Effects of climate change on boreal wetlands

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1) WETLAND LOSS: Due to the discontinuous nature of permafrost and variation in depth wetland loss is not uniform across the landscape

The northwest boreal zone of North America receives relatively little precipitation (often <30 $cm \cdot year^{-1}$), and the abundant wetlands result largely from (1) cool, short summers with low evapotranspiration, and (2) an impermeable permafrost layer which prevents infiltration and impedes drainage of the upper unfrozen layer (Ford and Bedford 1987). Widespread melting of permafrost which has already been documented (Osterkamp and Romanovsky 1999; Jorgenson et al. 2001), and increased evapotranspiration, will result in fewer, more nutrient-rich wetlands (Rouse et al. 1997; Moser et al. 2002; Yoshikawa and Hinzman 2003; Klein et al. 2005; Smith et al. 2005).

2) CHANGES IN TIMING OR AVAILABILITY OF AQUATIC INVERTEBRATES: Longer growing seasons, warmer water temperatures, and higher nutrient levels may lead to changes in trophic status and invertebrate communities.

Nutrients will be concentrated as wetlands dry (lose water volume); and as permafrost underlying wetlands and adjacent uplands melts, rates of nutrient mineralization and leaching into surface waters will increase. Resulting changes in trophy may cause major shifts in community structure (Bayley and Prather 2003). Climate also affects the timing of important life-history events. In a review of phenological shifts, 62% of 677 species showed trends toward spring advancement (Parmesan and Yohe 2003). If different species show unique responses to changing temperature, their interactions with other species may be altered (Winder and Schindler 2004). An example is the temporal mismatch that has developed between peak food demands of nestling songbirds and peak insect availability, due to earlier leaf flush resulting from warmer springs in Europe (Thomas et al. 2001; Both et al. 2006). Such changes have already occurred in aquatic food webs as well. A longer ice-free season in boreal lakes of Ontario has resulted in higher total nitrogen and cations, and increased populations and diversity of phytoplankton despite overall declines in chlorophyll (Schindler et al. 1990; Schindler et al. 1996). Over 3 to 4 decades in some north-temperate lakes, peak densities of herbivorous rotifers and some *Daphnia* spp. have advanced by up to 3 weeks in response to earlier algal blooms due to warming (Winder and Schindler 2004; Carvalho and Kirika 2003). In polar tundra of Spitsbergen, chironomid emergence was normally spread evenly across the summer, but higher temperatures caused a large early emergence (Hodkinson et al. 1996, 1998). As a result, very high biomass early in the growing season became exhausted toward the end of the season, with potentially severe consequences for seasonally breeding predators of invertebrates such as birds (Thomas et al. 2001).

In wetlands on Yukon Flats nutrient levels had increased significantly since the 1980s and we saw non-significant changes in invertebrate communities with increases in filter-feeding zooplankton (cladocerans, copepods, ostracods) and their predators (chaoborids), and declines in macrophyte and benthic associated invertebrates (amphipods, chironomids, and gastropods better known as scuds, midge larva, and snails). Because of their larger body-size and longer and more predictable availability the latter group may be more valuable prey to breeding birds.

3) WETLAND LOSS MAY CONCENTRATE NESTING BIRDS AND/OR NEST PREDATORS

Scaup hens on Yukon Flats nesting on large brood-rearing wetlands had lower nest survival then hens nesting on small wetlands and creeks (where we never observed broods) that later moved ducklings to larger wetlands for brood rearing. Small wetlands and creeks are expected to dry faster then large wetlands and thus hens may be concentrated in habitat where nest survival is reduced.

4) CHANGES IN NEST PREDATOR COMMUNITIES

Although I suspect this may be very important I know little about the subject. Longer growing seasons could lead to increased reproductive output in boreal rodents and their predators and milder winters could lead to increased over-winter survival (of both mammalian prey and predators). There's an interesting correlative analysis of duck productivity and mammalian cycles from Yellowknife, NWT. There was a negative correlation between snowshoe hare abundance and lesser scaup productivity as well as a negative correlation between ruffed grouse abundance and mallard productivity. Negative correlations suggest a possible shared predation relationship, where changes in main prey abundance (hares) may cause a numerical response in predators that influences predation rates of shared alternative prey (ducks, eggs and ducklings). The authors concluded that a great deal of variation in boreal duck productivity might be explained by the indirect effects of coexisting prey abundance. (Brook et al. 2005). How much boreal waterfowl production is limited by top-down predator effects is still very uncertain.

Literature Cited

Bayley, S.E., and Prather, C.M. 2003. Do wetland lakes exhibit alternative stable states? Submersed aquatic vegetation and chlorophyll in western boreal shallow lakes. Limnol. Oceanogr. **48**: 2335–2345.

Both, C., Bouwhuis, S., Lesselles, C.M., and Visser, M.E. 2006. Climate change and population declines in a long-distance migratory bird. Nature **441**: 81–83.

Brook, R.W., D.C. Duncan, J.E. Hines, S. Carriere, and R.G. Clark. 2005. Effects of small mammal cycles on productivity of boreal ducks. Wildlife Biology **11**:3-11

Carvalho, L., and Kirika, A. 2003. Changes in shallow lake functioning: response to climate change and nutrient reduction. Hydrobiologia **506–509**: 789–796.

Ford, J., and Bedford, B.L. 1987. The hydrology of Alaskan wetlands, U.S.A.: a review. Arctic and Alpine Research **19**: 209–229.

Hodkinson, I.D., Coulson, S.J., Webb, N.R., Block, W., Strathdee, A.T., Bale, J.S., and Worland, M.R. 1996. Temperature and the biomass of flying midges (Diptera: Chironomidae) in the high Arctic. Oikos **75**: 241–248.

Hodkinson, I.D., Webb, N.R., Bale, J.S., Block, W., Coulson, S.J., and Strathdee, A.T. 1998. Global change and arctic ecosystems: conclusions and predictions from experiments with terrestrial invertebrates on Spitsbergen. Arctic and Alpine Research **30**: 306–313.

Jorgenson, M.T., Racine, C.H., Walters, J.C., and Osterkamp, T.E. 2001. Permafrost degradation and ecological changes associated with a warming climate in Central Alaska. Climatic Change **48**: 551–579.

Klein, E., Berg, E.E., and Dial, R. 2005. Wetland drying and succession across the Kenai Peninsula Lowlands, south-central Alaska. Can. J. For. Res. **35**: 1931–1941.

Moser, K.A., Smol, J.P., MacDonald, G.M., and Larsen, C.P.S. 2002. 19th century eutrophication of a remote boreal lake: a consequence of climate warming? J. Paleolimnol. **28**: 269–281.

Osterkamp, T.E., and Romanovsky, V.E. 1999. Evidence for warming and thawing of discontinuous permafrost in Alaska. Permafrost and Periglacial Processes **10**: 17–37.

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

Rouse, W.R., Douglas, M.S.V., Hecky, R.E., Hershey, A.E., Kling, G.W., Lesack, L., Marsh, P., McDonald, M., Nicholson, B.J., Roulet, N.T., and Smol, J.P. 1997. Effects of climate change on the freshwaters of arctic and subarctic North America. Hydrol. Processes **11**: 873–902.

Schindler, D.W., Bayley, S.E., Parker, B.R., Beaty, K.G., Cruikshank, D.R., Fee, E.J., Schindler, E.V., and Stainton, M.P. 1996. The effects of climatic warming on the properties of boreal lakes and streams at the Experimental Lakes Area, northwestern Ontario. Limnol. Oceanogr. **41**: 1004–1017.

Schindler, D.W., Beaty, K.G., Fee, E.J., Cruikshank, D.R., DeBruyn, E.R., Findlay, D.L., Linsay, G.A., Shearer, J.A., Stainton, M.P., and Turner, M.A. 1990. Effects of climate warming on lakes of the central boreal forest. Science **250**: 967–970.

Smith, L.C., Sheng, Y., MacDonald, G.M., and Hinzman, L.D. 2005. Disappearing Arctic lakes. Science **308**: 1429.

Thomas, D.W., Blondel, J., Perret, P., Lambrechts, M.M., and Speakman, J.R. 2001. Energetic and fitness costs of mismatching resource supply and demand in seasonally breeding birds. Science **291**: 2598–2600.

Winder, M., and Schindler, D.E. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology **85**: 2100–2106.

Yoshikawa, K., and Hinzman, L.D. 2003. Shrinking thermokarst ponds and groundwater dynamics in discontinuous permafrost near Council, Alaska. Permafrost and Periglacial Processes **14**: 151–160.