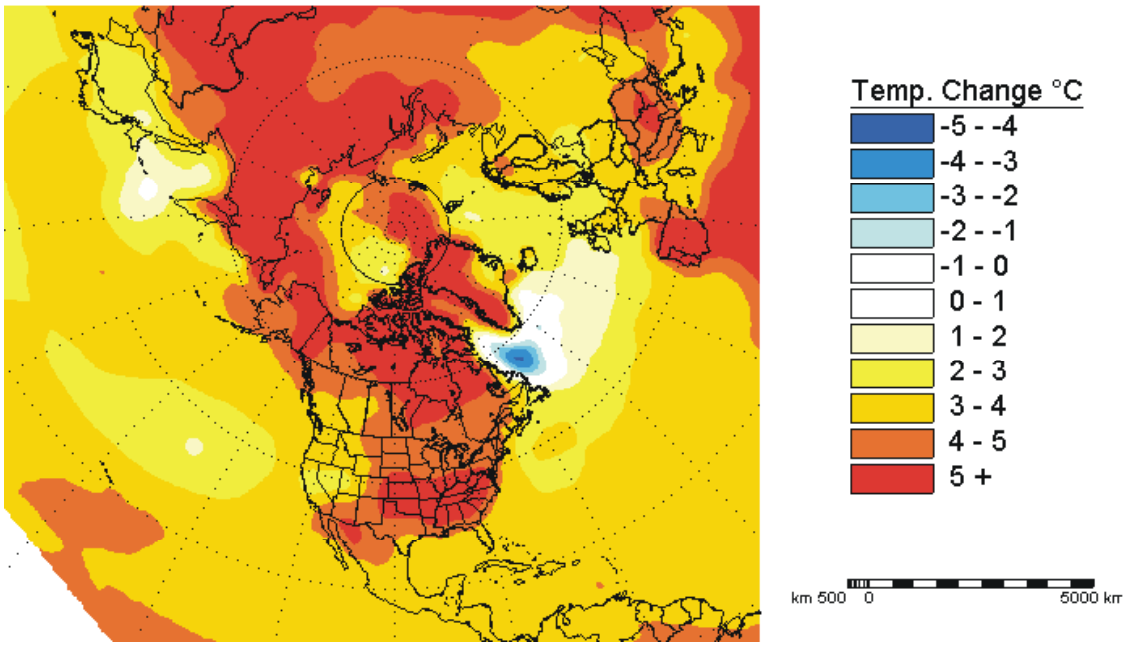

Figure 1. Canadian Global Climate Model predictions for 2100 summer temperature changes (Hengeveld 2000).

Climate change has gained global attention due to impacts from severe storms, droughts, fires, and other climate extremes on natural systems, human society and communities, industry, and resources. Canada, along with much of the international community, has adopted the Kyoto Protocol as a means of mitigating and reducing greenhouse gas emissions. While mitigation is important, it will only slow the rate of accumulation of greenhouse gases; it cannot alter the accumulated impacts or stop the progression of climate warming. In Canada, it is essential that agencies, researchers, industry, and stakeholders understand the potential impacts of climate change, and develop effective and appropriate methods of adapting to them. Proactive adaptation through altered management, regulation, built environments, and research can help reduce the present and future impacts of climate change.

The unpredictable nature of climate and the predicted trends towards accelerated warming complicate the risks faced by threatened species and the management of vulnerable habitats and land conservation initiatives (e.g., parks, conservation and protected areas). This paper summarizes some of the important issues relevant to species at risk, biodiversity, and habitat protection within the context and scope of impact and adaptation responses to climate change in Canada.

Impacts on Species at Risk and Biodiversity

Climate change is expected to directly and negatively impact the spatial and temporal conditions in which plant and animal species currently live (Dokken et al. 2002). Predicted increased climate warming, variation, and change over the next century will impact the physical characteristics of freshwater, terrestrial, and marine environments through degradation, loss, and fragmentation of optimal habitat for many species. The general impacts of climate change on the physical environment include altered

- air and water temperatures;
- frequency of extreme weather and storm events;
- patterns of precipitation and freshwater supply;
- sea levels;
- ice cover (Arctic, coastal, freshwater);
- ocean upwelling events (El Niño, La Niña) and circulation patterns;
- ocean salinity;
- terrestrial and coastal sediment transport and erosion;
- soil moisture;
- patterns of nutrient availability; and
- frequency of catastrophic events.

Climate change is also expected to impact the distribution and biological characteristics of plant and animals, and affect individuals, species, populations, and ecosystems through altered

- spatial distribution, range, and migration of individual species;
- growth and physiology of individuals within a population;
- timing match (i.e., mismatches between climate patterns and a species' life history);
- diversity of prey, predators, and competitors within communities;
- species composition and distribution within ecosystems;
- migration and movement corridors;
- exotic and invasive species introductions and distribution; and
- parasite and disease risks.

Climate change is linked to the survival and success of a species' population or an entire community through biological mechanisms which (a) directly impact the habitat characteristics of a species, or (b) indirectly impact the food webs or community structures in which individual species currently live. Direct impacts alter optimal habitat suitability by influencing a species' level of stress or exceeding its tolerance to environmental variables such as temperature, moisture, sunlight, and currents (ocean, stream). Indirect impacts alter availability of food and nutrients; abundance and characteristics of predators and competitors, including invasive and exotic species; and vulnerability to disease and parasites.

Species at Risk, Biodiversity, and Extinction Risk Due to Climate Change

Four recent studies used climate scenarios over the next century to predict loss or degradation of species' habitats and to extrapolate those changes to global biodiversity, numbers of species at risk, and rate of species extinctions (Sala et al. 2000; Parmesan and Yoho 2003; Root et al. 2003; Thomas et al. 2004). These analyses suggest that (a) anthropogenic climate change is a recognized threat to global species biodiversity, (b) climate change is potentially the greatest threat to habitat conditions where species currently live, and (c) the severity of climate change impacts will be compounded due to interactions with various other anthropogenic threats or footprints on habitats. Thomas et al. (2004) predict that by 2050, 15–35% of all land-based species in the regions studied could be extinct from climate change. If these predictions were extrapolated across the globe, more than one million species of terrestrial animals and plants could be threatened with extinction in 50 years.

Figure 2 shows the spatial distribution and numbers of listed species at risk across Canada in 2003 (COSEWIC 2003). The greatest proportion of species at risk in Canada is associated with habitats in proximity to urban growth and development in the southern portion of the country (World Wildlife Fund Canada 2003). A number of species at risk, however, are found in areas of the north and the Arctic (Hansell et al. 1998; Anisimov and Fitzharris 2001). The predictions from Thomas et al.'s (2004) analysis can be extended to Canada through a mapping exercise that illustrates the overlap between species at risk and predictions of climate change impacts on scrubland, temperate deciduous forest, warm mixed forest, temperate mixed forest, and plains/savannah. The resulting overlap suggests that ecosystems in Canada's mixed forests and plains may be at greatest risk of plant and animal extinctions associated with climate change.

Adaptation in Conserving and Protecting Natural Ecosystems, Biodiversity, and Species at Risk

The final report on climate change from Canada's Standing Senate Committee on Agriculture and Forestry (2003) concludes that mitigation and adaptation must be complimentary activities used by communities, industry, and agencies to effectively cope with a changing climate.

Mitigation of greenhouse gas emissions alone cannot stop climate change; it can only slow the rate of change. A conscious response to the anticipated impacts and perceived risks of climate change through planned adaptation can result in directed decisions and adjustments in ecological, social, economic, and statutory systems (Smit and Pilifosova 2003). Adaptation refers to actions or adjustments in practices, processes, or structures that are taken in response to actual or anticipated changes in climate to reduce negative impacts and to take advantage of new economic opportunities (Smit et al. 2000; Smit and Pilifosova 2001). Adaptation can be implemented at local, regional, national, and global scales, and may involve technological, institutional, and social behavior change over short or long periods.

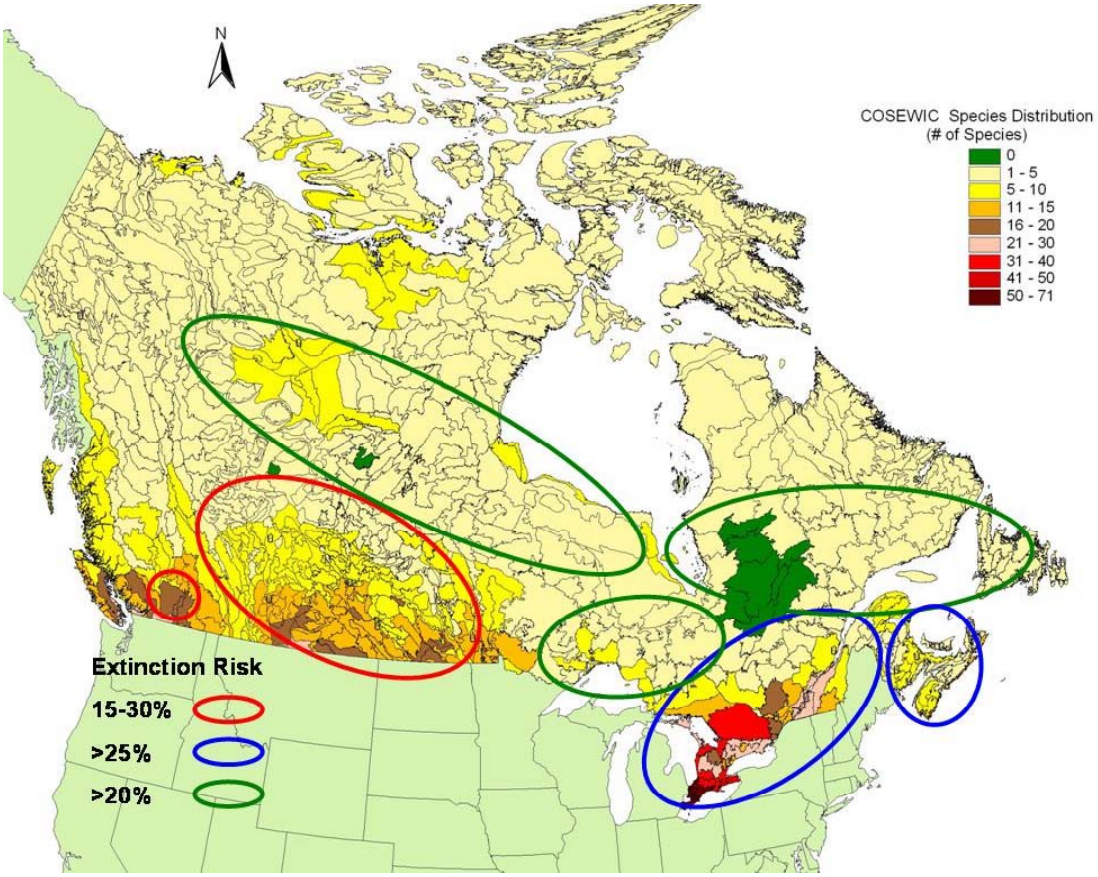

Figure 2. Spatial distribution of COSEWIC-listed species at risk in Canada. Overlay polygons illustrate extrapolated predictions of future extinctions risks in habitats that are vulnerable to climate change (from Table 2, Thomas et al. 2004).

Evidence suggests that the influence of climate change on Canada's vulnerable habitats, biodiversity, and species at risk over the next century will be significant and widespread. Anthropogenic climate change and warming ranks alongside other recognized threats to global biodiversity. Research must be used to understand ecosystem, habitat, and species responses to climate variation and change, and must lead to increased dialogue among scientists, policy

makers, and managers as a means of developing and improving adaptive decision making and research effectiveness. The management and conservation of Canada's biodiversity, vulnerable habitats, and species at risk should involve adaptation to climate change as a means of

- raising awareness and understanding of climate change issues;
- reducing risks by preparing for adverse effects of climate change;
- providing opportunities to capitalize on the positive effects of climate change; and
- providing flexibility and integrated decision making for the resource, for human development, and for land protection and conservation so that responses can be made to unpredicted residual impacts of climate change.

Climate change adaptation strategies should become an integral component of local, regional, and national planning, management, and operations with regards to conserving and protecting habitats and natural systems. This could be achieved through planned adaptation and sustainable management. Planned adaptation could be used to

- define ecological rationale and management goals (e.g., restoration, the use of fire in parks);
- establish land use for parks, protected areas, refuges, reserves, and resource extraction and development; and
- identify cultural, socio-economic, and ecological attributes in the planning and management process.

Sustainable management for biodiversity could be achieved by

- balancing land use activities and biodiversity goals;
- conducting risk management for economic development, conservation, and biodiversity; and
- establishing strategic planning to develop alternate views and contexts for sustainable resource use and reduced vulnerability of natural systems.

It has been suggested that climate change will accelerate over the next century leading to unpredicted weather and climate-related extremes or events, which may reduce or eliminate current vulnerable habitats and, subsequently, threatened species. Including adaptation in management and decision making for biodiversity, habitats, and species at risk requires an integrated view of physical and biological ecosystems in association with human social, economic, infrastructure, and built environments. Climate variation and change is a new area of focus in Canada's species at risk management and research. Future research and management of climate change and its potential impacts on species at risk in Canada should progress through a framework which aims to

- promote enhanced awareness and understanding;
- explore and fill knowledge gaps;
- link researchers with stakeholders to provide answers about impacts;

- work with industry, researchers, agencies, and communities to explore adaptation options; and
- work with agencies, industry, and communities to monitor and manage vulnerability to future climate change through research and innovation.

Additional information and links on climate change and fisheries and aquatic science issues can be found at www.fishclimate.ca (Canadian Climate Impact and Adaptation Research Network—Fisheries Sector) and the national network site at www.c-ciarn.ca.

References

Anisimov, O., and B. Fitzharris, editors. 2001. Polar regions (Arctic and Antarctic). Chapter 16 in J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White, editors. Climate change 2001: impacts, adaptation, and vulnerability. Intergovernmental Panel on Climate Change, Cambridge University Press, New York, New York.

Canadian Standing Senate Committee on Agriculture and Forestry. 2003. Climate change: we are at risk. Final Report. Canadian Standing Senate Committee on Agriculture and Forestry, Ottawa, Ontario. 111 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2003. COSEWIC Assessment Results, November 2003. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. 44 pp.

Dokken, D.J., H. Gitay, A. Suarez, and R.T. Watson, editors. 2002. Climate change and biodiversity: IPCC Technical Paper V. Intergovernmental Panel on Climate Change, Geneva. 77 pp.

Hansell, R.I.C., J.R. Malcolm, H. Welch, R.L. Jefferies, and P.A. Scott. 1998. Atmospheric change and biodiversity in the Arctic. Environmental Monitoring and Assessment **49**:303–325.

Hengeveld, H. 2000. A discussion of recent simulations with the Canadian Global Climate Model. Climate change digest—projections for Canada's climate future. CCD00-01 Special Edition. Environment Canada, Downsview, Ontario. 32 pp.

Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, and D. Xiaosu, editors. 2001. Climate change 2001: the scientific basis. Intergovernmental Panel on Climate Change, Cambridge University Press, New York, New York.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White, editors. 2001. Climate change 2001: impacts, adaptation, and vulnerability. Intergovernmental Panel on Climate Change, Cambridge University Press, New York, New York.

Parmesan, C., and G. Yoho. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature **421**:37–42.

Root, T.L., J.T. Price, K.R. Hall, S.H. Schneider, C. Rosenzweigk, and J.A. Pounds. 2003. Fingerprints of global warming on wild animals and plants. Nature **421**:57–60.

Sala, O.E., F.S. Chapin III, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, and D.H. Wall. 2000. Biodiversity—global biodiversity scenarios for the year 2100. Science **287**:1770–1774.

Shuter, B.J., C.K. Minns, H.A. Regier, and J.D. Reist. 1998. Fishery sector. In G. Koshida and W. Avis, editors. Canada country study: climate impacts and adaptation. Volume VII. Environment Canada, Ottawa, Ontario.

Smit, B., I. Burton, R.J.T. Klien, and J. Wandel. 2000. An anatomy of adaptation to climate change and variability. Climatic Change **45**:223–251.

Smit, B., and O. Pilifosova. 2001. Adaptation to climate change in the context of sustainable development and equity. Pages 876–912 in J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White, editors. Climate change 2001: impacts, adaptation, and vulnerability. Intergovernmental Panel on Climate Change, Cambridge University Press, New York, New York.

Smit, B., and O. Pilifosova. 2003. From vulnerability to adaptive capacity and the vulnerability reduction. Pages 9–28 in J.B. Smith, R.J.T. Klein, and S. Huq, editors. Climate change, adaptive capacity and development. Imperial College Press, London.

Thomas, C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M. Ferreira de Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. van Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips, and S.E. Williams. 2004. Extinction risk from climate change. Nature **427**: 145–148.

World Wildlife Fund Canada. 2003. The nature audit: setting Canada's conservation agenda for the 21st Century. Report No.1-2003. World Wildlife Fund Canada, Toronto, Ontario.