CONSERVATION PLANNING FOR CLIMATE CHANGE IMPACTS TO LOWLAND BOREAL WETLANDS IN THE ADIRONDACK PARK, NY

Workshop Summary Report
November 17-18, 2010
Blue Mountain Lake, NY

Compiled by Zoe Smith[1], Michale Glennon[1],
Erika Rowland[2], and Molly Cross[2]

WILDLIFE CONSERVATION SOCIETY

[1] Wildlife Conservation Society, 7 Brandy Brook Avenue, #204, Saranac Lake, NY 12983 zsmith@wcs.org, mglennon@wcs.org
[2] Wildlife Conservation Society, 301 N. Wilson Avenue, Bozeman, MT 59715 mcross@wcs.org, erowland@wcs.org

Overview

On November 17-18, 2010, twenty-five stakeholders from multiple agencies, organizations, and academic institutions (Appendix A) gathered for a workshop hosted by the Wildlife Conservation Society (WCS) in Blue Mountain Lake, NY to initiate planning for the potential impacts of climate change on the lowland boreal wetlands of the Adirondack region (Appendix B). Lowland boreal ecosystems in the Adirondacks represent the southern edge of the distribution of large scale boreal wetlands. WCS pre-selected the lowland boreal as a conservation target for this workshop because WCS has been monitoring and documenting changes in the boreal wetland ecosystem of the Adirondacks for decades. These long term data sets provide a foundation for understanding and monitoring future changes. Choosing this target also offered an opportunity to conduct climate change adaptation planning for a regionally valuable system that is important for both habitat and carbon storage, and likely highly vulnerable to the impacts of climate change.

Workshop Goal: Identify priority conservation actions that will help protect lowland boreal ecosystems in a changing climate.

Workshop objectives

1. Provide background information on climate change and its effect on lowland boreal wetlands.
2. Introduce and apply a climate adaptation-planning framework to the lowland boreal wetlands.
3. Examine the implications of climate change on the lowland boreal using a conceptual model.
4. Develop and agree on priority conservation actions that may reduce climate change impacts on lowland boreal wetlands.
5. Look for opportunities for ongoing learning, collaboration and implementation of the priority actions for boreal conservation.

Background Presentations

The first morning started with presentations providing information relevant for participant engagement in the subsequent planning exercise.

Dr. Linda Mearns, *Senior Scientist*, *National Center for Atmospheric Research, Boulder, CO;*
Dr. Anji Seth, *Research Assistant Professor, Department of Geography, University of Connecticut*

Key points from this presentation included an overview of the historic climate trends and global climate model (GCM) projections for the Northeast in general, as well as specific to the Adirondacks.

- Through the 20th century, there has been a warming trend in mean annual temperatures in the Northeast.
- Winter temperatures show the greatest increase of all the seasons: +1.3^{o}F since 1970.
- Annual precipitation increased by 5-10% in the Northeast over the last century, much of which has occurred during the winter.
- Data presented specifically for the Adirondack region also exhibited a generally increasing trend in both temperature and precipitation through the 20th century, overlain by high inter-annual variability.

Dr. Mearns presented climate model projections for the region and introduced the two scenarios of future climate that served as the basis for the climate change adaptation planning exercise (Table 1).

Dr. Michale Glennon, *Science Coordinator, Wildlife Conservation Society Adirondack Program, Saranac Lake, NY.*

Key points from this presentation included a discussion of WCS's multi-year research on the bird species associated with boreal lowland systems and the potential implications of climate change for the subset of these birds whose populations are in decline. This work indicates that population numbers of four of the study's targeted boreal bird species, yellow-bellied flycatcher, black-backed woodpecker, grey jay, and olive-sided flycatcher, are currently declining and may be indicators of climate change. Climate change has been implicated in the decline of gray jay numbers in Algonquin Park in Canada, hypothesized to be the result of loss of winter food caches due to warming temperatures (Waite and Strickland, 2006)[1]. Because all of these species are on the southern extent of their range in the Adirondacks, at least within the eastern part of the US and because northward movements of birds in NY state have been attributed to climate change (Zuckerberg et al, 2009)[2], it is possible that climate change is a mechanism in the declines we have observed as well.

Dr. Molly Cross, *Climate Change Adaptation Coordinator, Wildlife Conservation Society North America Program*, *Bozeman, MT*.

Key points from this presentation included an introduction to the Adaptation for Conservation Targets (ACT) Framework (Cross et al. *in prep.*) (Figure 1), the guiding structure for the adaptation planning part of the workshop. The ACT Framework (developed by the Climate Change and Wildlife Working Group, which was convened by the Wildlife Conservation Society, the Center for Large Landscape Conservation, and the National Center for Ecological Analysis and Synthesis) was used in this workshop to translate general recommendations on climate change adaptation strategies into practical, specific actions for a given landscape. The ACT Framework is a multi-step process designed for collaborative application in a given landscape or seascape by a multidisciplinary group of natural resource managers, conservation practitioners, scientists, and local stakeholders—like those assembled for the Adirondack workshop.

The ACT Framework for climate change adaptation planning begins by selecting a concrete conservation target (e.g., species, ecological process or ecosystem), and articulating the conservation goal that we are striving given our understanding of projected climate change. Graphic conceptual models are then used to illustrate and understand the key climatic,

[1] Waite T.S., and D. Strickland 2006. Climate change and the demographic demise of a hoarding bird living on the edge. Proceedings of the Royal Society B, 273:2809-2813.
[2] Zuckerberg B., A.M. Woods and W.F. Porter 2009. Poleward shifts in breeding bird distributions in New York State. Global Change Biology 15(8): 1866-1883.

ecological, social, and economic drivers, and how these may change under different climate scenarios. Stakeholders then identify what conservation actions are necessary to achieve identified goals in light of different scenarios, with the goal of identifying those actions that are recommended across multiple scenarios, and therefore are relatively more robust to uncertainty in projecting future conditions.

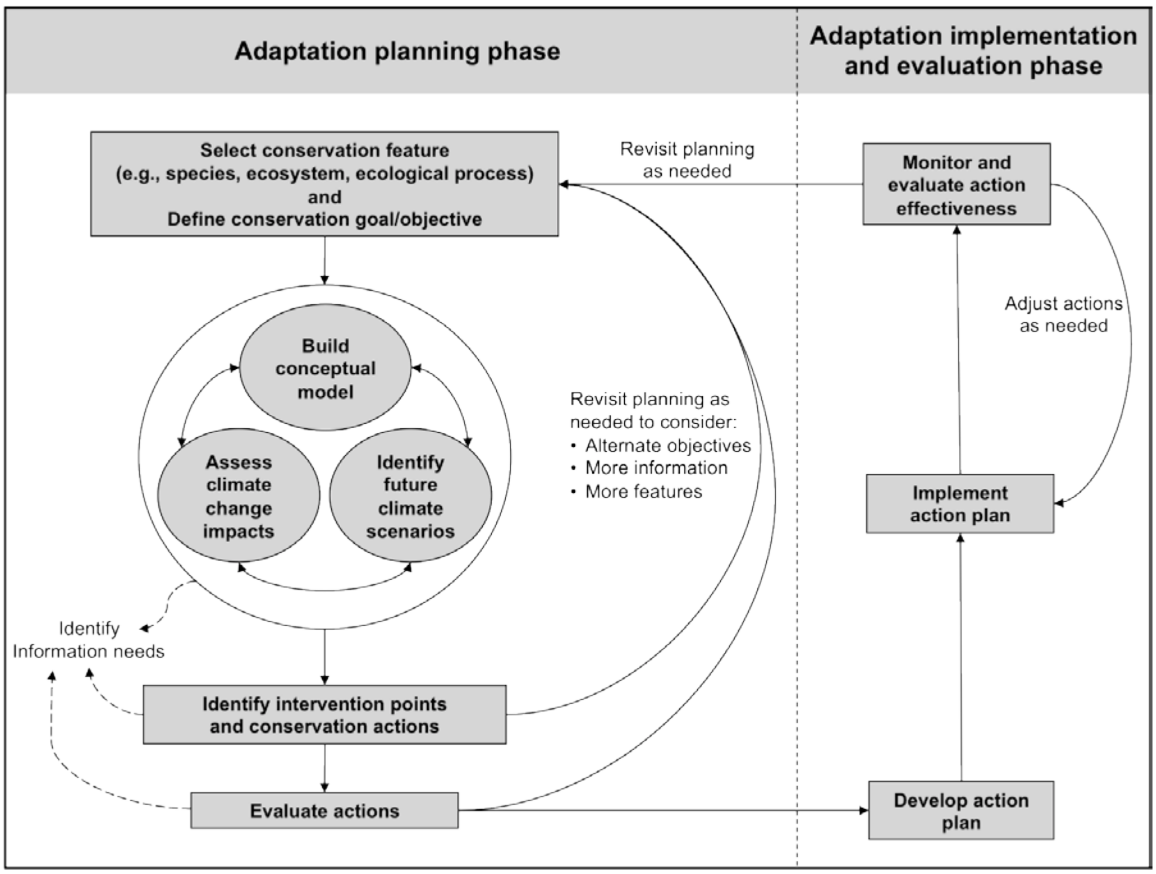

Figure 1. Adaptation for Conservation Targets (ACT) Framework for collaborative planning for the impacts of climate change and potential management and conservation.

Identifying Conservation Goal for the Lowland Boreal

Even with a well-defined conservation target, selecting conservation goals achievable under current and projected future climate conditions can be challenging. For most species and ecosystems, it is expected that current conservation goals will need to be revisited if anticipated climate change impacts fundamentally affect our ability to achieve particular goals.

There are several concepts that are useful in framing conservation and management goals in light of climate change, which were discussed at the workshop (adapted from Millar et al. (2007)[3] and the U.S. Forest Service Climate Change Resource Center at http://gis.fs.fed.us/ccrc/):

Spectrum of Management Options under Climate Change

- *Increasing resistance to climate change.* Forestalling the undesired effects of climate change and/or managing ecosystems so they are better able to resist changes resulting from climate change.
- *Promoting resilience to climate change.* Managing to increase the likelihood that ecosystems will accommodate gradual changes related to climate, and tend to return toward a prior condition after disturbance.
- *Enabling ecosystem responses to climate change.* Intentionally accommodating change rather than resisting it by actively or passively facilitating ecosystems to respond as environmental conditions change.

Understanding which of these concepts may be realistic under a changing climate and other environmental conditions depends on the nature of expected impacts on the conservation target. Therefore, conservation goals often need to be revisited as the implications of the potential climate-related impacts on the target unfold through the planning process.

As workshop participants began to identify a conservation goal for the lowland boreal, we chose to first work toward a common understanding about which wetland types defined the lowland boreal. A brief discussion led to consensus that the boreal wetland target that we were addressing included: conifer swamp, peatlands, open river corridors, some beaver flows, and shoreline bogs. We decided to initially focus on a conservation goal that represents the concept of increasing resistance to climate change and maintaining current conditions of the lowland boreal.

[3] Millar, C. I., N. L. Stephenson, and S. L. Stephens. 2007. Climate change and forests of the future: Managing in the face of uncertainty. Ecological Applications 17:2145-2151.

The initial conservation goal was to:

> *Maintain (or restore where necessary) current boreal wetlands with high ecological integrity, enabling them to perform key functions (e.g., provide wildlife habitat, carbon storage, water supply and filtration, recreation) by maximizing and/or maintaining the distribution of large, connected wetlands representative of diverse vegetation age classes/species composition.*

However, as the consequences of climate change for lowland boreal ecosystems became apparent, workshop participants revised this goal to acknowledge our likely inability to maintain all boreal wetlands in their current condition (see "Revising the Conservation Goal" section below).

Conceptual Model: Key Drivers Affecting the Adirondack Lowland Boreal Wetlands

The group was asked to discuss and refine a graphical conceptual model of the lowland boreal system highlighting the key physical, ecological, social and climate drivers (Figure 2). Those drivers highlighted by participants are depicted in Figure 2, and include factors related to hydrology (e.g., the quantity and timing of water inputs to the system), land use (e.g., rural development, forest management), disturbances (e.g., flooding, extreme weather events, fire, invasions), and climate (e.g., temperature, precipitation, growing season length, water balance).

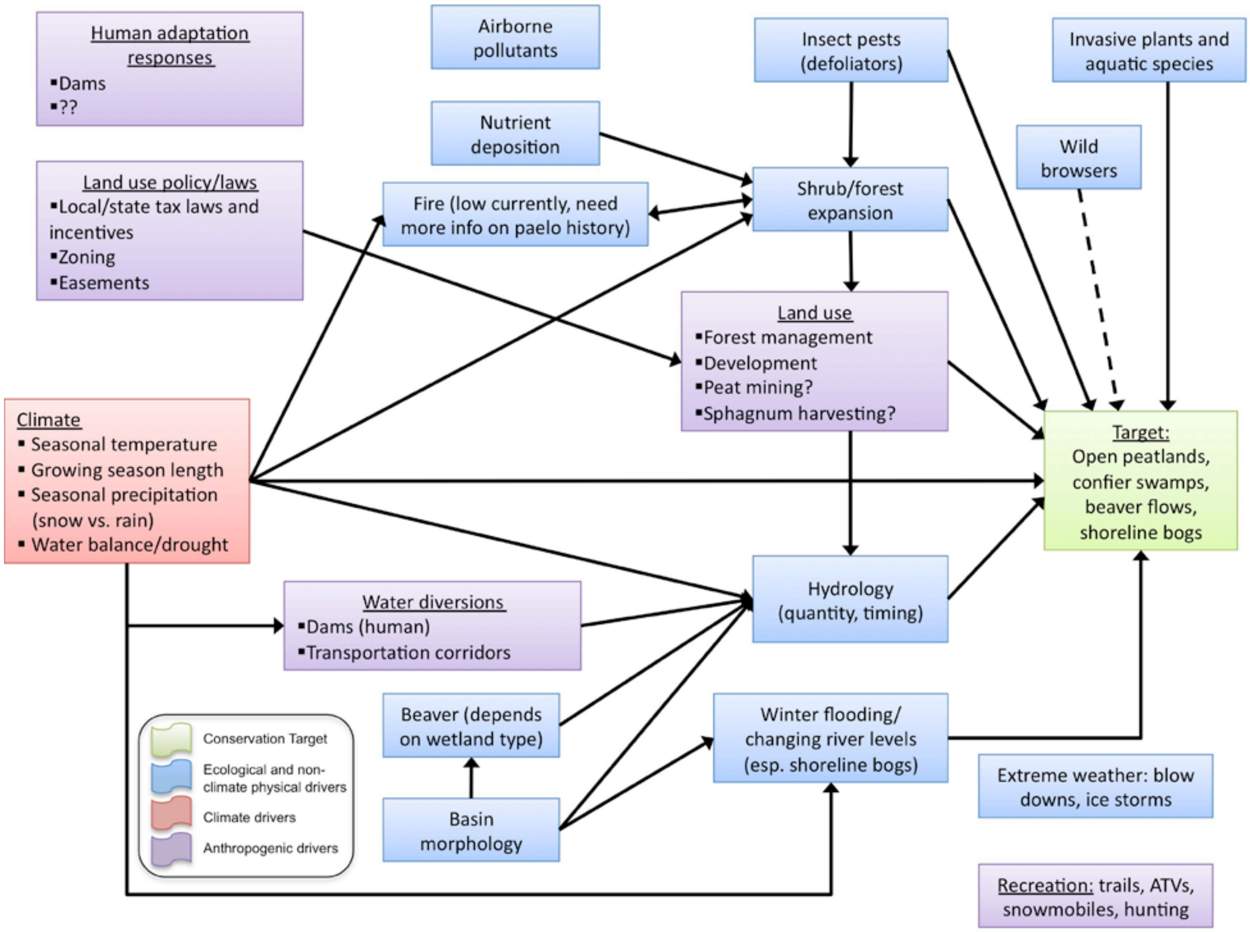

Figure 2. Graphical conceptual model of the key ecological, human, physical and climate drivers influencing the lowland boreal systems of the Adirondacks region.

Impacts to Lowland Boreal Wetlands from Climate Change

Using the conceptual model as a guide, participants considered the direct and indirect effects of two plausible scenarios of future climate (in 2050) for the Adirondacks that were developed by Dr. Mearns and Dr. Seth for consideration during the workshop (Table 1).

<u>Climate Scenario #1</u>: The first climate scenario roughly represented the mid-range of the distribution of global general circulation model (GCM) temperature and precipitation projections, generated using a relatively high greenhouse gas emissions scenario (the IPCC A2 emissions scenario); (Table 1). Climate Scenario #1 was characterized by similar increases in temperature (~2°C) across each season and little change in annual precipitation, but with a moderate increase in winter precipitation.

Climate Scenario #2: The second scenario embodied an equally plausible, but more extreme projection. In this scenario, the annual temperature increase was greater overall (~3°C) and winters warmed more than the other seasons. Also in this scenario, some decline in precipitation was projected for the summer, which, combined with the higher temperatures, would result in much drier conditions during the growing seasons when compared with the first scenario.

Table 1. Future climate scenarios for the Adirondacks in 2050 developed by Dr. Linda Mearns (NCAR) and Dr. Anji Seth (University of Connecticut) from global climate model output using the relatively high IPCC A2 greenhouse gas emissions scenario.

	Scenario #1		**Scenario #2**	
	Temperature Change	*Precipitation % Change*	*Temperature Change*	*Precipitation % Change*
Annual	2.1 °C (3.8 °F)	+6	3.3 °C (5.9 °F)	+2
Winter	2.3 °C (4.1 °F)	+16	4.1 °C (7.3 °F)	+14
Spring	1.7 °C (3.1 °F)	+4	3.3 °C (5.9 °F)	-2
Summer	2.1 °C (3.8 °F)	+1	2.6 °C (4.7 °F)	-7
Fall	2.2 °C (3.9 °F)	+4	3.3 °C (5.9 °F)	+3

A summary of the discussion around anticipated impacts on the Adirondack lowland boreal wetlands as a result of climate change for future scenarios (2040-2060) is represented in Appendix C.

Below is a summary of the potential impacts and knowledge gaps arising from the group discussion about Scenario #1:

- Significant degradation of wetland condition: In our discussions, degradation included changes in vegetation composition and structure that would lead to changes in current species' use of boreal wetlands as habitat.

  - Net loss of boreal wetlands: While there was uncertainty about whether there would be a net loss of boreal wetlands under Scenario #1, participants believed that the peat lenses underlying the larger wetlands would remain under this scenario. It was understood that these systems currently change very slowly, but that we don't know where tipping points are that would lead to dramatic change or loss of functions such as carbon storage. One question that arose was whether palaeoecological and/or paleohydrological reconstructions could inform our understanding of how boreal lowlands have responded to climate change in the past and the ability of these wetlands to tolerate warmer and drier conditions than what they experience under current climate conditions and variability.

In consideration of Scenario #2, participants felt that the warmer temperatures and declining precipitation would likely push boreal systems in the Adirondacks toward an ecological transition. The following are the summary points of this discussion:

- Dramatic changes in key system drivers: The influence of other stresses on and perturbations to the system will be exacerbated, such as:
  - Increased visitation to the region, land development, and human use of water resources;
  - Increased incidence of fire with drying, more frequent extreme weather events and other disturbances;
  - Increased pressures on agencies to actively manage to mediate impacts (e.g., to conduct salvage logging, as done during 1950's, 1995 blow-down and 1998 ice storm); this would include changing legislation to actively manage public lands and increased pressure on private lands.
  - Drought-related vegetation stress leading to greater susceptibility to existing and new pests and pathogens.

- Desiccation of the wetlands: The magnitude of temperature increase and lack of sufficiently offsetting precipitation increases would result in negative water balance that would significantly lower water tables.

- Major range shifts for ecological systems and species: For this scenario, conservation actions will need to focus on transitions from boreal wetlands to other ecosystem types and promote the species that will likely be moving into the region from the south including one's we don't presently have, i.e. invasives.

- Thresholds and tipping points: Because this scenario will push systems closer to and more likely beyond their tipping point, we need to know when to shift the conservation goal from resisting change to facilitating ecological responses toward new systems expanding into area. How do we identify tipping points to know when to shift our focus for conservation?

Revising the Goal

Some participants expressed concern about the ability of the lowland boreal to persist under the magnitude of warming and drying projected for the Adirondacks. Others were less certain about the magnitude of change in climate required to significantly alter the system. However, after deliberating the potential impacts of the two climate scenarios addressed, participants concluded that the original conservation goal of maintaining all current lowland boreal wetlands in their current state was likely unrealistic. Therefore, they decided to revise the goal to encompass both the concepts of promoting resilience and enabling ecosystem response in an adaptive management approach.

> ***Revised Conservation Goal:*** *Buffering boreal wetlands from the impacts of climate change in the near-term, while also facilitating/allowing for transitions to alternate ecological states in the longer-term (or under a more rapid rate of climate change).*

The goal revision broadened the discussion of conservation actions to include those that, while serving to resist and/or enhance resilience to near-term changes in climate, would also allow for or facilitate unavoidable ecological change in the future.

Intervention Points: Recommendations for Conservation Actions

Using the graphical conceptual model as guide, participants identified a number of intervention points (places within the system that can be influenced by conservation actions):

- Vegetation management
- Land protection and management
- Recreation
- Water diversion/hydrology
- Invasive species/pests
- Nutrient accumulation

Participants brainstormed potential actions at each intervention point that would help achieve the stated conservation goal (increasing the resistance/resilience of boreal wetlands in the near-term while also allowing/facilitating ecological transitions in the longer-term) under the anticipated climate change impacts from the two scenarios. A detailed list of conservation actions discussed is found in (Table 2).

The majority of actions recommended by participants fell under the land protection and management category, and was directed at buffering the wetlands from non-climate stressors. Some of the actions listed under Vegetation Management (e.g., prevention of tree encroachment via prescribed burns, herbicides and manual removal of saplings) are more closely tied to a goal of maintaining lowland boreal wetlands in their current state, rather than allowing or facilitating ecological transitions. But other actions listed by participants have utility even as the lowland boreal ecosystem undergoes more dramatic changes.

Table 2. Identification of Strategic Conservation Actions to Address Climate Change Impacts on Adirondack boreal wetlands. Actions are intended to help achieve the following Conservation Goal under the climate scenarios considered at the workshop (see Table 1): *Buffer boreal wetlands from the impacts of climate change in the near-term, while also facilitating/allowing for transitions to alternate ecological states in the longer-term (or under a more rapid rate of climate change).*

Observed & Predicted Climate Change Impact	**Intervention Point**	**Strategic Actions**
Degradation of boreal wetland condition, including changes in vegetation composition and structure (e.g., increased encroachment of trees and shrubs).	Vegetation Management	• Vegetation control (e.g., to manually remove saplings). • Prescribed fires (to control saplings and suppress fire) – but concerns about trying to apply prescribed fires as the peatland dries out, also unclear what the historic/paleo fire history is for these wetlands. • Herbicide to control encroaching shrubs/trees (concerns about impacts of herbicide use). • Combinations of prescribed fire and herbicides. • **NOTE**: these actions may not be appropriate under a goal of facilitating/allowing ecological change to occur.
All impacts.	Land Protection & Management	• Protecting connectivity between wetlands: o Mapping needed to understand connectivity dynamics between sites. o Land protection/land management strategies identified that allow connectivity to occur. o Need to be clear about what species we would be targeting, and what goals would be of increasing/maintaining/enhancing connectivity. • Develop a demonstration site to test out adaptation actions; communicate these ideas to other landowners. • Create/increase incentives for landowners to set aside buffers around wetlands and manage for connectivity. • Look at existing language for easements on boreal wetlands to include management recommendations that stem from climate change planning. • Shorter, renewable easements to allow for adaptive change. Look at existing programs such as USDA. Perhaps some exploration of time-bounded easements in other parts of northeast could serve as a model. • Green certification standards – are revisited through time and can include restrictions related to land management. • Identify "special areas" within easements and require additional monitoring and adaptive management components in those easements. [challenge: who is expected to pay for the monitoring?]. • Will need to provide incentives to cover additional expenses of adding monitoring and adaptive management requirements into easements. • Remove other potential stressors (logging, roads, development) to increase resilience of boreal wetlands to the effects of climate change. • Identify the most at-risk or ecologically significant patch or patches of boreal and prioritize for protection • Prioritize areas for protection based on "enduring land forms" rather than species and ecosystem distributions. • Protect as much land as possible to provide space for whatever species and ecosystems will be there in the

		future. • Think about these systems from a “metapopulation” perspective – not just that bigger is better, but distribution and spatial pattern matters, too. • Manage roads to increase landscape permeability – related to connectivity, land protection, hydrological function. At scales within and around the wetlands but also within and around the ADK Park.
Potential increases in recreation pressure and damage due to increased summer visitation and increased activity during marginal winter conditions.	Recreation	• Limit/control snowmobile use, especially during marginal conditions, to reduce localized effects. • Recreational planning for boreal wetlands areas (e.g., building boardwalks, buffering sensitive areas). • Educate users on the effects of recreation on boreal and other systems. • Minimize localized bird watching impacts. • Identify buffer zones for recreation – to keep recreation entirely out if highly sensitive areas.
Negative water balance leading to increased drying, and lower water tables; potential for increased water demand from ADK resources.	Water diversions / Hydrology	• Dam inspections and removal strategies on private and public lands. But also consider using dams to alter hydrology as climate changes. Identify places where dams may be a benefit to manipulating hydrology in ways that may benefit wetlands. • Beaver management: beaver as a tool for maintaining more, cooler water on the landscape – but they have already re-populated their historic range so it’s not clear that there are opportunities to add more beaver. • Update river regulations for the Adirondack Park Agency – deal with grey area about how to deal with altering stream channels. • Consider how to deal with requests for more stream channel changes if flooding increases. • Educate NYC about the value of protecting the ADKs and its role in providing ecosystem services (e.g., clean water). Work with state and local elected officials to make this happen. • Maintain/enhance regulations for water permitting/water rights. Not currently much in the way of limiting water use. NY does not have a water budget (although it is required to under transboundary agreements) – a recommendation in the NY Climate Action Plan is to do a water budget for the state.
Potential changes in invasion risk from species of current concern as well as from areas that are currently warmer and drier; stressed vegetation may be more susceptible to pest outbreaks and the invasion of exotics.	Invasive species / Pests	• Develop and fund rapid response plans for invasive species (have tried and have not yet been successful because of barriers: e.g., time it takes for permitting and public comment periods). Try to anticipate rather than be reactive. • Guard against the “over-response” to current and future invasives. • Example with exotic snake heads introduced to aquatic systems– were successfully able to deal with them, but still took months. • Currently an “Invasive species council” (state-wide, interagency, NGOs) to agree on best-management practices ahead of time to facilitate application of invasive species control measures. • Be prepared to assess and potentially use invasive management control methods that may not be currently allowed in the state to deal with invasives that come from other areas. • Regulate the sale and possession of invasive pests (e.g., pets, horticultural practices). • Control of “invasives” can buy time for establishment of new ecological systems in the future. • Need to be more careful of definition of “native” and “non-native” – perhaps expand our definition of the geographic area within which we consider something to be “native”.
Increased atmospheric deposition of nitrogen and airborne pollutants; potential changes in soil microbial activity.	Nutrient accumulation / Airborne pollutants	• Are current clean air regulations of nitrogen sources enough to limit nitrogen accumulation in these systems? If not, might need tighter regulations. • Win-win action: if we reduce fossil fuel use we will reduce greenhouse and nitrogen gases in the atmosphere at the same time.

		• Reduce mercury emissions (in US and globally).
All impacts.	Institutional Changes	• Increase cross-jurisdictional coordination, policy changes to allow actions, creation of funding opportunities and collaboration. • Establish state regulatory frameworks that are conducive to investment in material natural capitol
All impacts.	Education	• Cultivate citizen science opportunities (e.g., phenological monitoring). • Educate users on the effects of recreation on boreal and other systems. • Outreach and education to promote the value of boreal wetlands and the need for particular actions (management, conservation, policies, monitoring, research) to various audiences (e.g., funders, landowners, public, agencies).

Throughout the planning exercise, a number of research needs were identified that participants felt would help inform and prioritize conservation actions (Table 3). While participants felt these unknowns did not necessarily preclude taking some conservation actions in the near-term (especially those that are recommended for whether a lowland boreal wetland is able to tolerate expected climate changes or not), they recognize these are important questions and research avenues that would help support decision making about setting priorities for boreal wetland conservation.

Table 3. Lowland Boreal research needs identified through climate adaptation planning process.

RESEARCH NEEDS
Mapping • Mapping needed to identify the extent of lowland boreal wetlands in the Adirondacks, as well as current protection status of significant parcels. • Identify "enduring features" in this region and look at ways to protect and connect them. • Identify boreal wetlands that might have greatest chance of longer-term persistence based on factors such as: o Lake-dependent vs. rain-fed wetlands o Depth of peat layer/bog o Topographic situation (slope, aspect) o Surrounding vegetation o Size and proximity to other wetlands
Fire • What is the paleo- history of fire in the lowland boreal systems? • Could prescribed fire (under altered climate conditions) effectively serve as a tool for maintaining open boreal wetlands? • How do the conifers in lowland boreal wetlands respond to drying –can they survive, do they expand?
Vegetation • What will the lowland boreal wetlands transition toward? Use modeling of vegetation response (e.g., dynamic global vegetation models) to identify potential "tipping points" and overall vegetation change. • What is the paleoecology (vegetation history) of the lowland boreal wetlands during past intervals of warming and/or drying (e.g., mid-Holocene warm period, Medieval warm period, Little Ice Age)? • Look to peat communities further south to see what kind of peatland communities might be able to persist in the future climate we expect here in the Adirondacks. Are those areas performing similar/different functions?
Ecosystem Impacts • Will all lowland boreal wetlands respond similarly to climate projections, or is there the potential for boreal refugia to persist in the Adirondacks?
Hydrology • What is the paleohydrological record(s) of the lowland boreal? Have they responded to past warm periods with significant drying? • Is there evidence that peatlands have already begun to "dry up"?

Species and Habitat

- Do boreal bird species prefer large, open boreal peatlands? What role do the smaller peatlands play in population dynamics?
- Is maintaining connectivity between boreal peatlands important? If so, for what species, and what are their connectivity needs?

Invasive species

- Which peatlands are most at risk for colonization by invasive species (risk modeling)?

Many participants also advocated strongly for the need for project- and landscape-level monitoring of numerous system components to understand impacts on the lowland boreal and identify thresholds for change (Table 4).

Table 4. Monitoring recommendations developed through climate adaptation planning process.

MONITORING: Targets and Rationale

Birds and Plants

- Continue monitoring because baseline data exist through efforts of WCS, New York Natural Heritage Program, and others.

Insects

- While little is known about the specific climate-related tolerances of most species, this group is recognized as highly sensitive to environmental change.

Invasive species

- While not yet a serious problem in boreal wetlands, invasive species have begun to degrade wetlands outside Adirondack State Park. Monitoring is critical to respond rapidly to this stressor.

Hydrology

- Monitor water levels to establish baseline and understand sensitivity of system to moisture variability and change.

Phenology

- Exploit/collaborate with existing phenology networks (e.g., National Phenology Network) to track how climate changes may affect boreal wetland phenological relationships.

Approaches to Implementation of Conservation Actions

As a step towards discussing opportunities for implementing some of the actions listed during the brainstorming session, participants began characterizing the actions with reference to the spatial scale at which they would appropriately be carried out, that is, place-based versus landscape-scale activities. (Table 5).

Table 5. Opportunities for climate adaptation conservation actions at place-based versus landscape-scales for lowland boreal wetlands in the Adirondacks.

Place-based actions	Landscape-scale actions
• Evaluate current ecological, economic, and social values of sites, and include climate change vulnerabilities and impacts. • Evaluate social context to determine opportunities for outreach and citizen participation (e.g., in monitoring or restoration projects). • Shift short-term management strategies based on likely impacts. • Biological inventory and monitoring. • Eradication of invasive species (rapid response plan). • Specific restoration and management projects can be tested and rolled up into a “handbook” or best management practices. • Opportunities for outreach and education with specific landowners.	• Complete large-scale analysis of boreal (landscape level mapping). • Prioritize wetlands, i.e. increase the level of protection of the boreal wetlands core on private lands. • Develop model language that facilitates adaptation in conservation easements. • Develop private landowner guidelines for protecting boreal (handbook). • Incentives for protection and connections between wetlands. • Consider other kinds of management agreements (e.g., term easement, green certification). • Valuation of boreal functions & services. • Citizen participation at a large scale (tracking changes in bogs across the landscape).

Next Steps

Participants expressed interest in continued involvement in several future activities identified at the workshop. These activities were organized into topics relevant to key conservation actions and focused on moving their implementation forward in the Adirondack region:

Topic 1:
Demonstration Site. Identify a set of potential "demonstration" site(s) for implementation of adaptation actions. Potential sites identified at the workshop were Bloomingdale Bog, Shingle Shanty Preserve, Spring Pond Bog, a few other smaller bogs owned privately. Interested participants: Steve Langdon, Chris Hilke, Kathy Regan, Dan Spada, Glenn Johnson, Angie Ross, Michelle Brown, Anton Siemen

Topic 2:
Sample Conservation Easement language. Develop sample language that incorporates climate change adaptation strategies. Interested participants: Kathy Regan, Larry Master, Michelle Brown, Angie Ross, Erika Rowland, Dave Smith.

Topic 3:
Large scale conservation planning. Examine many of the research questions outlined in Table 2. Interested participants include: Larry Master, Chris Hilke, Dan Spada, Michelle Brown, Curt Stager, Mark Anderson, Jerry Jenkins, Cheryl Chetkiewicz.

Topic 4:
Outreach and education to landowners. Interested participants: Bill Schoch, Zoe Smith

Topic 5:
Monitoring. Combine resources and further discuss priorities for research in the boreal. Interested participants: Michale Glennon, Matt Schlesinger, Glenn Johnson, Anton Seimon, Angie Ross, Steve Langdon, Jerry Jenkins.

WCS will create four working groups that will explore these topics and develop a set of goals, objectives and action items relative to each topic as it relates to climate change adaptation in the lowland boreal. During the next year, WCS will lead the follow up communications and organization of the following working groups.

Working Group 1: Private landowners. Potential activities include identify a set of "demonstration" sites for implementation of conservation actions, conduct outreach and education to landowners, develop citizen science projects, and develop sample easement language that incorporates climate change adaptation strategies, refine adaptation strategies. Lead: Zoe Smith.

Working Group 2: Conservation planning. Potential activities include boreal mapping, modeling, addressing large scale issues associated with the lowland boreal and climate change. Lead: Jerry Jenkins.

Working Group 3: Boreal monitoring. Potential activities include pursuing the monitoring priorities identified at the workshop. Lead: Michale Glennon.

Working Group 4: Paleoeoclogical research. Potential activities include multi-proxy reconstructions of the ecological and hydrological conditions in and around one or more lowland boreal wetlands to understand their response (e.g., vegetation and ecological processes-e.g., fire) to past drought/warm climatic conditions. Lead: Erika Rowland/Curt Stager

Other actionable items identified during workshop discussions:

- Policy change; this work may be taken up by the revised New York State Wildlife and Climate Change Alliance; Tracey Tomajer, Zoe Smith and Chris Hilke expressed interest.
- Valuation of bogs – Jeff Mapes, Chris Hilke expressed interest.

Summary and Acknowledgements

WCS is very grateful to the participants of the Adirondack Climate Change Adaptation Workshop for their thoughtful participation and time commitment. We were impressed by the level of engagement the group has to this topic and we look forward to continuing to work together. We recognize that this group reflects a number of organizations and agencies and possesses a great deal of expertise and experience on this topic, however, we also acknowledge there are other individuals that represent agencies, NGOs and other groups that were not able

to attend but should be part of this process. We are hopeful that other interested partners will come forth to help this group identify and implement priority conservation actions that will help protect lowland boreal ecosystems in a changing climate.

Special thanks to the Kresge Foundation for generously funding WCS' climate change work in the Adirondacks and making this workshop possible. Many thanks to Linda Mearns and Anji Seth for developing and presenting the climate change scenarios. A special thanks to our Planning Committee, Michelle Brown from the Adirondack Chapter of the Nature Conservancy, Joe Racette of New York State's Department of Environmental Conservation Region 5, Angie Ross of New York State's Department of Environmental Conservation Region 6, and Kathy Regan from the Adirondack Park Agency, for helping with early brainstorming on workshop content and suggesting participants to invite to the workshop. Thanks also to WCS' Carrianne Pershyn for her great work in organizing the workshop logistics and for Minnowbrook Conference Center in Blue Mountain Lake, NY for treating us so well. We thank all of the participants for taking the time to attend the workshop, volunteering for follow up work, and for their time in reviewing this report. Thanks to all of you for your help in addressing climate change in the Adirondacks; we are grateful for your commitment to conservation and are appreciative of all you do in the region.

APPENDIX A. Workshop participants.

Organization	Name	**Contact information**
Adirondack Chapter of the Nature Conservancy	Michelle Brown	Michelle_brown@tnc.org
NYS Department of Environmental Conservation	Joe Racette Angie Ross John Ozard Tracey Tomajer Jeffrey Mapes Bill Schoch David Smith Mark Lowry	jaracett@gw.dec.state.ny.us amross@gw.dec.state.ny.us jwozard@gw.dec.state.ny.us tmtomaje@gw.dec.state.ny.us jamapes@gw.dec.state.ny.us bxschoch@gw.dec.state.ny.us dssmith@gw.dec.state.ny.us mdlowery@gw.dec.state.ny.us
NY Natural Heritage Program	Matt Schlesinger	mdschles@gw.dec.state.ny.us
Adirondack Park Agency	Kathy Regan	kdregan@gw.dec.state.ny.us
Ecologist	Larry Master	lawrencemaster@gmail.com
Bay Pond Park	Sally Bogdanovich	Pbogdan-sally@northnet.org
Shingle Shanty Preserve	Steve Langdon	sflangdon@gmail.com
National Wildlife Federation	Chris Hilke George Gay	hilkec@nwf.org gayg@nwf.org
Manomet Center for Conservation & NWF	Hector Gailbrath	hg2@hughes.net
National Center for Atmospheric Research	Linda Mearns	lindam@ucar.edu
University of Connecticut	Anji Seth	anji.seth@uconn.edu
Paul Smiths College	Curt Stager	cstager@paulsmiths.edu
Potsdam University	Glenn Johnson	johnsong@potsdam.edu
WCS North America Program	Molly Cross Erika Rowland	mcross@wcs.org erowland@wcs.org
WCS Canada	Cheryl Chetkiewicz Jenni McDermid	cchetkiewicz@wcs.org jmcdermid@wcs.org
WCS Global Climate Change Program	Anton Seimon James Watson	aseimon@wcs.org jwatson@wcs.org
WCS Adirondacks	Zoe Smith Michale Glennon Jerry Jenkins Heidi Kretser Leslie Karasin Carrianne Pershyn	zsmith@wcs.org mglennon@wcs.org jjenkins@wcs.org hkretser@wcs.org lkarasin@wcs.org cpershyn@wcs.org

APPENDIX B. Workshop agenda.

Agenda
Climate Change Planning Workshop: Adirondack Lowland Boreal Systems

November 17-18, 2010
Minnowbrook Conference Center
Blue Mountain Lake, NY

Workshop Goal: Identify priority actions that will help protect lowland boreal ecosystems in a changing climate.

Workshop Objectives:

1. Provide background information on climate change and its effect on the boreal
2. Introduce and apply a climate adaptation planning framework for the Adirondack boreal
3. Examine the implications of climate change on the boreal using the conceptual model
4. Develop and agree on priority actions that may reduce climate change impacts on the boreal
5. Look for opportunities for ongoing learning, collaboration and implementation of the priority actions for boreal conservation

Wednesday November 17

9:30am	Check in and registration
10:00–10:15	Welcome and Introduction to the Workshop • Zoe Smith, *Wildlife Conservation Society-Adirondacks*
10:15–10:45	Projected Climate Changes in the Adirondacks • Linda Mearns, *National Center for Atmospheric Research*/Anji Seth, *University of Connecticut*
10:45–11:15	Consequences for Boreal Lowland Habitats and Birds • Michale Glennon, *Wildlife Conservation Society-Adirondacks*
11:15–11:30	Boreal Forests and Climate Change in Canada • Cheryl Chetkiewicz, *Wildlife Conservation Society-Canada*
11:30–12:00	Overview of Climate Change Adaptation Planning • Molly Cross, *Wildlife Conservation Society-North America Program*
12:00 – 12:30	Questions and discussion

12:30 – 1:30 Lunch *(provided)*

1:30–5:00 *(with one afternoon break)* – Facilitated adaptation planning exercise

Objectives for the afternoon include:

- *Identify management goal*
- *Refine a graphical conceptual model*
- *Discuss potential impacts of alternate future climate change scenarios*

Dinner at 6pm (provided)

Thursday November 18

7:30 – 8:00 Breakfast *(provided)*

8:00–12:00 *(with one mid-morning break)* – Facilitated adaptation planning exercise

Objectives for the morning include:

- *Identify management intervention points*
- *Identify strategic actions for climate change adaptation*
- *Develop criteria for prioritizing actions*
- *Begin to prioritize strategic actions*

12:00–1:00 Lunch *(provided)*

1:00–4:00 *(with break)* - Discussion of priority actions and next steps

Objectives for the afternoon include:

- *Evaluate priority actions and consider opportunities for implementation*
- *Identify recommendations for research and monitoring needs and further planning.*

APPENDIX C. Climate Change Impacts on Adirondack lowland boreal wetlands for future climate scenarios (2040-2060).

Key Climate-Influenced Drivers/Effects	Observed & Predicted Climate Change Impact
Warmer temperatures	• +4°F is the equivalent to temperatures in Pennsylvania and West Virginia. • Do not currently find ADK boreal species (birds, plants) in areas that are 1°F warmer than the ADKs (but can't necessarily separate out temperature influence vs. other factors).
Vegetation changes	• Experiments and observational changes in other boreal areas show evidence of warming leading to more open shrub thickets (often via enhanced N cycling and availability). • Observed trends towards tree encroachment (due to ditching plus climate changes, can't necessarily separate out). • Drier, shorter growing season favors tree and shrub establishment. • Increased winter flooding → increased number of ice storms • Increased drought will lead to drier peatlands and increased fire risk, which will affect vegetation → but will it burn trees and shrubs and keep areas open? Or will we see a move away from boreal wetlands to another vegetation type? • Wider range of fluctuation in water levels can lead to a shift from "bog" to "fen" vegetation. • Wet/dry cycles might maintain an open vegetation structure because less suitable for tree/shrub establishment/survival. • Some areas can only be harvested when ground is frozen, and we're already seeing areas that no longer freeze. This could lead to use of roads under more marginal conditions, with greater damage to soils and vegetation in and around wetlands.
Hydrology	• Even with the same amount of precipitation, warmer temperatures will lead to increased evaporation and drying, and lower water tables. • Drying in other areas could add pressure for tapping into ADK water resources for human use. • Water limitations are not currently an issue, but may become one as climate changes.
Recreation / visitation / economics	• Warmer and drier summers (even despite small increases in precipitation) may lead to increased summer visitation. • As conditions warm and dry in other parts of the east/country, more people may come to the ADKs for recreation, and the summer recreation season may be longer. • More winter freeze/thaw cycles and increased winter rain may make the impacts of winter recreation more damaging (because more recreation during marginal conditions). • If game populations change, could affect hunting pressures. • Changes in recreation pressure may increase land development pressure for second homes, maybe tourism infrastructure – also could be some economic benefits if increased tourism. • Change in winter snow will affect local economics (have already seen a decrease in ice fishing, potentially changes

	in snowmobiling but not clear that climate change is the driver).
Fire	• Variability in plant productivity and drying across years and seasons will alter fire risk and regime.
Extreme weather events	• Likely to experience an increase in the frequency of blowdown events (especially in western ADKs) → consequences for nutrient cycling, and vegetation in/around wetlands.
Pests and pathogens	• Wet/dry cycles could stress out vegetation and make the vegetation more susceptible to pests and the invasion of exotics.
Invasive plants and insects	• Invasives are in areas around boreal bogs → as nutrient status changes, invasives might increase. • Human nuisances/effects on recreation/tourism: Ticks, poison ivy • Phragmites? Loosestrife? Do we need to look at invasives that are a problem in areas further south that might come north? • Wooly adelgid? Ash borer? • Black flies? Might be a longer and more variable black fly seasons.
Transportation corridors	• Not too much concern that new road building will be a problem, but potential for energy transmission lines issues. • Turn railroad beds into snowmobile trails – avoids further impacts on wetlands. • Increased need for road salting.
Nutrient changes / atmospheric deposition	• Increased atmospheric deposition, changes in soil microbial activity (which affected by temperature and precipitation). • Acid pulses from snowmelt may be dampened if releases are more dispersed across winter and spring due to more precipitation as rain than snow.
Other wildlife and species	• Imagine we'll lose some strongly obligate birds, but small mammals may be less impacted because they are less temperature-sensitive and more habitat generalists. Dragonflies (and perhaps other bird food sources?) may be sensitive to this scenario

For more information about this project, please contact the Wildlife Conservation Society Adirondack Program in Saranac Lake, NY at 518-891-8872 or accp@wcs.org.