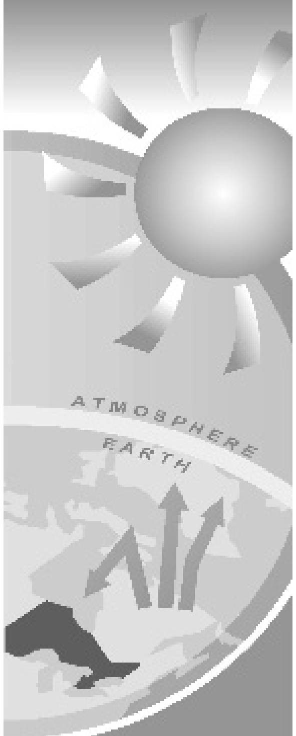
Ministry of Natural Resources

24

CLIMATE CHANGE RESEARCH REPORT
CCRR-24

Climate Change Vulnerability Assessment and Adaptation Options for Ontario's Clay Belt – A Case Study



Responding to Climate Change Through Partnership

Ontario

Sustainability in a Changing Climate: An Overview of MNR's Climate Change Strategy (2011-2014)

Climate change will affect all MNR programs and the natural resources for which it has responsibility. This strategy confirms MNR's commitment to the Ontario government's climate change initiatives such as the Go Green Action Plan on Climate Change and outlines research and management program priorities for the 2011-2014 period.

Theme 1: Understand Climate Change

MNR will gather, manage, and share information and knowledge about how ecosystem composition, structure and function – and the people who live and work in them – will be affected by a changing climate. Strategies:

- Communicate internally and externally to build awareness of the known and potential impacts of climate change and mitigation and adaptation options available to Ontarians.
- Monitor and assess ecosystem and resource conditions to manage for climate change in collaboration with other agencies and organizations.
- Undertake and support research designed to improve understanding of climate change, including improved temperature and precipitation projections, ecosystem vulnerability assessments, and improved models of the carbon budget and ecosystem processes in the managed forest, the settled landscapes of southern Ontario, and the forests and wetlands of the Far North.
- Transfer science and understanding to decision-makers to enhance comprehensive planning and management in a rapidly changing climate.

Theme 2: Mitigate Climate Change

MNR will reduce greenhouse gas emissions in support of Ontario's greenhouse gas emission reduction goals. Strategies:

- Continue to reduce emissions from MNR operations though vehicle fleet renewal, converting to other high fuel efficiency/low-emissions equipment, demonstrating leadership in energy-efficient facility development, promoting green building materials and fostering a green organizational culture.
- Facilitate the development of renewable energy by collaborating with other Ministries to promote the value of Ontario's resources as potential green energy sources, making Crown land available for renewable energy development, and working with proponents to ensure that renewable energy developments are consistent with approval requirements and that other Ministry priorities are considered.
- Provide leadership and support to resource users and industries to reduce carbon emissions and increase carbon storage by undertaking afforestation, protecting natural heritage areas, exploring opportunities for forest carbon management to increase carbon uptake, and promoting the increased use of wood products over energy-intensive, non-renewable alternatives.
- Help resource users and partners participate in a carbon offset market, by working with our partners to ensure that a robust trading system is in place based on rules established in Ontario (and potentially in other jurisdictions), continuing to examine the mitigation potential of forest carbon management in Ontario, and participating in the development of protocols and policies for forest and land-based carbon offset credits.

Theme 3: Help Ontarians Adapt

MNR will provide advice and tools and techniques to help Ontarians adapt to climate change. Strategies include:

- Maintain and enhance emergency management capability to protect life and property during extreme events such as flooding, drought, blowdown and wildfire.
- Use scenarios and vulnerability analyses to develop and employ adaptive solutions to known and emerging issues.
- Encourage and support industries, resource users and communities to adapt, by helping to develop understanding and capabilities of partners to adapt their practices and resource use in a changing climate.
- Evaluate and adjust policies and legislation to respond to climate change challenges.

Climate Change Vulnerability Assessment and Adaptation Options for Ontario's Clay Belt

– A Case Study

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Summary

In response to the Ontario government's Climate Ready: Ontario's Adaptation Strategy and Action Plan, 2011-2014, the Ministry of Natural Resources sponsored vulnerability assessments for selected natural resources in the Clay Belt of northeastern Ontario as part of a pilot study to help Ontarians develop adaptive solutions to a changing climate. A multi-step vulnerability assessment and adaptation framework was used to explore how ecosystems within the Clay Belt may be vulnerable to change. Stakeholders and partners were engaged early in the process to identify potential adaptation options for natural, managed, and social systems in the Clay Belt. In this report, overall study methods are described and results of the vulnerability assessments and adaptation options scoping process are summarized. Recommendations provided in support of adaptation planning and management include approaches for implementation, additional research needs, and guidance for future climate change adaptation strategies that involve vulnerability assessments.

Résumé

Évaluation de la vulnérabilité au changement climatique et possibilités d'adaptation relativement à la ceinture d'argile en Ontario – Étude de cas

En réponse au plan du gouvernement de l'Ontario « Faire face au changement climatique : Stratégie d'adaptation et plan d'action de l'Ontario, 2011-2014 », le ministère des Richesses naturelles a financé des évaluations de la vulnérabilité de certaines ressources naturelles dans la ceinture d'argile du nord-est de l'Ontario dans le cadre d'une étude pilote pour aider les Ontariens à trouver des solutions adaptatives à un changement climatique. Un cadre d'évaluation de la vulnérabilité et d'adaptation à phases multiples a été utilisé pour explorer dans quelle mesure les écosystèmes de la ceinture d'argile peuvent être vulnérables au changement. Dès le début du processus, les intervenants et les partenaires ont travaillé à trouver des possibilités d'adaptation quant à des systèmes naturels, gérés et sociaux dans la ceinture d'argile. Ce rapport offre une description des méthodes d'étude générales et un sommaire des résultats des évaluations de la vulnérabilité et du processus de détermination des possibilités d'adaptation. Les recommandations fournies pour appuyer la planification et la gestion des adaptations comprennent des façons d'aborder la mise en œuvre, l'existence de besoins de recherche supplémentaires et des conseils sur de futures stratégies d'adaptation au changement climatique qui englobent des évaluations de la vulnérabilité.

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Foreword

This is one in a series of reports to help resource managers evaluate the vulnerability of natural assets to climate change. Given that vulnerability assessment techniques continue to evolve, it is important for resource managers to learn by doing and to pass on knowledge gained to support the Ontario Ministry of Natural Resources and others engaged in adaptive management. Accordingly, the vulnerability assessment reports included in the Climate Change Research Report Series have been prepared using the best available information under the circumstances (e.g., time, financial support, and data availability). Collectively, these assessments can inform decisionmaking, enhance scientific understanding of how natural assets respond to climate change, and help resource management organizations establish research and monitoring needs and priorities.

Cameron Mack

Acting Director, Applied Research and Development Branch

Contents

1.0 Introduction

Ontario's climate is warming and becoming increasingly variable. The combined effects of continued warming and increased occurrences of extreme events are expected to change ecosystem function, with significant implications for the social and economic health of the people who depend on them. Therefore, an adaptive approach to managing for climate change will be an important aspect of life in 21st century Ontario.

Fundamentally, adaptation is to "learn while doing" (Lee 1999). In the context of climate change, the goal of adaptation is to reduce negative effects and risks and increase the magnitude and likelihood of preferred outcomes (Williamson et al. in prep.). An important precursor to managing for climate change is knowledge about ecological and social system vulnerability, where vulnerability is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change (see sidebar). To assess vulnerability, a suite of ecological and social indicators are used to provide information about how a system is responding to change. Some indicators, such as an animal's thermoregulatory tolerance, are species specific while others, such as water temperature, provide information about changes in entire systems. From a social perspective, indicators such as the timing of ice formation and melting inform decisions about winter road design and establishment, ice fishing, snowmobiling, trapping, and opportunities for other lake-related activities. With this knowledge, management actions can be devised and implemented to avoid, reduce, or eliminate vulnerability as the climate changes.

In the context of climate change, vulnerability is defined as *the degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, [and] the sensitivity and adaptive capacity of that system* (IPCC 2007a).

Brief definitions for each component of vulnerability are:

Exposure: The nature and extent to which a species or system is exposed to significant climate variation.

Sensitivity: The extent to which a species or system is affected by being exposed to a stressor.

Adaptive capacity: The ability or potential of a species or system to respond successfully to climate variability and change.

To manage for climate change, the Ontario government uses two complementary approaches: mitigation and adaptation. In 2007, the government released a mitigation plan, Go Green: Ontario's Action Plan on Climate Change (Government of Ontario 2007) that includes greenhouse gas emission reduction targets. Subsequently, the government appointed the Expert Panel on Climate Change Adaptation with a mandate to evaluate government programs and recommend how to move forward on adaptation. In its 2009 report, this panel provided 59 recommendations, which included the need to complete vulnerability assessments to inform development of adaptation options for use in strategic, forward-thinking land use planning (Expert Panel on Climate Change Adaptation 2009). In response, the government issued Climate Ready: Ontario's Adaptation Strategy and Action Plan, 2011-2014 (Government of Ontario 2011), which committed the Ontario Ministry of Natural Resources (MNR) to several actions including the development of vulnerability assessment tools and techniques to inform adaptive natural resources-related decisionmaking.

Managing for climate change is an MNR priority and in support of the government's ongoing commitment, MNR issued a renewed program-level strategy, Sustainability in a Changing Climate (OMNR 2011), which supports and aligns MNR's actions and priorities for 2011 to 2014 with the provincial strategy. Under the auspices of the Climate Ready action plan and its program-level climate change strategy and as part of a pilot study designed to help Ontarians develop and implement adaptive solutions, MNR sponsored vulnerability assessments for selected natural resources in the Clay Belt of northeastern Ontario.

In this report we outline the process used to complete the vulnerability assessments and to identify adaptation options for the management of natural resources in a rapidly changing climate. Results from the vulnerability assessments are summarized and the adaptation options identified by study participants are listed. We conclude with recommendations and advice (lessons learned) for practitioners responsible for completing vulnerability assessments.

2.0 The Eco-geography of the Clay Belt

The Clay Belt ecodistrict (3E-1) is nested within the Lake Abitibi Ecoregion (3E) and encompasses about 41,287 km² (4.2% of the province) (Figure 1). The Ontario part of the Clay Belt is delineated by the Ontario-Quebec border in the east, by glacial morainal deposits that transition into organic deposits in the north, and by lacustrine deposits in the south and west (Henson et al. in prep.).

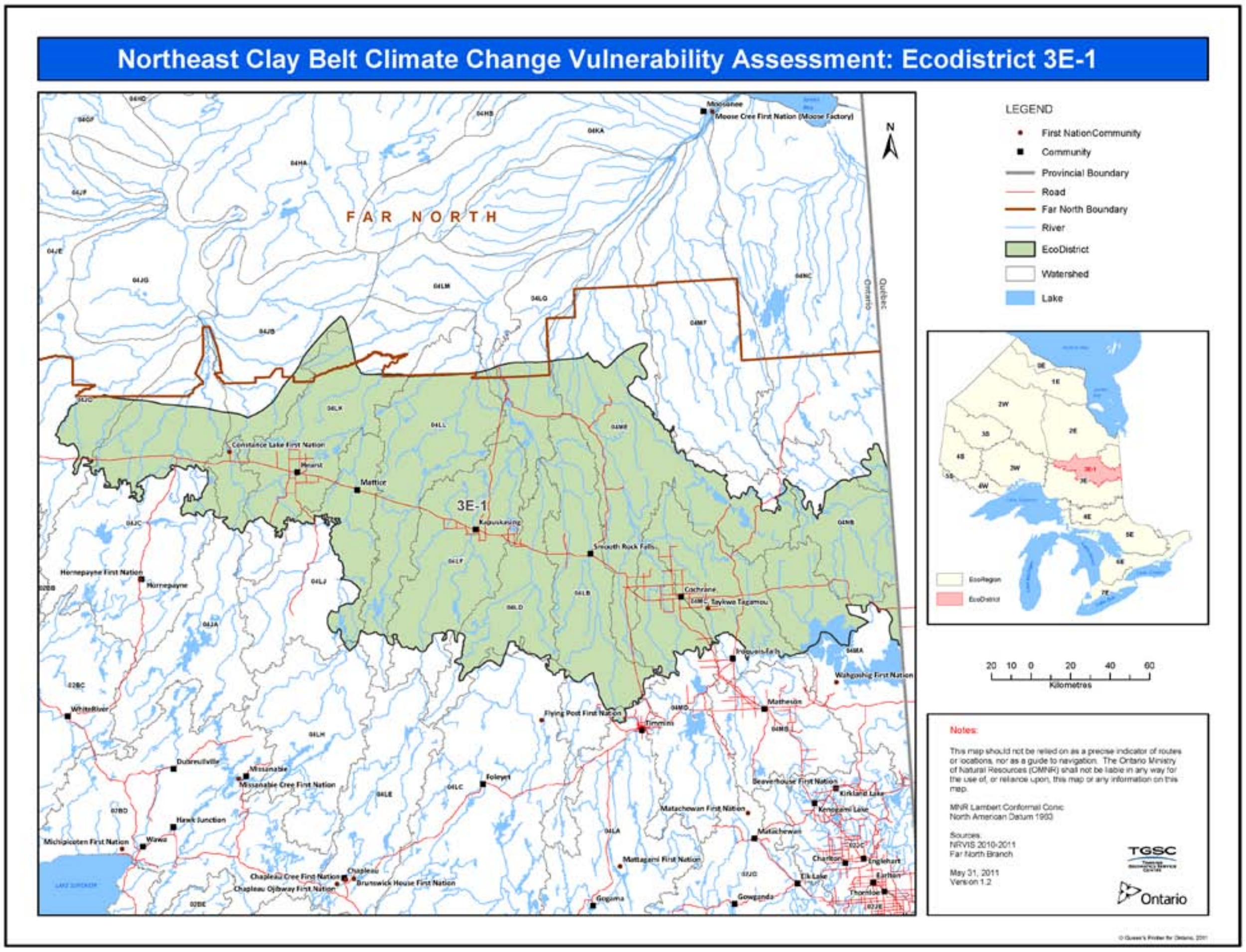


Figure 1. *Location of the Clay Belt ecodistrict (3E-1) in Ontario.*

2.1 Climate

Mean annual temperature in the Lake Abitibi Ecoregion 3E ranges from -0.5 to 2.5 °C and mean annual precipitation ranges from 652 to 1,029 mm, with more precipitation in the eastern part of the ecodistrict. The length of the growing season ranges from 167 to 185 days, with the Clay Belt ecodistrict at the lower end of this range (Crins et al. 2009). Overall, the Clay Belt is influenced by a sub-polar, sub-humid, continental climate characterized by long cold winters and short warm summers (Lefort 2003).

In the last century, the Clay Belt's climate has changed. For example, the average annual mean temperature in Kapuskasing has increased 1.0 °C since 1938 (Figure 2). The magnitude of this increase has varied by season: average annual temperature has increased 1.0 °C in winter, 1.9 °C in spring, 0.6 °C in summer, and 0.3 °C in fall.

2.2 Bedrock and surficial geology

The Clay Belt is on the Precambrian Shield, which is underlain by granitic or gneissic bedrock, and metavolcanic and metasedimentary rocks of Precambrian age (Crins et al. 2009). The surficial geology is diverse and reflects the glaciation history of the area. The topography is subdued, characterized by extensive, poorly drained plains comprising clayey and loamy soils with smaller pockets of sand and tills (Lefort 2003).

When the ice receded about 9,000 years ago, postglacial Lake Barlow-Ojibway formed over the stony, bouldery sandy tills that were deposited. As the ice front continued to recede northwards, Lake Barlow-Ojibway drained and a large lake bed containing the glaciolacustrine deposits of sands, silts, and clays remained. The next series of glacial events within the area (called the Cochrane re-advance) deposited additional clay material from the Hudson Bay Lowlands as well as loam tills, increasing the relief in this relatively flat area (Boissonneau 1966).

2.3 Hydrology

The Clay Belt is in a river-dominated landscape in the Hudson Bay Watershed. More than 15% of the ecodistrict supports aquatic ecosystems with wetlands on about 4,780 km² and lakes and streams covering more than 1,600 km². Large river systems within the Clay Belt area include the Abitibi, Mattagami, Groundhog, Kapuskasing, and Missinaibi. Only a few large lakes have formed, including Pierre Lake and Lake Abitibi, the northwestern portion of which is in the Clay Belt (Crins et al. 2009).

2.4 Land cover

Coniferous forests (35% of the area) and mixed forests (28%) blanket the landscape (Henson et al. in prep,) (Figure 3). In low lying areas and on gently sloping uplands black spruce (*Picea mariana*) is the primary species while jack pine (*Pinus banksiana*) thrives on well-drained sites. Deciduous species in mixed forests in the Clay Belt include trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*), which generally occur on well-drained sites adjacent to rivers and lakes. In the absence of fire, succession leads to balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*) in these forests (Lefort 2003). Other less common species include tamarack (*Larix laricina*) and eastern white cedar (*Thuja occidentalis*). Wildfire and forest harvesting exert the largest effect on land cover in the area.

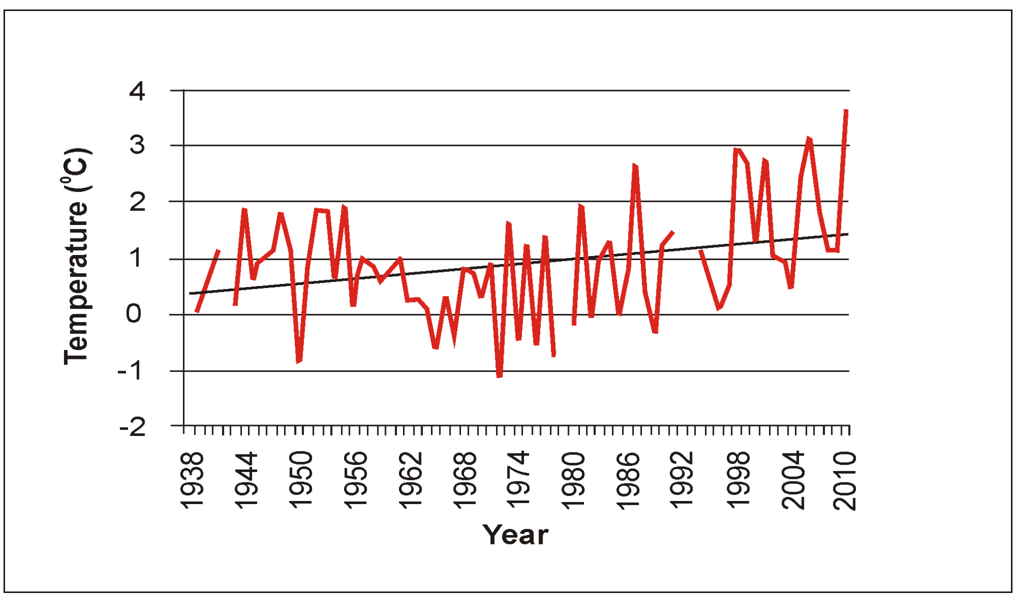


Figure 2: *In Kapuskasing, Ontario, average annual mean temperature has increased 1 °C since 1938 (line breaks occur where data were not collected for five years during the 1938 to 2010 period) (Source: Environment Canada 2011).*

2.5 Fish and wildlife

Clay Belt wildlife are typically boreal. Mammals include moose (*Alces alces*), gray wolf (*Canis lupus*), American marten (*Martes americana*), Canada lynx (*Lynx canadensis*), snowshoe hare (*Lepus americanus*), red squirrel (*Tamiasciurus hudsonicus*), beaver (*Castor canadensis*), southern red-backed vole (*Clethrionomys gapperi*), and woodland caribou (*Rangifer tarandus caribou*). Birds include common loon (*Gavia immer*), great blue heron (*Ardea herodias*), bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), spruce grouse (*Falcipennis canadensis*), gray jay (*Perisoreus canadensis*), common raven (*Corvus corax*), and several species of warblers, sparrows, and finches. Spotted salamander (*Ambystoma laterale*), frogs, turtles, and the eastern gartersnake (*Thamnophis sirtalis sirtalis*) also inhabit the Clay Belt. Common fish species include brook trout (*Salvelinus fontinalis fontinalis*), lake whitefish (*Coregonus clupeaformis*), northern pike (*Esox lucius*), walleye (*Sander vitreus vitreus*), and yellow perch (*Perca flavescens*) (Crins et al. 2009).

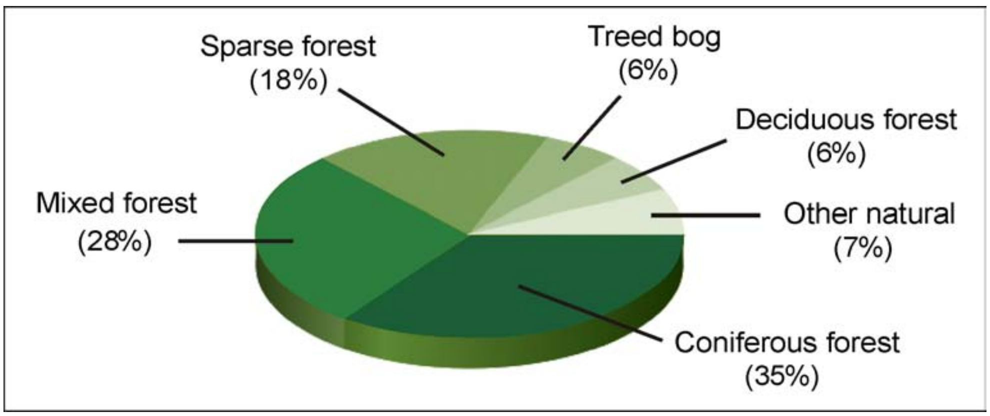


Figure 3: *Proportion of land cover types in the Clay Belt ecodistrict (3E-1) (Source: Henson et al. in prep).*

2.6 Resource management

Land use planning

Most of the area within the Clay Belt is Crown land managed by the government of Ontario. The principal land use designation is *general use area*, which means managed to maintain ecological health while simultaneously providing for a variety of resource (e.g., aggregate extraction) and recreational uses. In addition, part of the Clay Belt is managed based on the Approved Cochrane District Remote (Wilderness) Tourism Strategy with the vision *to collectively share the responsibility for the wise use, protection and conservation of the natural resources in a manner that promotes the long-term economic, social and environmental well-being of the Cochrane District* (OMNR 1997). This strategy is unique to Cochrane District and the intent is to protect remote tourism values while permitting use by First Nations, visitors engaged in a variety of recreational opportunities, and resource extraction industries. Natural heritage areas in the Clay Belt include 72,542 ha designated as provincial parks and 85,072 ha as conservation reserves; these represent 3.8% of the land area (Gray et al. 2009).

Fish and wildlife management

The Clay Belt occurs within Zones A and B of Ontario's Cervid Ecological Framework (OMNR 2009a). Cervid management is designed to maintain natural low to moderate moose densities and to sustain and restore woodland caribou populations. Under the *Endangered Species Act,* forest-dwelling woodland caribou are listed as a threatened species. Clay Belt caribou populations live in a continuous habitat zone identified in Ontario's Woodland Caribou Conservation Plan (OMNR 2009b).

In Ontario, hunted wildlife species are managed within wildlife management units of which 10 are located in part or in whole within the Clay Belt. Recreational hunting opportunities for residents and non-residents include moose, black bear (*Ursus americanus*), grouse, and some waterfowl species. Trapping of marten, fisher (*Martes pennanti*), lynx, beaver, and wolf occurs throughout the ecodistrict.

Similar to wildlife, fish are managed within fisheries management zones. In the Clay Belt, work in zones 3, 7, and 8 is focused on maintaining natural fish populations and providing fishing opportunities. While walleye and northern pike are the primary sport fish species, others such as lake trout and brook trout, are available for angling in natural and stocked lakes and rivers. Several large river systems within the Clay Belt support native populations of lake sturgeon (*Acipenser fulvescens*), currently listed under the *Endangered Species Act* as a species of *special concern* and cannot be harvested. Baitfish species are harvested across the ecodistrict for commercial and personal use. Hunting and fishing opportunities are provided by several tourist outfitters for both residents and non-residents.

Forest management

The Clay Belt includes significant portions of the Abitibi River, Gordon Cosens, and Hearst forest management units, as well as small portions of the Kenogami and Romeo Mallete forest management units. Of these, the Abitibi River, Gordon Cosens, and Hearst forests cover most of the area. These forests are managed for multiple timber values, including jack pine, black spruce, and balsam fir for lumber as well as pulp and paper production. Poplar and white birch are used to produce composite wood products such as veneer and fibreboard. At present, sawmills operate in Calstock, Hearst, Kapuskasing, and Cochrane. Pulp and paper mills are located in Kapuskasing and Iroquois Falls, and a veneer facility is operating in Hearst.

Forest harvesting practices primarily follow a clear-cut system and are designed to emulate the patterns created by stand-replacing fires to which these ecosystems are adapted. Selective logging techniques are employed in some multi-aged stands.

Agriculture

Beef and dairy cattle operations dominate the farming industry. The short frost free period limits agriculture to cool season crops such as timothy, brome, and high moisture barley and oats (OMNR 1983a, b, c). Market gardens provide produce for local consumption (OMNR 1983a).

Renewable energy

Several river systems in the Clay Belt are under various stages of operation, planning, and development of water power. These rivers are within the headwaters of the Moose River and Albany River basins and flow north towards James Bay. Several solar power projects have been proposed for construction on private land, including sites previously used for agriculture.

Mining

Mining is a major economic activity in several communities within and adjacent to the ecodistrict. Primary minerals extracted include gold, silver, and base metals such as zinc, copper, and nickel.

2.7 Socio-economic conditions

Hearst, Kapuskasing, Smooth Rock Falls, and Cochrane are the largest communities in the Clay Belt. The territories of the Matawa, Muskegowuk, and Wabun Tribal Councils are located in the Clay Belt. Hunting, fishing, and trapping are actively pursued by residents of Aboriginal communities.

About 30,000 people live in the ecodistrict, mostly along the Highway 11 corridor in major centres (Table 1). For example, Kapuskasing is surrounded by many smaller communities and provides a variety of services to a population of about 15,000 (Robichaud 2010). The economy of these communities has long been tied to natural resources, notably forestry, mining, and agriculture. In addition, the tourism industry, particularly winter recreation opportunities such as snowmobiling, is also important. Declines in the traditional forest sector have been offset somewhat with new investment in manufacturing, value-added wood products, and renewable energy generation. However, in recent years the area's population has declined by about 5.1% (Table 1).

Table 1. *Population estimates (number of people) for the major communities located in the Clay belt ecodistrict (3E-1) in northeastern Ontario (Source: Statistics Canada 2012a, b, c, d).*

Year	Cochrane	Hearst	Kapuskasing	Smooth Rock Falls
2011	5,340	5,090	8,196	1,376
2006	5,487	5,620	8,509	1,473

3.0 Study Objectives

Integrating climate change into natural resource management requires an understanding of the vulnerabilities and risks to ecosystems and the people who rely on them. Climate change vulnerability assessments are part of an adaptive approach to managing natural resources and help to identify emerging issues and potential future effects. Vulnerability assessments are also a way to incorporate climate change into management plans and activities by helping decisionmakers and practitioners identify adaptation options.

Recognizing the need to complete and test vulnerability assessments in the province, the MNR, in partnership with the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR), sponsored vulnerability assessments for selected natural resources in the Clay Belt. The primary objectives were to:

1. understand and identify where and how ecosystems within the Clay Belt are vulnerable to climate change
2. work with stakeholders and partners to identify potential adaptation options to cope with climate change effects
3. provide information and support tools for resource managers to help them integrate climate change into decisionmaking
4. develop and test tools and techniques that can be translated and applied to other vulnerability assessments in the province

4.0 Vulnerability Assessment Methods

The Clay Belt vulnerability assessment study was completed under the auspices of a climate change adaptation framework (Figure 4). This process-oriented framework was adapted from existing generic frameworks and guidance documents that subscribe to the principles of adaptive management (e.g., Gleeson et al. 2011). The methods used to complete each step in the framework are outlined below.

4.1 Step 1: Set context and establish study team

The first step was to assemble a study team and draft a charter to guide the vulnerability assessment process and the development of adaptation options. In the charter, the study team described the study area, outlined the deliverables, timelines, potential stakeholders and partners, and identified candidate experts for selected ecological and socio-economic themes.

Study area

Ontario's Ecodistrict 3E-1, commonly referred to as the Clay Belt, was selected as the study area for this pilot because:

- land-use planning occurs at the ecodistrict-level of mapping making it an ideal scale
- in the absence of regional climate models, the ecodistrict-level approach aligns well with downscaled general circulation models (GCMs)
- available information included data from historic and current forest research plots
- working relationships among the study team and First Nations, the forest industry, community members, and MNR district staff were already established
- the area's diversity provides an opportunity to explore the effects of climate change on an array of ecological and socio-economic values.

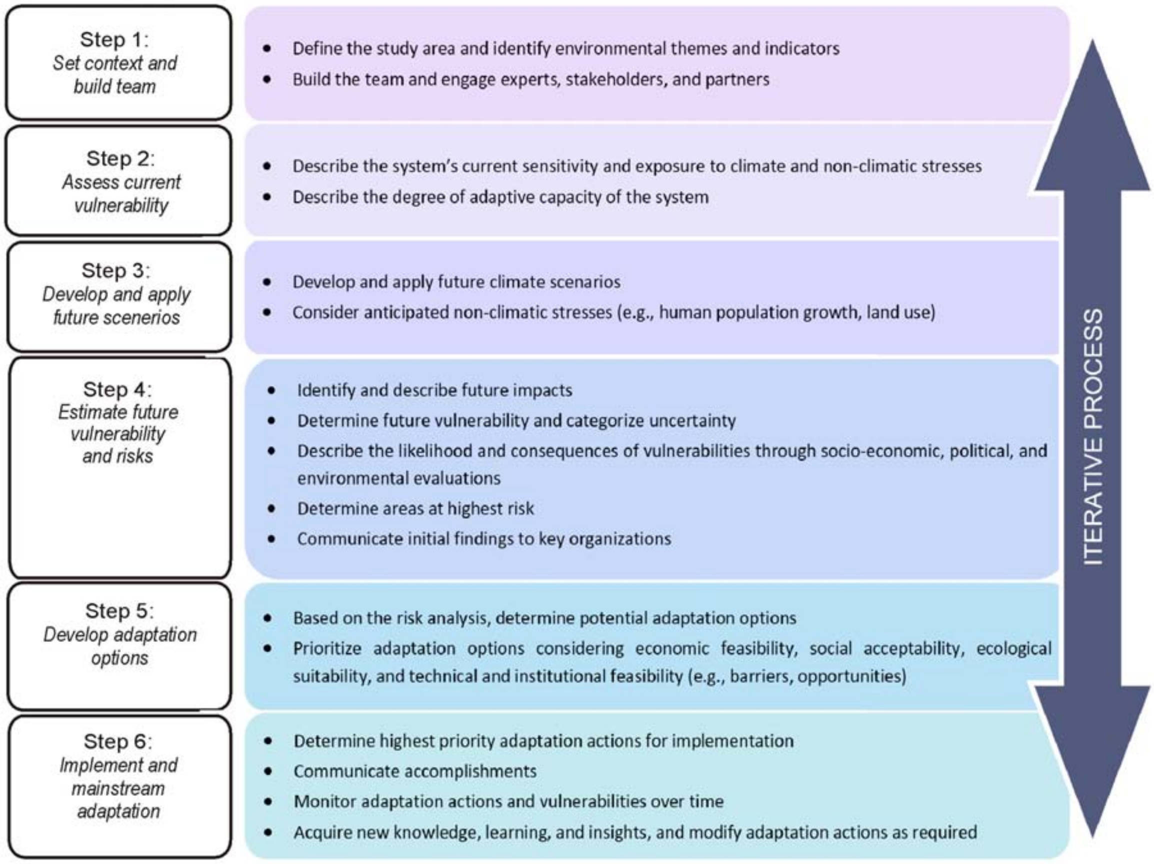


Figure 4. *A process and framework for exploring vulnerability and developing adaptation options in a rapidly changing climate (Gleeson et al. 2011).*

Assessment team, environmental and socio-economic themes, and indicators

Scientists within the Ontario government, the Association for Canadian Educational Resources, and academics from the Université du Québec en Abitibi-Témiscamingue and the University of Toronto were invited to participate in this pilot study. In response, 11 experts joined the assessment team.

Availability of resources, data and information, and expertise influenced the selection of themes. Based on the qualifications of the experts and their interests, nine themes were selected: aquatic habitat, forest windthrow, forest fire, forest productivity and composition, hydrology, peatlands, paludification (the process by which peatlands are formed in the boreal zone), socio-economics, and wildlife (i.e., ungulates, furbearers, and waterfowl). For each of the nine themes, ecological and socio-economic vulnerability to climate change was examined using measurable indicators selected by the experts. For example, aquatic habitat indicators included air temperature, water temperature, precipitation, groundwater discharge potential, and the distribution of coldwater fish species (Chu and Fischer in prep.). Furbearer indicators included distribution and abundance of competitors and pathogens, distribution and abundance of cold-adapted species, onset of breeding, and changes to synchrony in the lynx-snowshoe hare cycle (Bowman and Sadowski 2012).

Stakeholder and partner engagement

Most stakeholders and partners involved in the study lived and worked in the Clay Belt (Table 2) and were encouraged to participate from the outset. With emphasis on learning and collaboration, participants were kept apprised of the results of completed work and overall study progress. Knowledge about the vulnerability of natural resources to climate change increased their capacity to contribute to the identification of adaptation options during the entire process, and specifically at the workshop (Step 4) and in an online ‘adaptation survey’ (Step 5). Study information was provided via fact sheets, one-on-one conversations, workshops, webinars, website postings, and e-mail updates. For example, the fact sheet (Appendix I) was created and used as a reference to explain the purpose and outline the objectives of the study. The OCCIAR hosted meetings in Hearst, Kapuskasing, Smooth Rock Falls, and Cochrane to discuss climate change effects and adaptation and to introduce the Clay Belt pilot study. Mayors, council members, economic development officers, tourism outfitters, and members of the public attended these meetings. Many of these people participated in later stages of the study.

Table 2. *Stakeholders and partners involved in the Clay Belt ecodistrict (3E-1) vulnerability assessment study.*

Stakeholders and other interested organizations		
Municipal and Local Organizations • Mayor and Council • Chamber of Commerce • Economic Development Office • Northeast Community Network • Local Citizens Committee	National • Canadian Council of Forest Ministers	International • US Forest Service
Partners		
MNR • Hearst District • Kapuskasing Area • Cochrane District • Timmins District • Northeast Science and Information Section • Northeast Planning Unit • Southern Science and Information Section • Far North Branch • Applied Research and Development Branch	Aboriginal Communities, Councils, and Organizations • Wabun Tribal Council • Matawa Tribal Council • Mushkegowuk Tribal Council • Constance Lake First Nations • Mushkegowuk Environmental Research Centre (MERC) • Four Rivers	Forest Industry • First Resource Management Group • Tembec • Hearst Forest Management Inc.

4.2 Step 2: Assess current vulnerability

The study team assembled data and information (e.g., climatic data from weather stations within the Clay Belt, population census data, fire history, and land use change) for the experts who used it to select and create indicators of vulnerability. Data and information compiled during this step allowed the experts to compare current and potential future vulnerabilities.

4.3 Step 3: Develop and apply future scenarios

General circulation model data were provided by the Canadian Forest Service (CFS) as described by McKenney et al. (2006), and interpreted, plotted, and mapped by staff at MNR's Northeast Geomatics Services Centre to provide projections of future climate for the Clay Belt. The study team elected to use projections derived from a combination of models (called an *ensemble* approach) to capture a range of potential future climate conditions. This approach is recommended by the Intergovernmental Panel on Climate Change (IPCC 2007b) and Environment Canada (N. Comer, pers. comm., 2011). The ensemble model was created by combining aspects of four general circulation models:

- Canadian Coupled Global Climate Model 3 (CGCM-3)
- U.S. National Center for Atmospheric Research (NRCAR-3) model
- Japanese Model for Interdisciplinary Research on Climate (MIROC32)
- Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) model

Initially, experts were asked to complete vulnerability assessments using both the CGCM-3 and the ensemble model. However, after determining that differences in the output of the two models were not significant (Figure 5), experts were advised to use either model to complete their assessments.

To develop possible climate change scenarios, assumptions are needed about changes to the rate of increase in the volume of greenhouse gases in the atmosphere based on probable trends in human behaviour. Forty greenhouse gas emission scenarios have been approved by the IPCC for use in climate change effect and assessment initiatives (Nakićenović et al. 2000). The study team selected the A2 and B1 emission scenarios because they are commonly used and represent opposite ends of the spectrum of potential greenhouse gas emissions. The A2 scenario is based on assumptions of higher greenhouse gas levels by 2100, increased human population, and reduced environmental protection, whereas the B1 scenario is based on assumptions of a high level of environmental and social consciousness combined with a globally coherent approach to sustainable development (Nakićenović et al. 2000). Note that current global anthropogenic greenhouse gas production exceeds levels assumed in the A2 scenario (IEA 2011).

The IPCC recommends fixed time horizons of at least 30 years to capture long-term trends rather than seasonal or annual variations in weather. The 1971 to 2000 period was used as the baseline from which to project changes in temperature and precipitation patterns for three future periods: 2011 to 2040, 2041 to 2070, and 2071 to 2100. Mapped information was provided in two perspectives: projected total values for the three future periods (Figure 6) and projected differences between the base period (1970-2000) and the three future periods (Figure 7).

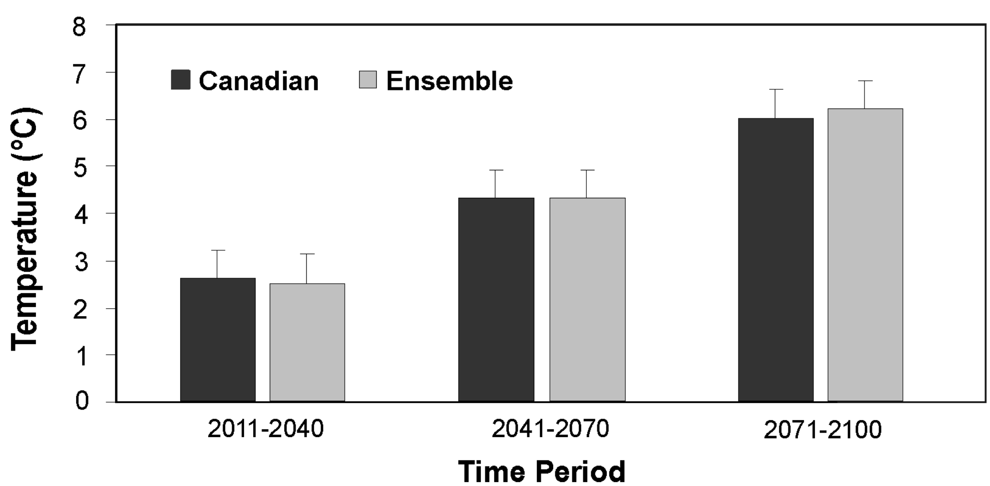
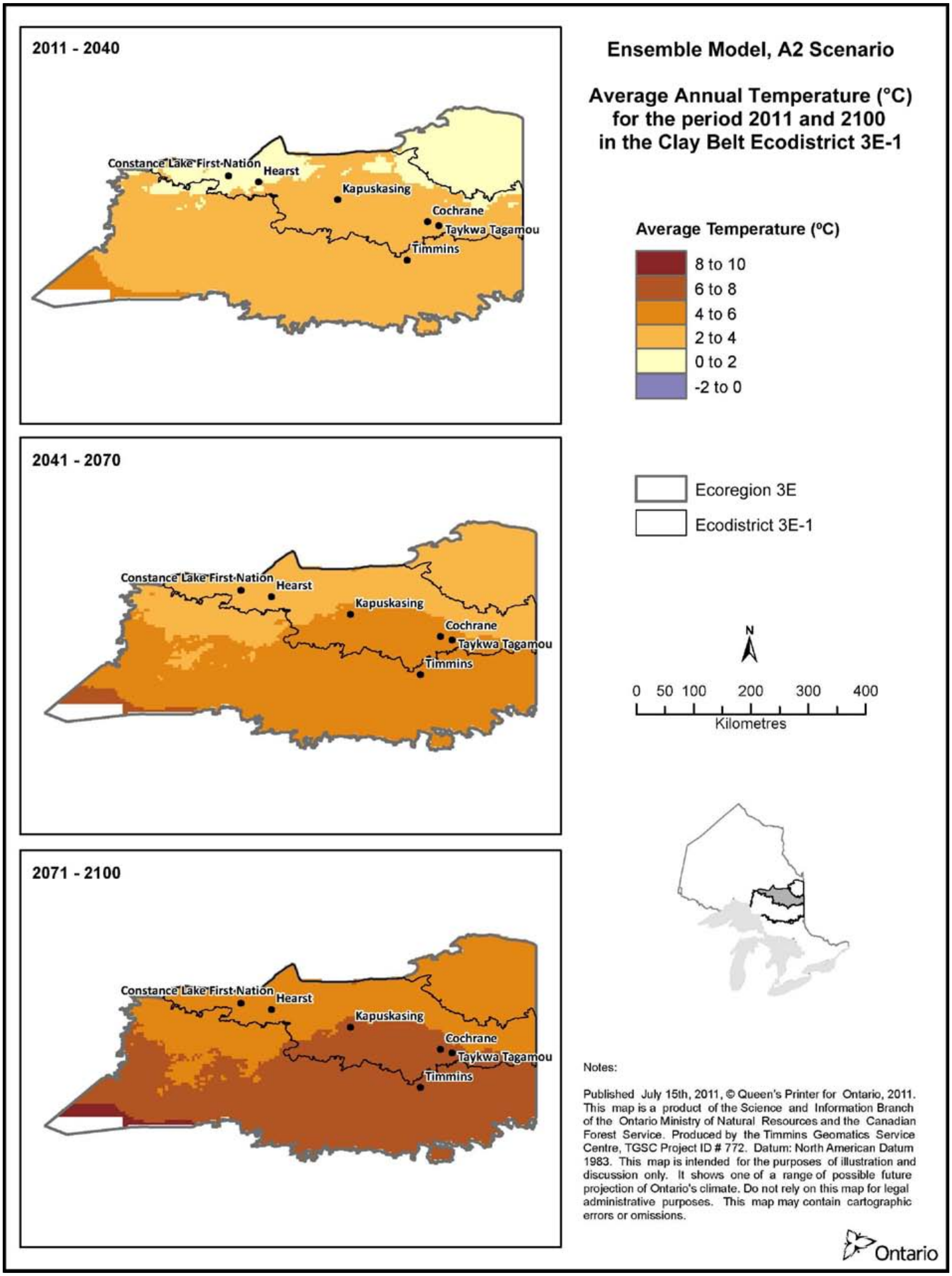


Figure 5. *Comparison of temperature projections for the Canadian Coupled Global Climate Model (Version 3) and the ensemble model using the A2 scenario for three time periods in the Clay Belt ecodistrict (3E-1). No significant differences were detected between model projections.*

(A)


Ensemble Model, A2 Scenario
Average Annual Temperature (°C) for the period 2011 and 2100 in the Clay Belt Ecodistrict 3E-1
2011 - 2040
2041 - 2070
2071 - 2100
Constance Lake First Nation
Hearst
Kapuskasing
Cochrane
Taykwa Tagamou
Timmins
Average Temperature (ºC)
8 to 10
6 to 8
4 to 6
2 to 4
0 to 2
-2 to 0
Ecoregion 3E
Ecodistrict 3E-1
N
0 50 100 200 300 400
Kilometres
Notes:
Published July 15th, 2011, © Queen's Printer for Ontario, 2011. This map is a product of the Science and Information Branch of the Ontario Ministry of Natural Resources and the Canadian Forest Service. Produced by the Timmins Geomatics Service Centre, TGSC Project ID # 772. Datum: North American Datum 1983. This map is intended for the purposes of illustration and discussion only. It shows one of a range of possible future projection of Ontario's climate. Do not rely on this map for legal administrative purposes. This map may contain cartographic errors or omissions.
Ontario

(B)

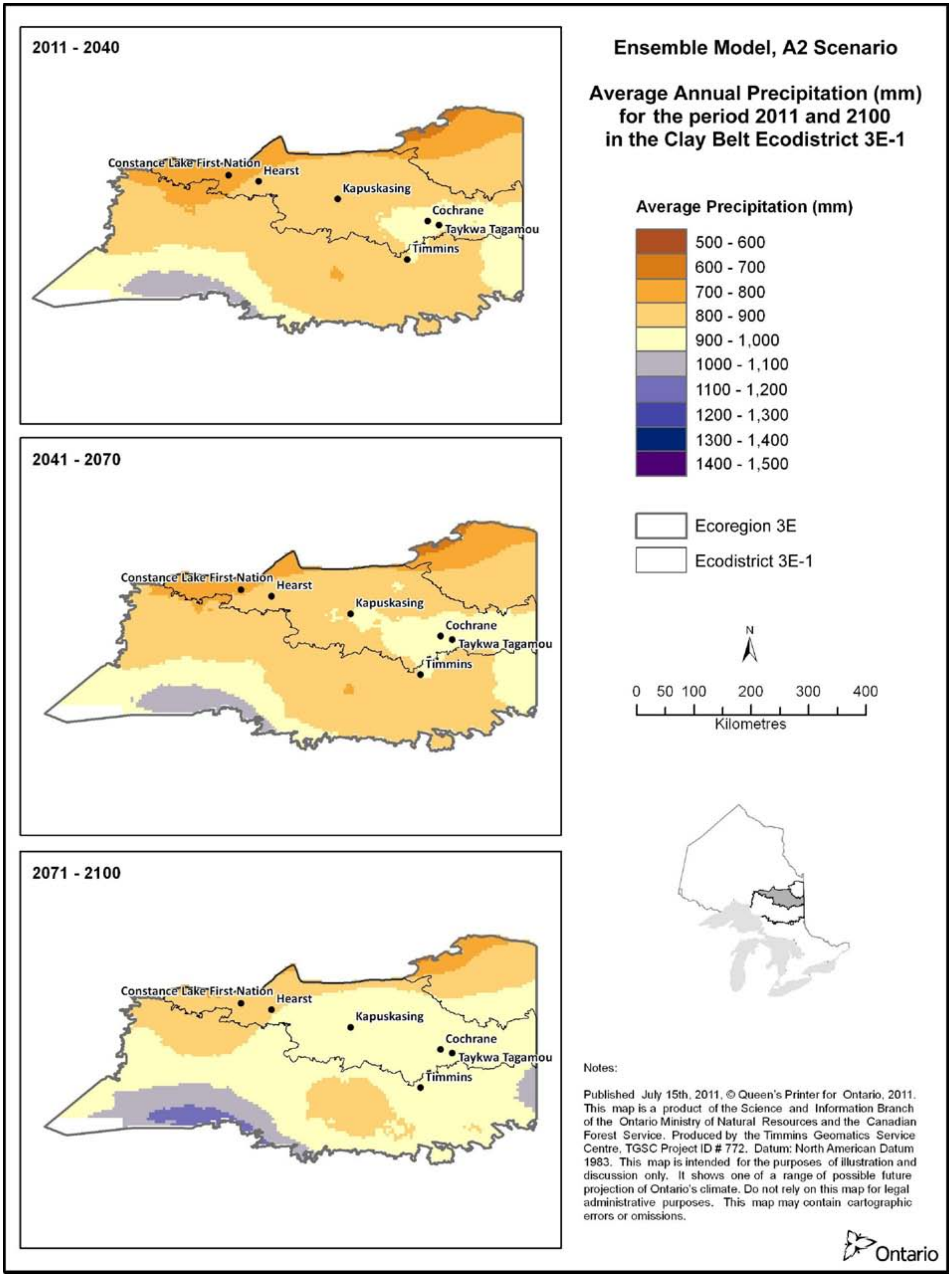
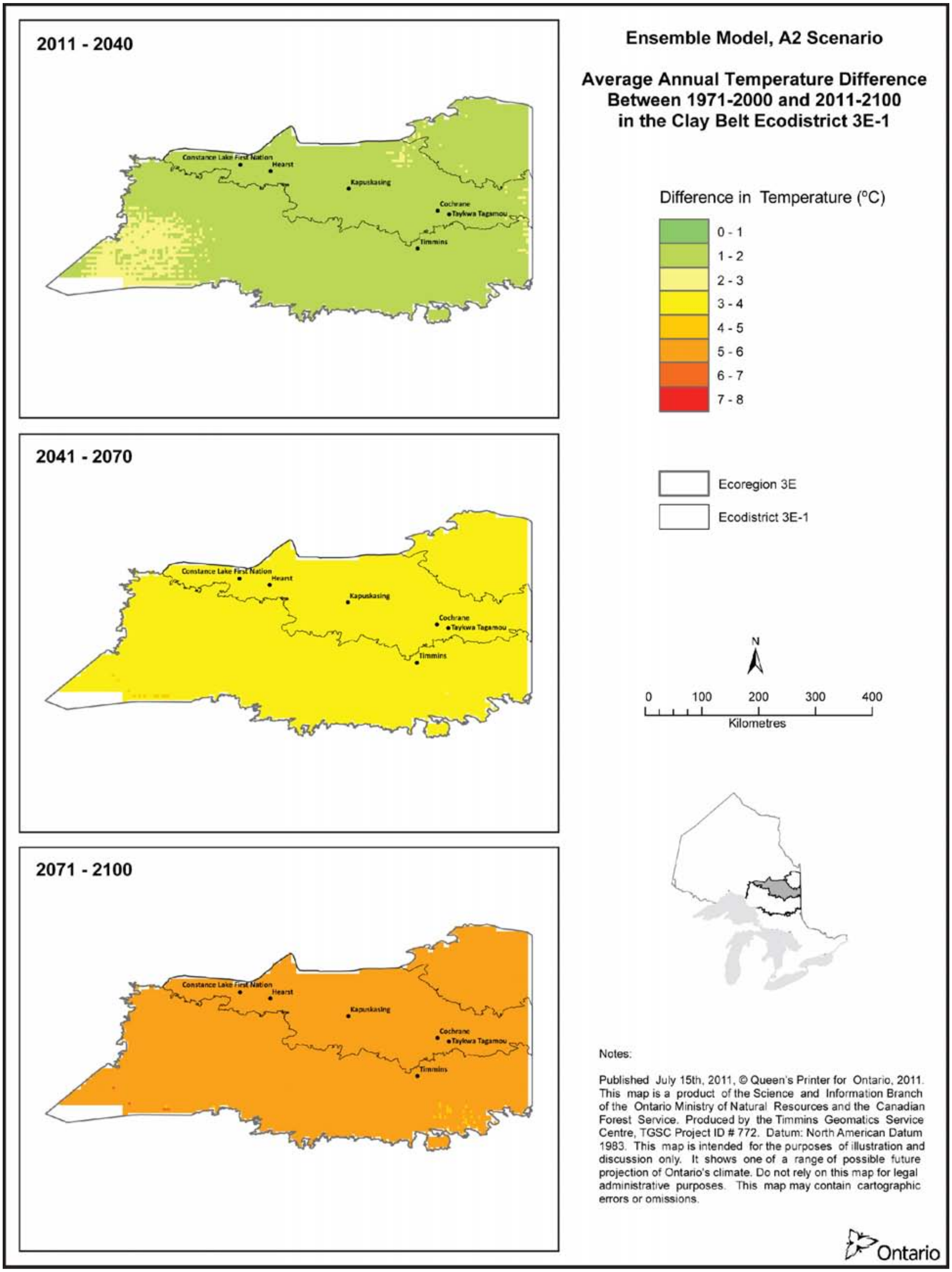


Figure 6. *Temperature (A) and precipitation (B) patterns for the Clay Belt ecodistrict (3E-1) projected by the ensemble climate model using the A2 scenario for three future time periods.*

(A)


2011 - 2040
2041 - 2070
2071 - 2100
Constance Lake First Nation
Hearst
Kapuskasing
Cochrane
Taykwa Tagamou
Timmins
Ensemble Model, A2 Scenario
Average Annual Temperature Difference Between 1971-2000 and 2011-2100 in the Clay Belt Ecodistrict 3E-1
Difference in Temperature (°C)
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
Ecoregion 3E
Ecodistrict 3E-1
N
0 100 200 300 400
Kilometres
Notes:
Published July 15th, 2011, © Queen's Printer for Ontario, 2011. This map is a product of the Science and Information Branch of the Ontario Ministry of Natural Resources and the Canadian Forest Service. Produced by the Timmins Geomatics Service Centre, TGSC Project ID # 772. Datum: North American Datum 1983. This map is intended for the purposes of illustration and discussion only. It shows one of a range of possible future projection of Ontario's climate. Do not rely on this map for legal administrative purposes. This map may contain cartographic errors or omissions.
Ontario

(B)

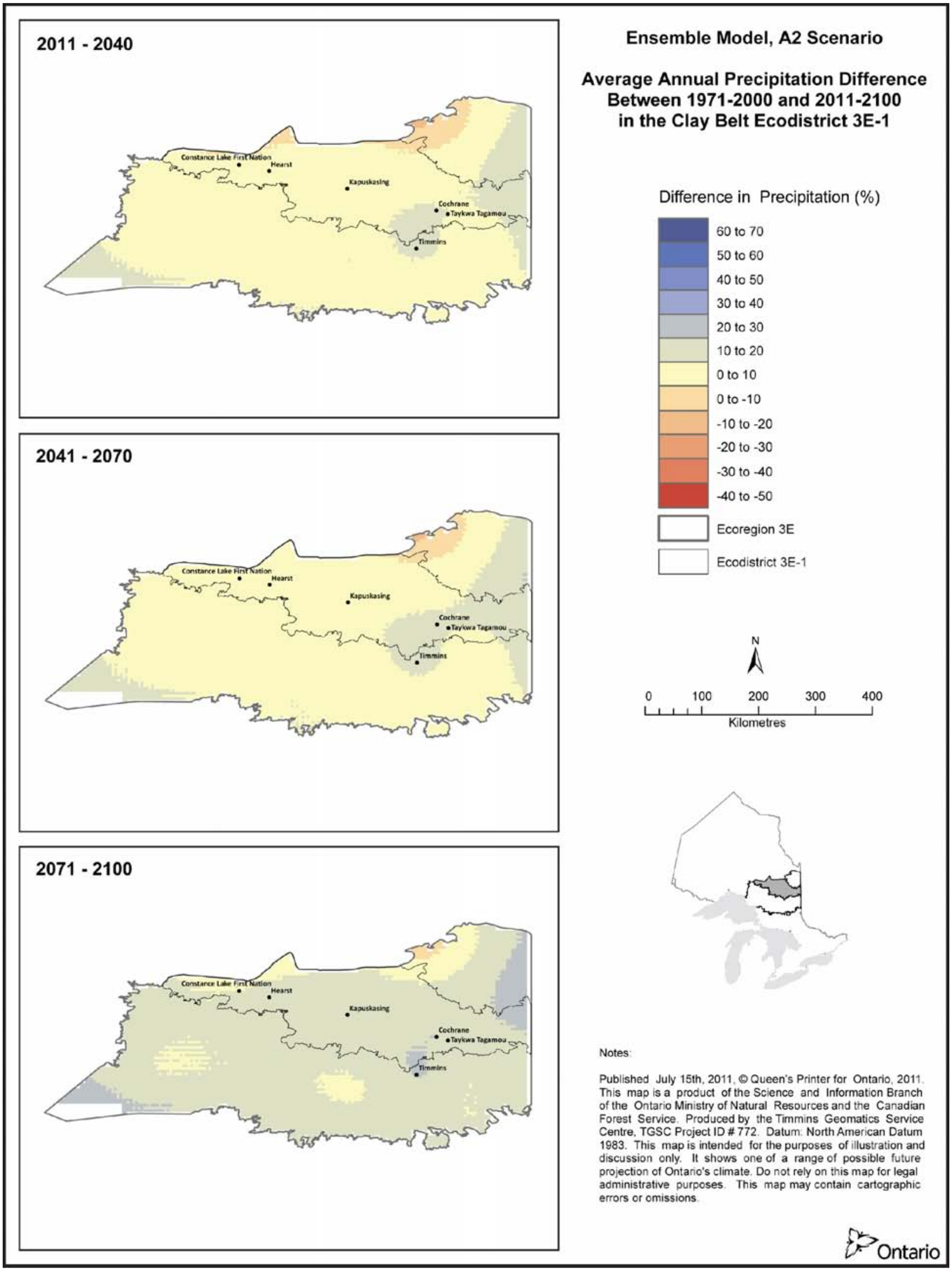


Figure 7. *Difference in temperature (A) and precipitation (B) patterns for the Clay Belt ecodistrict (3E-1) projected by the ensemble climate model using the A2 scenario for three future time periods.*

Experts selected eight climatic variables to use in climate projections based on both the A2 and B1 scenarios: (1) mean annual temperature (°C), (2) minimum and (3) maximum temperatures (°C) for the warmest/coolest quarter, (4) mean annual precipitation (mm), (5) minimum and (6) maximum precipitation (mm) in the warmest/coolest quarter, (7) isothermality (measure of constancy of temperature), and (8) growing degree days. Overall, 64 maps were generated to illustrate baseline climate data and projected differences from these values and 48 maps were created to illustrate projected total values.

4.4 Step 4: Estimate future vulnerability and risks

Experts used the indicators to identify potential future vulnerabilities under projected climate conditions and prepared two to four statements that highlighted potential effects of climate change for each environmental theme for use by workshop participants. Given the level of uncertainty involved in vulnerability assessments, experts also commented on uncertainty related to their statements of possible effects. Experts used a range of ecological response and dynamic models to conduct their assessments. Detailed descriptions of the methods used to assess vulnerability for several of the themes explored in the overall vulnerability assessment will be documented in MNR's climate change report series over the coming year.

Workshop

In January 2012, a two-day workshop (Appendix II) was held to review results of the vulnerability assessments with stakeholders and partners. Experts reported the results of their vulnerability assessments and provided impact statements; participants used this information to complete risk assessment statements. Upon completion of the vulnerability assessments and risk statements, participants formed small working groups and engaged in a world café (http://www.theworldcafe.com/method.html) discussion session to identify adaptation options. As the name implies, this approach involves café style seating where the participants visit all of the tables for facilitator-led discussions to meet others and share ideas. By rotating through the café and adding to the ideas and information developed by previous groups, participants built on the insights shared in prior conversations and ultimately increased the collective knowledge on effects and solutions.

Risk assessment

A risk statement can be formulated by evaluating the likelihood and consequences of a given outcome. For this study, risk assessment was used to prioritize the effects identified by the experts and identify adaptive measures to best reduce those risks. 'Consequence rankings' were determined by workshop participants and 'likelihood rankings' were determined by the study team. Because of their familiarity with the Clay Belt, participants were asked to identify the consequence rankings.

After each presentation by an expert on one of the themes, participants were asked to rank the consequences of the effects of projected climate change on that theme by the year 2050 (Appendix III). Each effect was ranked based on social (e.g., health and safety, livelihood, and cultural), economic (e.g., property damage and financial effect), and ecological (e.g., air, water, land, and ecosystems) factors. Participants were also given the option of identifying the consequence as positive, neutral, or negative. In addition, participants were encouraged to provide written statements about the consequences.

Using the technique described by Bruce et al. (2006) to rank risk for each effect, the consequence rankings developed by participants were combined with the likelihood rankings developed by the study team and plotted in an evaluation matrix to help compare the risks. A qualitative continuum denoted by *low*, *moderate*, and *high* was used to ensure that the risk rankings did not imply an accuracy that was not implicit in the comparative values.

4.5 Step 5: Develop adaptation options

A goal of climate change adaptation is to reduce or eliminate vulnerability and/or to enhance resilience to the effects of realized or projected changes in climate, including extreme weather events. Given that no one tool or technique will remediate all effects or threats, the most adaptable agencies and organizations develop, maintain, or obtain access to a range of tools and techniques that enable them to respond to their unique circumstances as they emerge. Adaptation options were identified by developing a portfolio of options and ranked via an adaptation options survey.

Adaptation options portfolio

To provide stakeholders and partners with information on the range of adaptation options available, a portfolio of options was created (Appendix IV). To populate the portfolio, a literature review was completed to compile adaptation options identified in reports in MNR's climate change series (e.g., Browne and Hunt 2007, Varrin et al. 2007, Colombo 2008, and Dove-Thompson et al. 2011) and the published literature. Options identified ranged from high-level strategic actions (e.g., integrate principles of adaptive management and an ecosystem-based approach into resource management plans) to on-site operational actions (e.g., specific silvicultural activities in forest management).

Adaptation options were organized into six themes: forests, wildlife, aquatic habitat, paludification and peatlands, socio-economics, and overall measures. Within each theme, options were classified by management activity: (1) policy, (2) resource management, (3) monitoring and science, and (4) education and public engagement. At the workshop, participants explored the variety of tools and techniques available to address vulnerabilities identified by the assessment experts. Through these interactive discussions participants could add adaptation options to the portfolio.

Adaptation options survey

Adaptation options were ranked using a post-workshop electronic survey sent to workshop participants. The online survey was run using Flash Q (http://www.hackert.biz/flashq/home/), a software product that allows respondents to rank option statements (Appendix V).

Participants were asked to complete at least two surveys, one for overall measures and one other theme of their choice. Based on lessons learned from the Lake Simcoe pilot study (see Douglas et al. in prep.) and given the busy schedule of many participants, an incentive (a draw for a GPS unit) was provided to increase survey participation. Participants from MNR, other agencies, and the Clay Belt communities prioritized more than 200 adaptation options across the six themes by considering the feasibility and effectiveness of each option. Based on the survey, a prioritized list of options was compiled for each theme. Ultimately, the Flash Q-method resulted in a smaller, more concise set of adaptation options. Advantages of using the Flash Q tool include that it:

- provides respondents a 'safe environment' in which to express new and perhaps controversial ideas by guaranteeing anonymity
- eliminates the risk of the one-idea 'bandwagon' effect
- ensures that recommendations are not developed by a biased few who might be more vocal in round table discussions
- is cost effective and can be completed remotely at the convenience of respondents

5.0 Results

5.1 Climate projections for the Clay Belt

Climate model projections suggest that the climate of the Clay Belt will change significantly by the end of the century (see Figures 6 and 7). For example:

- by 2100, average annual temperature will increase 5 to 6 °C and 3 to 4 °C under A2 and B1 climate change scenarios, respectively
- by 2070, annual precipitation will increase slightly and then level off under both climate change scenarios
- temperature increases that are not matched by equivalent precipitation increases will lead to more evapotranspiration resulting in drier conditions
- an east-west moisture gradient within the Clay Belt will be noticeable, with the west being drier
- under the A2 scenario isothermality will increase slightly then level off after 2070 but under the B1 scenario will not change
- under both scenarios the number of growing season degree days will steadily increase as the century progresses; under the A2 scenario, growing degree days in the eastern part of the ecodistrict will increase 35 days by 2100

5.2 Vulnerability assessments

The vulnerability assessments suggest that climate change will significantly affect ecological and socio-economic conditions in the Clay Belt (Table 3). Some of the most noticeable effects will likely include changes in forest composition as the Clay Belt's climate becomes more favourable to Great Lakes-St. Lawrence tree species, and in the distribution and abundance of fish and wildlife species. Other, more subtle changes to the physical and biological characteristics of the Clay Belt's ecosystems include effects on soil moisture, water quantity, nutrient cycling, and paludification.

5.3 Risk assessments

Most of the vulnerability assessment indicators suggest that the risk of climate effects on ecological and socio-economic conditions will be low-moderate to moderate by mid-century (Figure 8). However, the risk of negative effects of climate change on aquatic habitat (e.g., coldwater fish species may be extirpated from some streams), hydrological function (earlier spring streamflow peak), and woodland caribou populations (decline) will be moderate-high. If climate change continues at the current rate and magnitude, more significant effects to all of the natural resources evaluated are likely during the post-2050 period.

While the known and potential negative effects of climate change far outweigh those that are neutral or positive, some positive effects were identified during the risk assessment process. Given the importance of some of these on the socio-economic conditions of communities, there is merit in exploring opportunities (ICLEI 2010) that may result from:

- Increased forest productivity and composition: Growth of boreal tree species in the Clay Belt may improve over the next 30 to 60 years as the climate becomes warmer and wetter, with some species being favoured more than others.
- Decreased paludification: The effect of climate change on fire severity and paludification may result in less paludified and therefore more productive forests.
- Increased greenhouse gas sequestration in peatlands: Methane emissions may be reduced and carbon dioxide sequestration increased because of increased tree and shrub productivity.
- Increased fishing opportunities: Increased walleye productivity will enhance revenues at remote tourism establishments.
- More summer recreation opportunities: A longer summer season will increase opportunities for activities such as boating and golfing.
- Increased agricultural potential: A longer growing season will improve conditions for agricultural crops and products.

Table 3. *Potential effects of climate change in Ontario's Clay Belt ecodistrict (3E-1) by topical area.*

Designation	Theme/effect
Forest productivity and composition	
1A	Future climate may favour Great Lakes-St. Lawrence forest tree species.
1B	Growth of boreal tree species may improve over the next 30 to 60 years as the climate becomes warmer and wetter, with some species being favoured more than others.
Forest fire	
2A	Overall the total number of fires (includes human- and lightning-caused fires) is expected to decrease slightly.
2B	The decline in Phase 3+ days in the late summer period may reflect a decrease in the overall fire hazard in northeastern Ontario.
2C	Fire season length is projected to increase by about 11 days by 2041.
Windthrow	
3A	Potential for increased incidence of severe windthrow of trees.
3B	Likelihood of increased incidence of wind damage to infrastructure (e.g., buildings).
Ungulates	
4A	Moose are not expected to be highly vulnerable to climate change in the Clay Belt.
4B	Under a B1 scenario, moose density is expected to increase initially and then stabilize.
4C	Increases in moose and associated wolf densities in northern ecosystems could increase risks to caribou populations.
Furbearers	
5A	Potential for introduction of southern competitors and pathogens.
5B	Increased risk of extirpation of cold-adapted species.
5C	Increased selection for early onset of breeding.
5D	Enhanced asynchrony in ecological systems.
Waterfowl	
6A	Given their sensitivity to wetland availability, spring snow cover, and loss of forest habitat, climate change is expected to affect waterfowl populations
Paludification	
7A	Interaction between the effect of climate change on fire severity and paludification may result in less paludified forests.
7B	Less paludified forests could mean increased productivity (although also higher fire risk).
7C	Species that depend on open paludified habitat (e.g., woodland caribou) could be negatively affected.
Peatlands	
8A	No overall change in peatland area is expected, but area of bogs is expected to increase while that of fens is expected to decrease.
8B	Enhanced shrub and tree establishment and growth.
8C	Reduced methane emissions.
8D	Enhanced carbon dioxide sequestration because of higher tree/shrub growth.
Hydrology	
9A	Soils in the western portion of the ecodistrict will be increasingly drier in summer.
9B	Earlier spring stream-flow peak.
9C	Later fall stream-flow peak.
Aquatic habitat	
10A	Wetlands may be lost or decrease in quality due to drying.
10B	Coldwater fish species may be extirpated from some streams.
10C	Smallmouth bass distribution may increase in lakes throughout the Clay Belt.
10D	Walleye productivity may increase in some lakes and decrease in others.
Socio-economics	
11A	Increased walleye productivity will increase revenues at remote tourism establishments.
11B	Smallmouth bass introductions will reduce revenues at remote tourism establishments.
11C	The length of the snowmobiling season may decrease.
11D	The length of the ice fishing season may decrease.

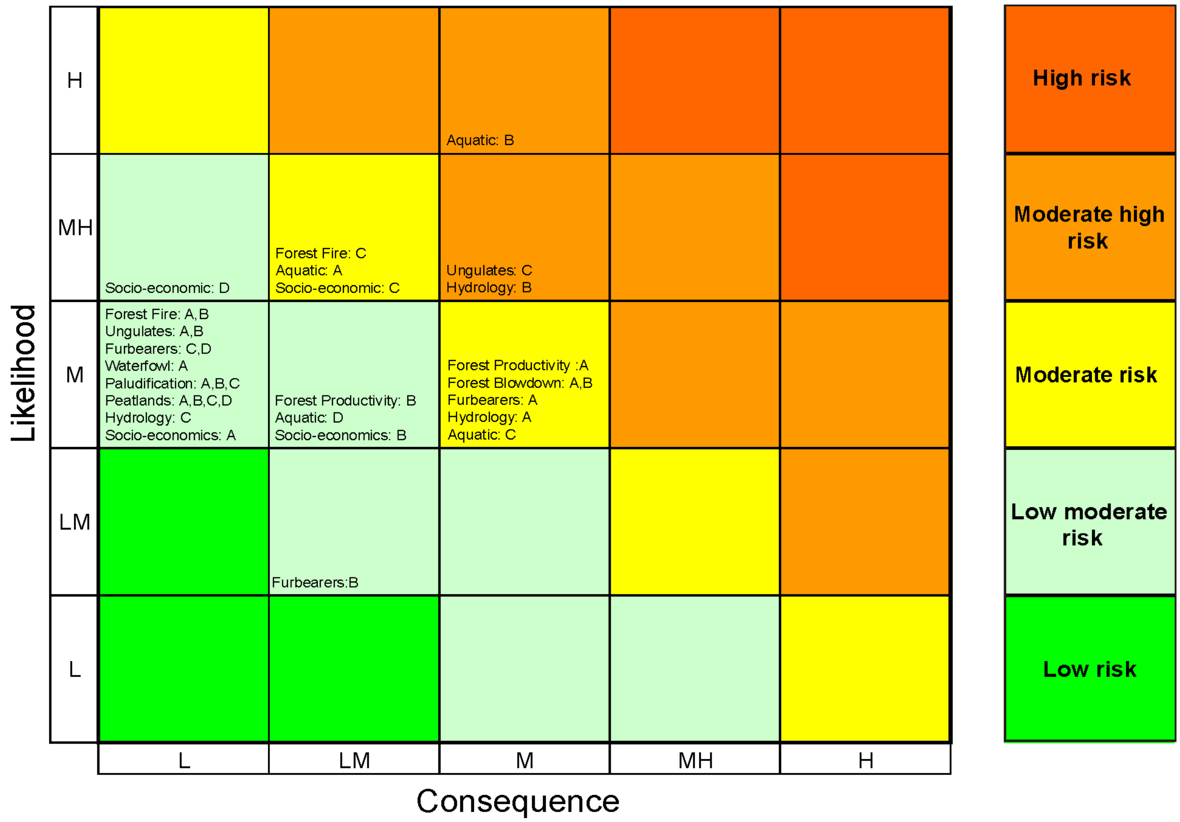


Figure 8: *A mid-century (2050s) risk evaluation matrix developed for the Clay Belt ecodistrict (3E-1) vulnerability assessment pilot study (modified from Bruce et al. 2006). Refer to Table 3 for descriptions of effects by topic area and letter designation.*

5.4 Adaptation options

More than 60 adaptation options were identified by workshop participants and were integrated into the adaptation portfolio (Appendix IV). Some key characteristics of an adaptive approach to managing for climate change (Table 4) include:

- Everything has a spatial and temporal context and it is important to design mapping tools that allow practitioners to work with a variety of ecological, thematic (e.g., parks), and administrative themes at various scales and time periods.
- No one organization has the capacity to do it alone – partnerships are critical to the success of an adaptive approach to management.
- Practitioners can learn from decisions and actions to increase opportunities for adaptation.
- Many existing programs can help practitioners manage for climate change.
- Practitioners can understand how ecological and socio-economic systems are changing (e.g., monitoring) and use that knowledge to design a way forward.
- An adaptive approach requires nimble on-the-ground decisionmaking with the proper tools and techniques.
- People with the appropriate expertise and experience are a key asset in managing for climate change.

Table 4: The top 10 adaptation options for each of the six themes used to assess vulnerability in the Clay Belt ecodistrict (3E-1).

Overall	
1	Identify which indicator species to monitor for response (e.g., abundance, distribution, and health) to climate change over time.
2	Evaluate effectiveness of existing monitoring network for tracking the effects of climate change on natural resources and ecosystems and address gaps in the monitoring network.
3	Integrate principles of adaptive management and an ecosystem-based approach into all resource management plans (e.g., forest management plans and fisheries management plans).
4	Incorporate use of climate change scenarios and vulnerability assessments into planning initiatives (e.g., forest management plans, wildlife management plans, and municipal plans).
5	Communicate trends in species distribution and abundance and other ecosystem changes relative to historic data.
6	Develop dynamic landscape conservation plans that identify a desired future condition based on projected shifts in the distribution of species and ecosystem components driven by climate change.
7	Support and develop “citizen science” projects that allow the public to get involved in monitoring climate change effects (e.g., species arrival dates, insect emergence, frog calling, leaf out, and flowering dates).
8	Identify a suite of existing sites for refugia (e.g., reserve areas that may be buffered or otherwise protected from climate change effects) that can be maintained to protect existing populations of sensitive and at-risk species or communities.
9	Establish and expand protected areas, reserves, and other natural heritage areas to link habitats and serve as refugia (see #8) for threatened native species.
10	Consider revisiting the mandate of protected areas, which is currently focused on protecting current ecological communities versus facilitating ecological transformation.
Forests	
1	When setting forest management goals and objectives, promote diversity in age classes, species, and ecosystem structure.
2	Educate forest management planning teams about climate change science and adaptation tools and techniques they can use in planning.
3	Increase support for forest inventory and monitoring including growth and yield, insects, disease, and silvicultural effectiveness.
4	Retain biological legacies (e.g., seed and seed sources) by retaining individual trees of a variety of species.
5	Educate forest managers on climate-appropriate silvicultural tools and techniques including information and examples in Ontario’s silvicultural guides.
6	Use ‘fire-smart’ management in high value forested areas.
7	Enhance early detection methods and rapid response of new forest pest infestations.
8	Develop a more flexible seed zone policy that permits the use of seeds from a greater geographic range and supports the modification of zones in response to climate change.
9	Ensure flexibility for maximum harvest season to capitalize on the core winter season and to prevent soil erosion and compaction.
10	Examine the adaptive capacity and genetic variation within tree species to determine which populations will grow best in a future climate and how far practitioners can move seed.
Wildlife	
1	Understand the effects of climate change on 1) ecosystems (e.g., food webs), 2) wildlife species and their habitats, and 3) invasive species.
2	Understand species biology, particularly traits such as vagility (how a species can move or spread), genetic variability and biotic interactions.
3	Improve monitoring to detect, prevent, and respond to new pests and wildlife diseases.
4	Identify wildlife indicator species that can be used to monitor responses (e.g., abundance, distribution, and health) to climate change over time.
5	Expect the spread of deer ticks into northern habitats and prepare adequate education programs for visitors and Ontarians who work outdoors.
6	Reduce habitat fragmentation by protecting, enhancing, and rehabilitating greenways and blueways.

cont.

Table 4. Cont.

7	Manage furbearer populations (including beavers) to maintain their positive effect on wetlands and other habitats.
8	Re-assess definitions, policies, and management of invasive species in a changing climate.
9	Enhance connectivity and wildlife corridors through landscape-scale planning and partnerships and collaboration among organizations, (see also #6).
10	Ensure that hunting schedules correlate with shifts in seasonal breeding times.
Aquatic assets	
1	Develop protection measures for groundwater areas and eskers within the Clay Belt.
2	Conduct research on how climate affects aquatic ecosystem productivity, including fish community dynamics.
3	Monitor the range expansion of aquatic invasive species.
4	Incorporate integrated watershed planning (i.e., managing human activities and natural resources on a watershed basis) into water and aquatic resource management practices.
5	Reduce habitat fragmentation by protecting, enhancing, and rehabilitating critical habitat (e.g. access to coldwater refuges, spawning, and nursery areas).
6	Restrict development in floodplains.
7	Develop a protection strategy for wetlands within the southern portion of the Clay Belt.
8	Install and support more stream gauges.
9	Develop an accurate inventory of current wetland features on the landscape and monitor over time.
10	Revise the Water Management Planning Guidelines for Waterpower to incorporate anticipated changes in water levels and aquatic habitat.
Peatlands and paludification	
1	Identify the type of paludified forest to help with landscape characterization in forest management planning.
2	Integrate paludification issues into existing silvicultural guides and other best practices.
3	Educate practitioners and forest managers on the function and role of peatlands in the global carbon cycle.
4	Understand mercury production and its effects on water quality through cumulative effects assessment.
5	Increase monitoring to help understand fire behaviour.
6	Monitor the rate of change of peatland succession.
7	Educate practitioners and forest managers on paludification processes and effects on forest productivity.
8	Understand the evolving role of hydrology in paludified forests in the context of climate change.
9	Include paludified sites in fire suppression strategies.
10	Explore alternative values to peat extraction (e.g., pharmaceuticals, cranberry production, and cosmetics).
Socio-economics	
1	Develop emergency preparedness strategies that help communities prepare for increased flooding, drought, and other extreme weather events.
2	Diversify local forest-based economies (e.g., value added products, non-timber forest products, tourism, and agriculture).
3	Understand environmental goods and services provided by healthy ecosystems.
4	Improve flood forecasting.
5	Apply socio-economic models to quantify the social and economic effects of key vulnerabilities and risks in the area.
6	Explore opportunities for forest exports in niche markets (e.g., certified wood products).
7	Attract new visitors to Ontario by developing marketing strategies that target winter sports participants in locations (e.g., Michigan and Vermont) that already have shorter seasons.
8	Extend the summer operating period and camping seasons in parks.
9	Research recreational activity substitution to help offset revenue losses within parks and tourism operations.
10	Enhance support for communities in source water protection planning and training.

6.0 Discussion

6.1 Implications for Clay Belt ecosystems

Climate is a primary driving force that shapes the ecosphere—temperature, precipitation, and wind combine to affect ecosystem composition, structure, and function. Known and potential effects of climate change on natural assets in the Clay Belt include, but are not limited to:

- Shifts in forest composition: Shifts in forest composition are likely to accelerate in the coming decades, resulting from the decline or extirpation of current species that are not suited for the new climates. New conditions may be suitable for a variety of other species, particularly those that have traditionally inhabited the Great Lakes-St. Lawrence forest ecosystems, though clay soils may be a limiting factor. Although annual precipitation in the Clay Belt is projected to increase, seasonal shifts and increased evapotranspiration will potentially increase moisture stress on many sites, which will offset productivity gains, particularly on xeric sites and in lowland areas relying on saturated organic soils (Parker et al. in prep.; McLaughlin and Webster in prep.).
- Increased risk of wildfire: Longer, drier summers may increase the risk of wildfire, which could further alter soil conditions with the combustion of dry peat layers (MacRitchie and Turnbull in prep.; McLaughlin and Webster in prep.).
- Longer fire season: Projections suggest that the fire season could begin 13 days earlier by 2041-2070 and 24 days earlier by 2071-2100 (Brown and McAlpine in prep.).
- Slower paludification: The combined effects of climate change and wildfire will slow the rate of paludification in the Clay Belt potentially increasing forest productivity (Lafleur et al. in prep.).
- Increased risk of windthrow: Projected increases in windthrow (Waller et al. in prep.) caused by more severe weather events will have socio-economic ramifications.
- Increased susceptibility of caribou populations: As wolf populations increase in response to increasing moose populations, woodland caribou populations will be increasingly more susceptible to predation (Rempel 2012).
- Increased susceptibility of cold-adapted species: As temperatures rise, cold-adapted species may be affected by changes in breeding cycles, loss of synchrony between species (e.g., lynx and snowshoe hare), and potential increases in pathogens (Bowman and Sadowski 2012).
- Loss of wetlands: Any loss of wetland area in the Clay Belt will affect invertebrate, amphibian, and fish populations (Chu and Fischer in prep.) and water storage capacity (MacRitchie and Turnbull in prep.).
- Increased risk of invasive species: As waters get warmer, habitat is projected to become less suitable for coldwater species such as brook trout and more suitable for warmwater invasive species such as smallmouth bass (*Micropterus dolomieu)* (Chu and Fischer in prep.).
- Loss of aquatic habitat: Decreased duration of ice cover, later freeze-up, and earlier thaw may alter aquatic community dynamics and affect spawning period and habitat availability (Chu and Fischer in prep.; Minns et al. 2012).

6.2 Implications for biodiversity in Clay Belt ecosystems

Principal questions about biodiversity in the Clay Belt are whether it will increase in response to a warmer climate and what the new configuration of species will look like. In response to emerging habitat conditions, new or more abundant competitors and predators, and more suitable conditions for invasive species, some species will thrive and others will disappear. For example, as temperatures warm, some species historically limited to more southerly habitats will successfully test the habitability of evolving northern ecosystems.

Given that species richness is related to temperature (e.g., Kerr and Packer 1998), it is possible that Ontario's biodiversity will increase. Ecosystems are complex entities, however, comprising many forces and factors working simultaneously at a variety of spatial and temporal scales to affect the distribution and abundance of plants, animals, and other organisms. In addition to changing climatic conditions such as temperature, Varrin et al. (2009) suggested that several complex forces and factors merit consideration:

- Asymmetry: Occurs when responses to the effects are not proportional across species or populations. For example, some species have the capacity to keep up with the rapid northward movement of their climate envelope while others do not. Accordingly, climate change will select for species that can rapidly spread, such as invasives, and not others (Weber 1998).
- Asynchrony: Asynchrony occurs when species that have historically survived together (i.e., some form of dependence relationship exists) fall out of sync. For example, some bird species synchronize egg laying dates with the peak abundance of nestling food such as caterpillars (Visser and Both 2005). Warmer temperatures will change the phenology of caterpillar emergence, which in turn will affect the availability of food for nestlings.
- Synergy: Synergy is the interaction of two or more processes such that the total effect is greater than each process acting independently. Climate change combines with other forces to cause synergistic effects. For example, in highly fragmented landscapes, species may be prevented from moving in response to a shifting climate envelope. Synergies can also occur between climate and disease. For example, the Isle Royale gray wolf population crashed following an outbreak of parvovirus resulting in a trophic cascade that affected moose populations and their primary food source: balsam fir. Moose switched from being regulated by wolves to being regulated by food and climate (Wilmers et al. 2006).
- Thresholds: A threshold is a point at which an organism can no longer exist in a habitat. For example, a threshold response to climate change can result when temperatures exceed the physiological capacity of an organism to survive.

Given the complexity of these and other forces and factors affecting ecosystem function, the future of species richness in Ontario is unclear. For this and other reasons, it is important to note that monitoring programs are a critical part of any decision to detect and evaluate change to ecosystem composition, structure, and function.

6.3 Implications for socio-economic conditions in the Clay Belt

People benefit from natural resources, including access to clean air, water, and soil, the provision of food, medicines, building materials and other products, access to recreational opportunities, and attainment of psychological well-being (Browne and Hunt 2007). Climate change has the potential to significantly affect many of these benefits. For example, under the A2 scenario, the ice fishing season is projected to decline 15% from an average length of 171 days to 146 days by 2100 with associated economic effects. In addition, industrial sectors that rely on winter roads will be negatively affected as the winter/ice road season gets shorter (Hunt and Kolman in prep.). On the other hand, even though the snowmobile season will be shorter, it will likely remain viable in Ecodistrict 3E-1 for the rest of the century. In fact, the Clay Belt ecodistrict potentially is the most resilient part of the current Ontario Federation of Snowmobile Clubs snowmobiling network (Gilmour 2010, Hunt and Kolman in prep).

6.4 Implications for decisionmakers and practitioners

While some of the effects of climate change will be positive, it is anticipated that most will be negative. Accordingly, the most adaptive agencies and organizations will make an effort to mitigate the negative effects by reducing or eliminating vulnerability where possible and embracing opportunities presented by positive effects. Decisionmakers and practitioners have many tools and techniques at their disposal to proactively manage for climate change and to strategically plan for the future. An important initial step is to determine the organizational readiness of the community, agency, or organization to respond to climate change by identifying strengths and capabilities and weaknesses and gaps. Capacity to respond to climate change is determined by a unique combination of institutional (government and industry) structure and function, financial resources, acquisition and use of information, know-how, and a commitment to adaptive decisionmaking. Gray (in prep.) proposes that an organization or community can assess its readiness to adapt by determining how it is positioned to deliver integrated place- and time-based perspectives and employ community-empowered, knowledge-driven programs.

7.0 Recommendations

7.1 What's next?

During the next phase the study team will work with MNR staff and external stakeholders and partners to explore priority setting for and implementation of adaptation options. It is recommended that the adaptation options developed during this pilot study (e.g., Table 4) serve as basis for these discussions.

7.2 Issues and additional research needs identified by the assessment team

Assessment team experts identified several issues and research needs related to the themes included in this vulnerability assessment. Their recommendations were as follows:

Forest productivity and composition:

- If assisted migration is selected as a management tool, decisions about forest species composition require application of species' population management techniques that consider the range of potential future climates. Use genetic climatic niche modelling to inform decisions about assisted migration.
- Use the U.S. Forest Service Forest Inventory and Analysis approach to complete a census of forest tree and other plant species (i.e., collect information on species rarity and age distribution) in support of vulnerability assessments.

Forest fire:

- Encourage communities to promote the FireSmart Program to help people protect their property, reduce property damage, and increase resilience to wildfire and other natural disasters.
- Evaluate the use of prescribed burning to maintain the important role of fire on the landscape in a more controlled fashion to reduce the risk of wildfire.

Forest windthrow:

- Increase the number of climate stations in northern Ontario that monitor wind.
- Ensure that monitoring programs are designed to measure wind gust values to assist analyses of windthrow.
- Provide continuous wind data recording.
- Improve recording of the exact date and time of wind effects and windthrow events, particularly during the warm season.
- Sponsor research to explore the dynamics of windthrow events and the vulnerability of Ontario tree species.
- Sponsor research to explore how extreme wind frequency patterns may change in response to various global climate model scenarios.

Ungulates:

- Establish permanent moose aerial inventory (MAI) plots; three each on the northern (Wildlife Management Unit [WMU] 24) and southern edges (WMU 30) of the Clay Belt.
- Within each permanent plot monitor:
    - moose, wolf, and deer density; cow:calf ratio; twinning rate (annually)
    - brainworm and liver fluke in deer and moose
    - temperature and precipitation by quarter

  - occurrence of freezing rain and extreme summer heat events
  - start of growing season
  - change in the distribution of mixedwood and pure conifer forest
  - winter tick density and moose coat condition
  - snow depth and crusting
- Sponsor model-based research that focuses on the effect of climate and associated biotic factors (e.g., brainworm and ticks) on demographic parameters such as recruitment (number of calves per hundred cows) and twinning rate.
- Sponsor research and monitoring to understand the relative influence of climate-driven habitat change (e.g., proportion of mixedwood and young forest) on moose recruitment and population growth.
- Sponsor research and monitoring to determine if climate change will result in increased moose and deer populations north of the "Area of the Undertaking", and if wolf populations will also increase.

Furbearers:

- Consider the four processes leading to vulnerability of furbearers as hypotheses (i.e., introduction of southern competitors and pathogens, increased risk of loss of cold-adapted species, selection for early breeding, and enhanced asynchrony in ecological systems) and use an adaptive management framework to measure projected changes in indicators associated with these four processes.
- Test the hypothesis that species with higher genetic variability for fitness traits will be selected for by rapid climate change. Identifying genetic variability of fitness traits for furbearers should be a research priority.
- Develop methods to model snow depth. Climate change scenario models that include snow depth as a model output should be a research priority.

Waterfowl:

- Sponsor research designed to explore the effects of climate change across the entire breeding range of waterfowl species.
- Increase collaboration among provincial and federal agencies and investment in citizen science monitoring programs.

Paludification:

- Construct a better mechanistic model for paludification with a more complete fire sub-model.
- Improve paludification models to allow for sensitivity analyses.

Peatlands:

- Reduce 'net ecosystem exchange' measurement uncertainties for future peatland carbon assessments. This could be accomplished through remote sensing methods that measure leaf area index, peat temperature, and moisture (or water table levels) that are calibrated at field research sites.

Hydrology:

- Use higher resolution hydrological models in association with regional climate models to provide additional insight into the effects of climate change on hydrological regimes.
- Improve weather data coverage by installing additional automated weather stations.
- In locations where weather data collection only occurs during operational hours, install automated stations to improve the accuracy of forecasts and to inform climate change research.
- Sponsor the collection of broad-scale data monitoring programs to detect change (e.g., wetland extent and condition) in all wetland types (e.g., bogs, fens, swamps, and marshes) throughout the Clay Belt.

- Monitor wetland species (e.g., waterfowl and amphibians) to determine the effect of changes in wetland extent on their distribution and abundance.

Streams:

- Expand the network of HYDAT (Water Survey of Canada) stations in the Clay Belt to ensure that accurate baseline flows, temperatures, and water levels of streams are monitored.
- Use data from hydropower environmental assessment reports in the design of a stream monitoring network for the Clay Belt.

Aquatic species:

- Thirty-two of the 90 quaternary watersheds in the Clay Belt have no readily available stream fish data. Establish a water quality monitoring network that includes a fish and benthic invertebrate inventory for Clay Belt streams.
- Sponsor aquatic invasive species research.

Lakes:

- Continue to support and where possible expand the broad-scale monitoring program (e.g., water quality, zooplankton, and fish distribution and abundance) to detect changes in the condition of Clay Belt lakes.

Socio-economics:

- Sponsor long-term monitoring programs to detect and examine the effects of climate change on tourism and other industries.

7.3 Guidance for future climate change adaptation strategies that involve vulnerability assessments

During development of the charter and methods for this pilot study, the study team used the 'learnings' from the Lake Simcoe Vulnerability Assessment reported by Douglas et al. (in prep.). In continuing this tradition, the following suggestions are provided to help practitioners design successful vulnerability assessment approaches:

Leadership: Given the complexity of the study, the following leadership qualities were important to its success:

- a committed and well-coordinated study team that met regularly and actively managed the process
- scientific experts with the knowledge and expertise to complete vulnerability assessments
- support by senior managers

Partnership: Early engagement of partners and stakeholders was important to the success of the study. The study team identified potential partners and stakeholders early on in the process with the goal of enabling collaborators to actively participate in the study.

Communication: Clear and regular communication with partners and stakeholders was critical. The variety of communication and messaging techniques used during this study contributed to the development and maintenance of strong relationships throughout the process.

Expertise: Ensure those with the appropriate expertise and experience participate in the study.

Team structure: Given the interconnectedness of ecosystem structure and function, experts should be provided a forum to interact and share methodologies and results.

Themes: Ecological and socio-economic themes should be relevant and important to the adaptive management process. In a perfect world, vulnerability assessments would be completed for all relevant themes and used to inform adaptive management. Unfortunately, it is not always possible to conscript work on all preferred themes. In the case of the Clay Belt study, for example, agricultural potential was not explored.

Data availability: It is important to ensure baseline data are available to help identify and describe current vulnerabilities. The lack of weather stations and dearth of continuous ecological monitoring programs within the Clay Belt increased the uncertainty associated with the vulnerability assessments.

Climate models*:* Use climate model scenarios that generate a range of potential future climatic conditions and use at least one ensemble model.

Optimize participation: Participatory approaches to developing adaptation options are encouraged. With this in mind, the study team explored possible tools to use for generating ideas to identify and prioritize adaptation options. Such tools need to be selected to match the scope of the study and the target audience. Also consider financial restraints, travel restrictions, and other logistical issues when creating tools that require people's input.

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Appendix I
Communciation Fact Sheet

Ministry of Natural Resources

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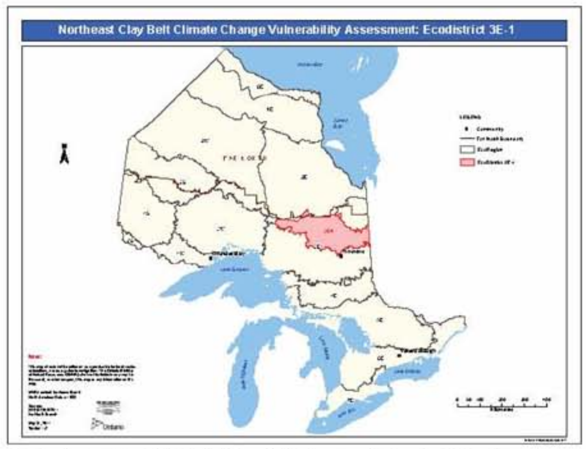
Climate Change Vulnerability Assessment and Adaptation Options for the Northeast Clay Belt

Ontario's climate is warming and becoming increasingly variable. Over the next century temperature, precipitation and wind patterns will continue to change, posing a number of challenges to ecosytems, biodiversity conservation, and natural resource management. Ministry of Environment's Climate Ready: Ontario's Adaptation Strategy and Action Plan as well as the Ministry of Natural Resources' (MNR) Sustainability in a Changing Climate strategy commit to completing vulnerability analyses to help develop and employ adaptive solutions to face these challenges.

Assessing potential climate change impacts in the Clay Belt

The vulnerability assessment is one component of this pilot project that will identify where and how ecosystems within the Clay Belt are vulnerable to climate change by examining multiple environmental themes. Themes will include several forest-related issues such as forest composition, forest growth and productivity, fire, and forest health. Other themes such as wildlife, hydrology, substrates, species-at-risk, aquatic habitat, and socio-economics will also be included.

With key vulnerabilities and risks identified, the project will then scope potential adaptation options that are available to cope with the impacts of climate change. Through a participatory process involving project partners, communities, and stakeholders, potential adaptation options will be prioritized considering economic feasibility, social acceptability, ecological suitability, and technical and institutional feasibility.



The study area - Ecodistrict 3E-1 (Clay Belt) - is approximately 4,128,732 ha and a prominent feature of Ontario's Northeast Region. It is situated on deep glaciolacustrine sediments and morainal clays and silts. Vegetation type within the ecodistrict is diverse with coniferous forests and bogs being most common.

MNR is responding to climate change through collaboration

Climate change is a complex issue that affects all sectors, agencies, and people. MNR places an emphasis on collaboration with partners, communities, and stakeholders to mainstream adaptation action into natural resource planning and decision-making. In this pilot project, MNR will seek to engage stakeholders and communities and build partnerships to integrate diverse expertise and perspectives in various components of the project.

Three project goals are:

- To help develop and test elements of vulnerability assessment and adaptation frameworks for Ontario;
- To identify vulnerabilities and adaptation options for the Clay Belt; and
- Identify ways to mainstream adaptation action into existing policies, programs, and decision-making processes.

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Appendix II
Workshop Agenda

Climate Change Vulnerability Assessment and Adaptation Options Workshop
January 25th & 26th, 2012
Cedar Meadows Resort, Timmins, Ontario

Day One: Vulnerability Assessment Results and Risk Assessments

Time	Workshop Details	Lead
7:45	**Breakfast (provided in conference room)**	
8:30	**Welcome & Opening Remarks** ▪ Climate change within MNR and the Northeast Region	**Mary Ellen Stoll**
8:45	**Meeting Purpose & Objectives** ▪ Meeting Structure & Logistics ▪ Key Objectives for the Day ▪ General Questions from Attendees ▪ Participant Introductions	**Karen Wianecki**
9:15	**Key-note Speaker**	**Paul Gray**
9:45	**Setting the Context: Overview of Clay Belt Project** ▪ Clay Belt Pilot Project Background o Environmental Themes o Climate Model Projections o Key Deliverables ▪ Workshop Structure o Vulnerability Assessment Results o Risk Assessment o Adaptation Options	**Rachelle Lalonde**
10:05	**Refreshment Break**	
10:15	**Assessment Team Reporting on Results** All Presentations Will Follow the Same Format: ▪ Assessment Team member presentation – 20 minutes ▪ Questions & Comments – 10 minutes ▪ Risk Assessment –15 minutes **Forest Composition & Productivity**	**Bill Parker**
11:00	**Forest Fire**	**Rob McAlpine**
11:45	**Lunch (provided in conference room)**	
1:15	**Forest Health** • Blow down (1:15 – 2:00)	**Simon Eng**
2:00	**Wildlife** • Ungulates (2:00 – 2:45)	**Rob Rempel**
2:45	**Refreshment Break**	
3:00	**Wildlife (continued)** • Furbearers (3:00 – 3:45) • Waterfowl (3:45 – 4:30)	**Jeff Bowman** **Ken Abraham**
4:30	**Hydrology**	**Scott MacRitchie**
5:15	**Overview of Day One**	**Karen Wianecki**
5:30	**Meeting Concludes Day One**	
6:00	**Dinner (provided in conference room)**	

Day Two: Vulnerability Assessment Results, Risk Assessments, and Adaptation Options

Time	Workshop Details	Lead
7:15	**Breakfast (provided in conference room)**	
8:00	**Welcome & Introduction** ▪ Recap from Day One Objectives for Day Two – Focusing on Adaptation Options	**Karen Wianecki**
8:15	**Paludification**	**Nicole Fenton**
9:00	**Aquatics**	**Cindy Chu**
9:45	**Socio-Economics**	**Len Hunt**
10:30	**Refreshment Break**	
10:45	**Peatlands**	**Jim McLaughlin**
11:30	**Community Engagement**	**Al Douglas**
12:00	**Lunch (provided in conference room)**	
12:45	**Developing Adaptation Options**	**Jenny Gleeson**
1:00	**Small Working Groups – Adaptation Options: Developing Collective Intelligence** ▪ Participants will be divided into one of five small working groups. Project and Assessment Team Leads will rotate through each of the five working groups to obtain input on adaptation options.	**All Participants**

SWG	1:15 - 1:35	1:40 - 2:00	2:05 – 2:25	2:30 – 2:50	2:55 – 3:15
1	Paludification & Peatlands	Forest	Socio-Economics	Wildlife	Aquatics
2	Aquatics	Paludification & Peatlands	Forest	Socio-Economics	Wildlife
3	Wildlife	Aquatics	Paludification & Peatlands	Forest	Socio-Economics
4	Socio-Economics	Wildlife	Aquatics	Paludification & Peatlands	Forest
5	Forest	Socio-Economics	Wildlife	Aquatics	Paludification & Peatlands

Time	Workshop Details	Lead
3:15	**Adaptation Options Report Back**	**Project Team**
4:00	**Homework Assignment – Adaptation Options: Survey**	**Jenny Gleeson**
4:15	**Recap, Wrap Up & Where To From Here – Next Steps**	**Karen Wianecki**
4:30	**Meeting Concludes…Safe Journey Home**	

Appendix III
Risk Assessment Form

Environmental Theme	Impact	Consequence (Low, Moderate, High)			Likelihood (Low, Moderate, High)	RISK RANKING
		Social Factors (Health & Safety, Livelihood, Cultural)	Economic Factors (Property Damage, Financial Impact)	Environmental Factors (Air, Water, Land, Ecosystems)		

Appendix IV
Adaptations Options Portfolio

Northern Ontario Clay Belt Climate Change Adaptation Options Portfolio

There is a wealth of information on the adaptation of ecosystems, natural resources and human activities to climate change. Some information in the literature is very broad and can be characterized as general principles (i.e., the need to protect and enhance genetic diversity of species).

While broad principles for adaptation are important, they may not be directly applicable at the scales most relevant to natural resource managers and/or communities. For these situations (or scales), there are also many options that are 'actionable' and operational in focus which may be more relevant. This synthesis of adaptation options serves as a portfolio from which practitioners can select or combine appropriate elements to fit the local situation. Integrating local vulnerabilities with a portfolio of adaptation options can help practitioners prioritize the most realistic adaptation actions for their needs.

The Northern Ontario Clay Belt Adaptation Options Portfolio focuses on measures that may be able to reduce or eliminate the climate change vulnerabilities and risks that have been identified in the Clay Belt region. The options in the Portfolio were synthesized from a large number of climate change papers in the scientific literature, MNR climate change research reports (refer to reference list) and other measures identified by participants at a Clay Belt climate change workshop.

Although it is possible to make generic recommendations about the best options to take, effort has been made to tailor the Portfolio to ecosystems of the Clay Belt region. Given the size of the Clay Belt region, (4,128,732 ha) and inherent diversity, not all approaches can or should be used in every location or situation.

Depending on the degree of vulnerability and risk posed by climate change, and the adaptive capacity of the area, the choice of adaptation options to implement will vary based on criteria such as environmental conditions, economic feasibility, social acceptability and which are deemed priority actions.
With a wide range of potential adaptation options, some options may be mutually exclusive or generally counteract each other. The input from diverse groups can be a useful tool to help resolve these issues.

The adaptation options presented in the Portfolio are grouped into five broad themes that are the focus of the Clay Belt project:

- forests,
- wildlife,
- aquatics (including hydrology),
- socio-economics, and
- cross-cutting measures that are relevant to multiple themes.

Within each theme, adaptation options have been categorized and colour-coded into four types of activity:

- policy,
- resource management,
- monitoring and science, and
- education and public engagement.

CROSS-CUTTING

Employ assisted migration techniques (e.g. planting seedlings from more southerly seed sources) to maintain vulnerable native species and introduce other future climate-suitable species
Integrate principles of adaptive management and an ecosystem-based approach into all resource management plans (e.g. forest management plans, fisheries management plans)
Consider mandate of protected areas which focuses on protecting current ecological communities versus facilitating ecological transformation
Regularly review Ontario's ecosystem framework (e.g. Ecoregions, Ecodistricts) for suitability in climate change context
Develop dynamic landscape conservation plans that identify a desired future condition based on projected shifts in distribution of species and ecosystem components driven by climate change
Develop biodiversity regulatory tools and legislation (e.g. Sustainability Act)
Enact measures to maintain natural diversity and ecosystem function to increase changes of species adapting
Establish and expand protected areas, reserves and natural heritage areas to link habitats and as refugia to protect threatened native species
Identify a suite of existing sites for refugia (e.g. reserve areas that are likely to be buffered or otherwise protected from climate change impacts) to protect existing populations of sensitive and at-risk species or communities on those sites
Identify indicator species to monitor response (e.g. abundance, distribution, health) to climate change impacts over time
Use climate change scenarios and vulnerability assessments and incorporate into planning initiatives including forest management plans, wild-life management plans, and municipal planning
Support and develop citizen science projects that allow the public to get involved in monitoring for climate change (e.g. species arrival dates, insect emergence, frog calling, leaf out, flowering).
Evaluate current monitoring network for tracking the impacts of climate change on natural resources and ecosystems and address identified gaps in monitoring
Communicate trends and changes in species distribution and abundance and ecosystem changes relative to historic data

LEGEND:
- policy
- resource management
- monitoring and science
- education and public engagement

2

FORESTS

Silviculture

- Adjust seed zone policy to be more flexible to use seeds from across a greater geographic range and to evolve zoning over time as climate changes
- Favour drought and heat-tolerant tree species and populations (e.g. retain vigorous survivors of a drought induced die-back event)
- Develop a forest gene management program to maintain diverse gene pools
- Retain biological legacies (e.g. seed and seed sources) by retaining individual trees of a variety of species
- Increase diversity of tree nursery stock
- Replant, particularly after disturbance, to assist slow natural regeneration
- Use genetically improved planting stock with higher growth rates, insect and disease resistance, and photosynthetic sensitivity to high CO_2
- Apply silvicultural techniques that maintain a diversity of age stands and mixes of species
- Increase use of shelterwood silviculture to protect young conifers from frost
- Use silvicultural practices such as thinning and managing at reduced stocking densities to increase water availability, improve stand vigour and reduce disease and fire hazard
- Manage herbivory (e.g. deer grazing) to promote regeneration by using fences and other barriers
- Use prescribed burning or other ground cover management to reduce risk of catastrophic fire
- Plant fire-resistant species such as hardwoods between more flammable conifers
- Examine the adaptive capacity and genetic variation within tree species to determine which populations will grow best in a future climate and how far we are able to move seed
- Study influence of climatic variability on tree species (e.g. frost damage risk and cold hardiness of boreal conifer species)
- Educate forest managers on climate-appropriate silvicultural tools and techniques including information and examples in Ontario's silvicultural guides

Forest Health

- Develop guidelines to prevent spread of invasives by forestry equipment during site preparation and harvesting
- Leave coarse woody debris to maintain moisture conditions, soil quality and nutrient cycling
- Leave snags standing as a natural source of nesting habitat
- Reduce the density of pest and pathogen 'host' tree species
- Use a diverse mix of native tree species in reforestation to reduces the risk of loss to insects and diseases
- Maintain appropriate rotation lengths to decrease the period of time that an older stand is vulnerable to insect pests and pathogens
- Address safety issues with wind damage in Provincial Parks
- Enhance early detection methods and rapid response of new forest pest infestations
- Develop spatial models of potential forest insect distribution (e.g. spruce budworm-balsam fir complex) and incorporate into planning
- Carry out a public awareness campaign with landscapers, garden centers, and the public to reduce the use of invasive species for horticultural purposes

LEGEND:
- policy
- resource management
- monitoring and science
- education and public engagement

3

FORESTS (cont'd)

Forest Management Planning

- When setting direction in Forest Management Planning, establish objectives for the future forest under climate change such as 100-year modelled projections and simulated range of natural variation in a changing climate
- Develop economic or social incentives for forest managers to integrate climate change adaptation into management
- Increase post-harvest patch size requirements to minimize forest fragmentation
- In Forest Management Planning, plan at the landscapes scale to minimize potential spread of insects and diseases
- Develop best practice guide for climate resilience as part of silviculture guides
- Provide incentives to landowners to plant trees to enhance connectivity
- Use forest growth and yield curve and site index curve information that incorporates climate change in Forest Management Planning
- Ensure flexibility for maximum harvest season to capitalize on the core winter season and to prevent soil erosion and compaction
- Construct more all-weather access roads
- When setting goals and objectives in Forest Management Planning, promote diverse age classes and species and structural diversity through fire and other management techniques
- Enhance connectivity through landscape-scale forest management planning and partnerships and collaboration among organizations
- Maintain and create habitat corridors through reforestation or restoration
- Minimize road networks, including the decommission and rehabilitation of existing roads, to sustain ecological functions such as soil nutrient cycling and to minimize sediment runoff from increased precipitation and permafrost melting.
- Consider harvesting forests that are most vulnerable to disturbance or general decline before they reach their otherwise optimal rotation age
- In Forest Management Planning, identify locations where a given forest type would be unlikely to successfully re-establish and develop a plan for replacement.
- Use of 'fire-smart' management in high value forested areas
- Establish fuelbreaks to slow spread of large fires
- Maintain buffer areas in clearcut to help protect trees in adjacent stands that would have not been previously exposed to wind.
- Increase salvage harvest of insect-disturbed stands to reduce fire risk
- Emphasize forest inventory and monitoring including growth & yield, insects, disease, silvicultural effectiveness
- Explore the role of elevated carbon dioxide on tree growth rates
- Educate Forest Management Planning Teams on climate change science and adaptation tools and techniques they can use in planning

LEGEND:
- policy
- resource management
- monitoring and science
- education and public engagement

4

AQUATICS

Fisheries Management

- Adjust provincial fishing regulations (e.g. timing and length of fishing seasons, species type, etc.) to reflect changing conditions
- Develop policy to limit smallmouth bass introductions to the Clay Belt
- For the sport fishery, promote the use of underutilized species where appropriate particularly species with populations that are increasing in response to climate change.
- With existing legislation and policies such as the Fisheries Act , protect and rehabilitate habitats for exploited species that are vulnerable to climate change
- Revise provincial fish stocking guidelines to incorporate climate change effects
- Strengthen aquaculture regulations to prevent the introduction on new invasive species
- For cold water species, protect thermal habitats and manage the fishery with appropriate catch limits, slot size limits, season length, sanctuaries, and other protected areas.
- Develop strategic fish stocking plans to reduce angling pressure on vulnerable fish populations
- Evaluate the feasibility of stocking 'at risk' fish species and the need for developing hatchery brood stock
- Work with First Nations and tourist operators to monitor changes to fishing levels and species
- Examine genetic variation within fish species and determine which populations will thrive in a future climate and how far we should consider moving fish species
- Explore opportunities for aquaculture development
- Monitor angler satisfaction and expectations
- Increase public awareness of the effects of climate change on fish populations, yields and angling opportunities (e.g. at fishing tournaments)

Aquatic Habitat

- Adjust MNR and DFO compliance protocols (e.g. Fish Habitat Protocol, Harmful Alteration, Disruption and Destruction-HADD rules) to reflect changes to fish habitat protection due to climate change
- Revise best management practices for sectors that impact aquatic ecosystems (e.g. agricultural runoff) to reflect effects of climate change
- Increase connectivity by removing dams where possible, installing fish ladders and other techniques to restore connectivity in freshwater systems
- Reduce habitat fragmentation by protecting, enhancing, and rehabilitating migration routes of critical habitat (e.g. access to coldwater refuges, spawning and nursery areas)
- In forested areas, promote conifer species to maintain cooler stream temperatures and stream shading
- Modify road construction and stream crossing standards to address changes in timing and volume of peak flow
- Use climate and landscape models (e.g. Conservation Blueprint) to focus habitat rehabilitation and species restoration efforts
- Protect and rehabilitate critical habitats for highly vulnerable fish species
- Encourage stewardship groups to protect and rehabilitate aquatic habitat, riparian zones and wetlands
- Develop a protection strategy for wetlands within the southern portion of Clay Belt
- Modify culvert size requirements or other control points to account for changes in water flow / peak flow and to better enable species to move
- Develop an accurate inventory of current wetland features on the landscape and monitor over time
- Find and evaluate feeding coldwater systems and examine the sensitivity of these systems to change
- Conduct research on how climate affects aquatic ecosystem productivity, including fish community dynamics

AQUATICS (cont'd)

Water Management

policy	Incorporate principles of adaptive management into water withdrawal regulations and waterpower developments to ensure that water levels can be maintained and aquatic ecosystem features are protected
policy	Encourage and support water conservation through implementation of watershed-wide water conservation strategies
policy	Revise the Water Management Planning Guidelines for Waterpower to incorporate anticipated changes in water levels and aquatic habitat
policy	Establish targets for water quality, quantity and aquatic ecosystem health that account for climate change projections
policy	Revise provincial guidelines for small dam removal or decommissioning to improve thermal conditions and fish access
policy	Develop protection measures for groundwater areas and eskers within Clay Belt
policy	Change regulations on the discharge of effluents
resource management	Incorporate integrated watershed planning (managing human activities and natural resources on a watershed basis) into water and aquatic resource management practices
resource management	Restrict development in floodplains
resource management	Assess vulnerable marinas, boat launches and shoreline properties and plan for changes in water levels.
resource management	Review existing gaps in flood plain mapping, and ensure use in planning and emergency management
monitoring and science	Increase research on the effects of changes to precipitation on minimum stream flows and aquatic ecosystems
monitoring and science	Install and support more stream gauges
monitoring and science	Evaluate potential changes to lake carrying capacity and determine if additional development (e.g. new cottage lots) would be affected
monitoring and science	Update Intensity, Duration and Frequency (IDF) curves for use in land use planning, infrastructure design, and emergency management
education and public engagement	Develop an information program for homeowners that explains the importance of maintaining stormwater management systems (i.e. rain barrels, rain gardens, etc.) on their property

Fish Health

policy	Develop an interagency approach to responding to fish disease, and ensure adaptability of related policies and programs
resource management	Incorporate climate change considerations into rapid response protocols for aquatic invasive species
resource management	Focus prevention and control methods, and rapid response protocols in areas at high risk of invasive species (e.g. restrict the use of live bait in high risk areas, increase signage on aquatic invasives near lakes and rivers, promote the use of artificial bait)
monitoring and science	Monitor range expansion of aquatic invasive species
monitoring and science	Understand impacts of climate change on fish species, their habitat, invasives and food web effects

LEGEND:
- policy
- resource management
- monitoring and science
- education and public engagement

WILDLIFE

Wildlife Management

- Integrate climate change into endangered species listings and Species at Risk Act recovery plans
- Encourage active habitat management, such as establishing nest boxes and protecting cavity trees, to facilitate the colonization of sites by species expanding their ranges
- Enhance connectivity and wildlife cooridors through landscape-scale planning and partnerships and collaboration among organizations
- Reduce habitat fragmentation by protecting, enhancing and rehabilitating migration routes of critical wildlife habitat
- Remove barriers and establish dispersal bridges for species movement (e.g. eliminating hanging culverts, building highway underpasses)
- For highly vulnerable and rare species that would otherwise go extinct, establish captive populations to conserve genetic diversity
- Focus conservation efforts on species-at-risk, species with small geographic ranges and low genetic variability, and sensitive ecosystems
- Regularly evaluate hunting levels and measures (e.g, tag draws) in light of climate change impacts on species populations
- Address potential increase in human-wildlife conflicts
- Ensure that hunting schedules correlate with long-term shifts in seasonal breeding times
- Increase waterfowl habitat (e.g. artificial ponds, beaver ponding) to mitigate potential losses in wetland waterfowl habitat
- Manage furbearer populations (including beavers) to maintain their positive effect on wetlands and other habitats
- Improve understanding of bird migration cues and how they may be affected by climate change
- Understand species biology, particularly traits such as vagility (how a species can move or spread), genetic variability and biotic interactions
- Increase collection of small game information to help respond to inquiries as species respond to climate change
- Educate hunters and trappers to adjust to changes in hunting levels and species in light of climate change impacts on species populations
- Update natural history field guides and knowledge transfer products to reflect changing species composition

Wildlife Health

- Re-assess definitions, policies and management of invasive species in a changing climate
- Develop policies for management of hybrid wildlife species and populations
- Identify wildlife indicator species to monitor response (e.g. abundance, distribution, health) to climate change over time
- Improve monitoring to detect, prevent, and respond to new pests and wildlife diseases
- Understand impacts of climate change on wildlife species, their habitat, invasives and food web effects
- Expect the spread of deer ticks into northern parks and prepare adequate education programs for visitors and Ontarians who work outdoors

LEGEND:
- policy
- resource management
- monitoring and science
- education and public engagement

PALUDIFICATION & PEATLANDS

Integrate paludification issues into existing silvicultural guides and other best practices
Require identification of the type of paludified forest to help characterize the landscape in forest management planning
Integrate paludified sites into fire suppression
Manage fire near communities by supporting hardwood plantations
Monitor rate of change of peatland succession
Understand mercury production and its effects on water quality through cumulative effects assessment
Understand evolving role of hydrology in paludified forests in context of climate change
Explore alternative peat extraction opportunities (e.g. pharmaceuticals, cranberry production, cosmetics)
Increase monitoring to help predict changing fire regimes
Educate practitioners and forest managers on paludification processes and impacts to forest productivity
Educate practitioners and forest managers on the function and role peatlands play in global carbon cycles

LEGEND:

- policy
- resource management
- monitoring and science
- education and public engagement

SOCIO-ECONOMICS

Tourism & Recreation

- Develop ice safety policies (e.g. requirements for ice huts, safety equipment)
- Extend summer operating period and camping seasons in Parks
- Consider improvements to transportation infrastructure for better access to remote tourism operations
- Work with winter tourism operators to assist them with diversifying their activities to adjust to tourism changes
- Update infrastructure for indoor recreational activities to address warmer shoulder seasons (e.g. curling clubs, hockey arenas)
- Increase monitoring of lake ice conditions to help inform decisions related to public access and travel in winter to ensure visitor safety in natural areas
- Research recreational activity substitution to help minimize revenue losses within Parks and tourism operations
- Evaluate impacts to ecosystems as a result of increased ATV use
- Understand environmental goods and services provided by healthy ecosystems
- Market emerging fishing opportunities (e.g. increase in walleye fishing) at tradeshows and fishing tournaments
- Promote night time ice fishing opportunities to concentrate the fishing season over shorter duration while still maximizing total angling hours
- Promote opportunities for recreation in shoulder seasons
- Attract new visitors to Ontario through developing marketing strategies that target winter sports participants in locations (e.g. Michigan and Vermont) that are already seeing reduced season lengths
- Develop and deliver educational program on damage caused by transferring smallmouth bass
- Develop education program for snowmobile trail use and non-use by ATVs
- Promote healthy alternatives to motorized recreation as new tourism opportunities (e.g. trail biking, snowshoeing)
- Use demonstration monitoring at parks to illustrate to visitors some of the environmental changes caused by climate change within natural areas.

Community

- Adjust Building Code for climate change impacts (e.g. wind gusts, snow load)
- Diversify local forest-based economies (e.g. value added products, non-timber forest products, tourism, agriculture)
- Modify wood processing technology so that local mills can use different tree species and altered wood quality
- Enhance support for communities in source water protection planning and training
- Explore opportunities for forest exports in niche markets (e.g. certified wood products)
- Apply socio-economic models to quantify the social and economic impacts of key vulnerabilities and risks in the area
- Apply socio-economic models to estimate the cost of implementing versus not implementing adaptation options
- Integrate climate change impacts and adaptation into school curriculum
- Produce a series of fact sheets to inform business people of climate change adaptation actions that could be pursued to make their operations more sustainable (e.g. wise water use)
- Develop a local climate change education and extension program to foster community engagement in adaptation planning

Emergency Management & Public Safety

- Develop emergency preparedness strategies that help communities prepare for increased flooding, drought, and other impacts from extreme weather events
- Improve coordinated federal and provincial disease and parasite surveillance programs
- Enhance surveillance of mosquito-borne and tick-borne diseases
- Improved flood forecasting
- Use a variety of disease and parasite prevention tools (e.g. vaccines and behavioural change)
- Develop a system of public health alerts and weather warnings, and follow these up with pre-specified actions

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Appendix V
Survey Web Page and Example of Flash Q Sorting Technique

Evaluating Adaptation Options for the Clay Belt Region of Ontario

About the surveys:

There are six thematic areas included in the evaluation of potential adaptation options for the Clay Belt region: aquatics, forests, wildlife, socio-economics, paludification & peatlands and 'cross-cutting' measures.

For each theme, the survey ranks the level of priority of implementing adaptation actions. This is based on feasibility and effectiveness of the adaptation measures.

Clay Belt Eco-district 3E-1
Northeastern Ontario

Complete the surveys:

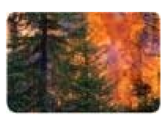
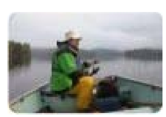
Before you start the survey, please read the Summary of Climate Change Vulnerabilities and Risks in the Clay Belt Region. You may also wish to review the Clay Belt Climate Change Adaptation Options Portfolio, which forms the basis of the survey's ranking process.

Please complete the survey for the 'cross-cutting' theme.

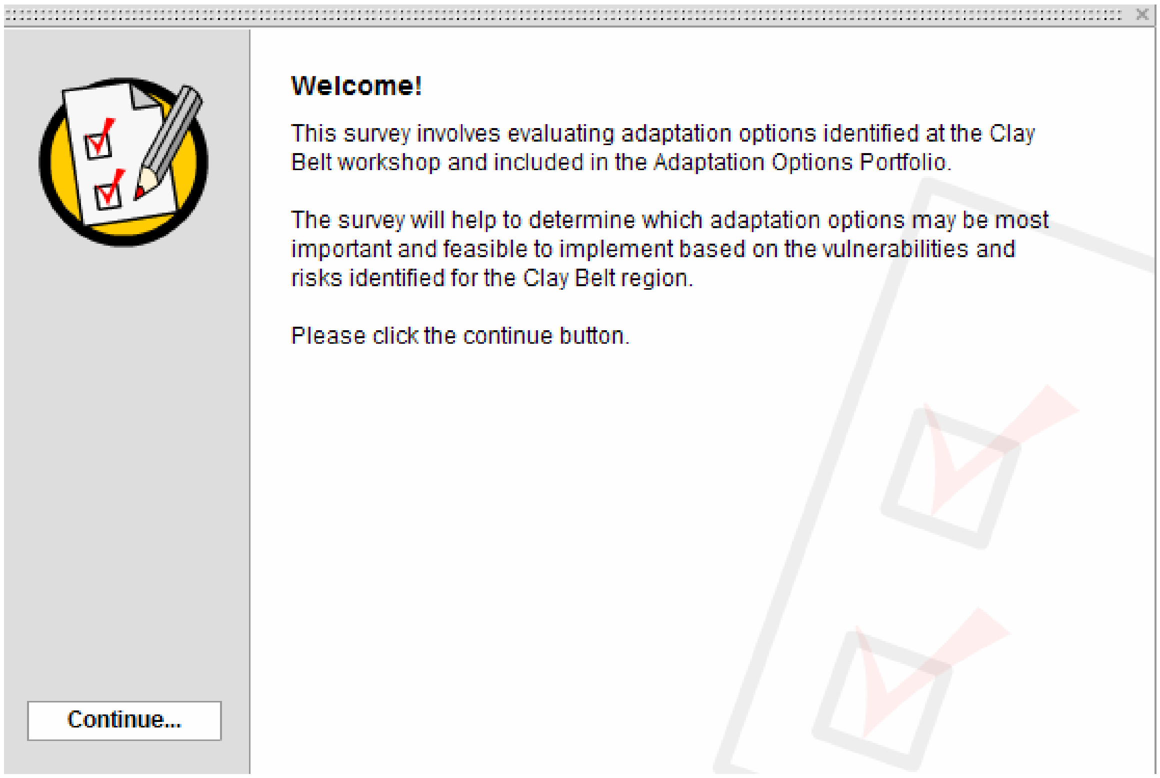
Complete one other theme based on your experience and interest and if you have additional time, please complete each of the themes. Each survey should take approximately 20 minutes to complete.

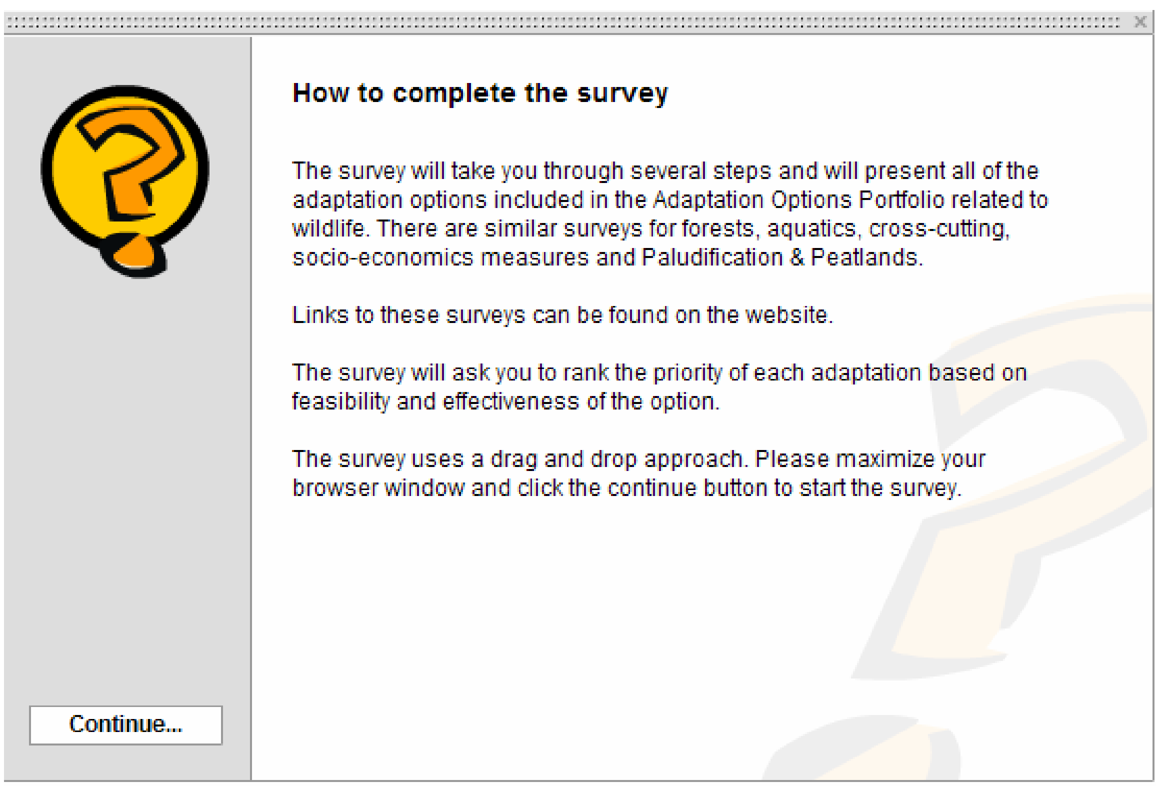
When you complete the survey, the information will automatically be sent to the Clay Belt Climate Change project team. You will be entered into a draw to win a GPS navigation unit for completing the survey.

Access the surveys:

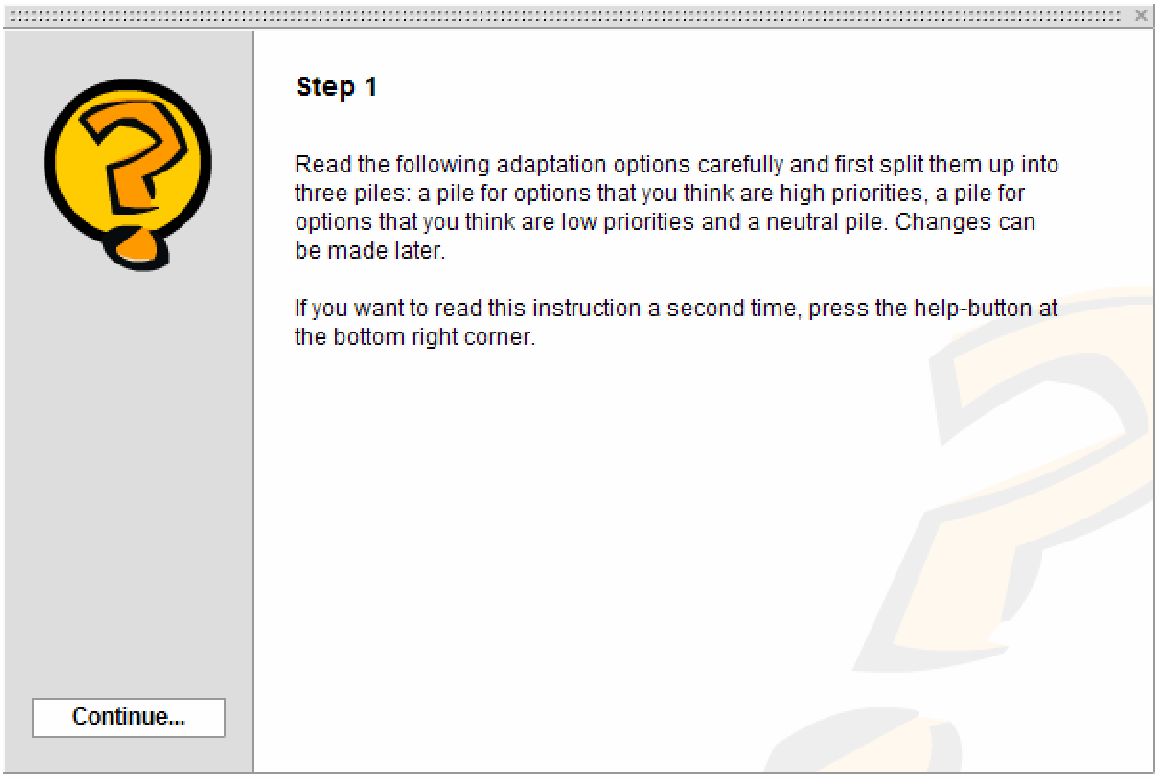
Cross-cutting	Aquatics	Forests	Socio-economics	Wildlife	Paludification & Peatlands
					

Sample Survey – Wildlife – Welcome and How to Complete the Survey

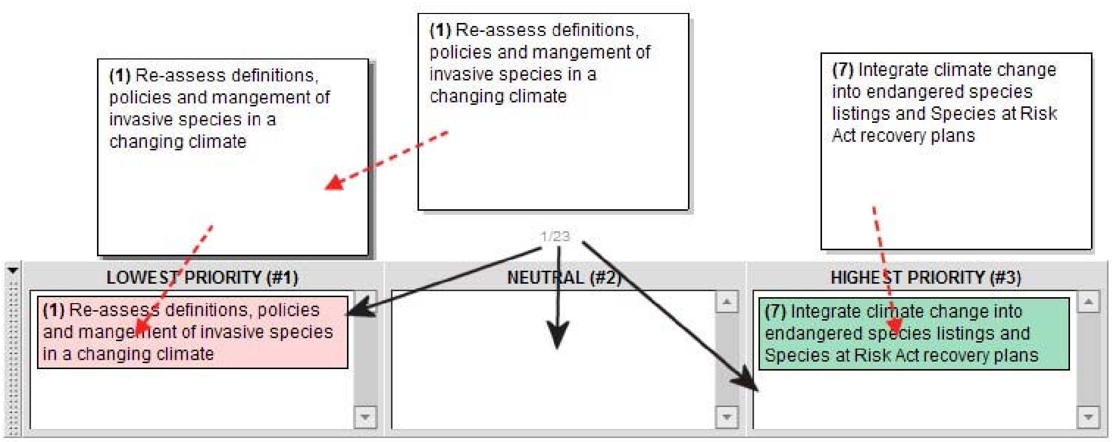




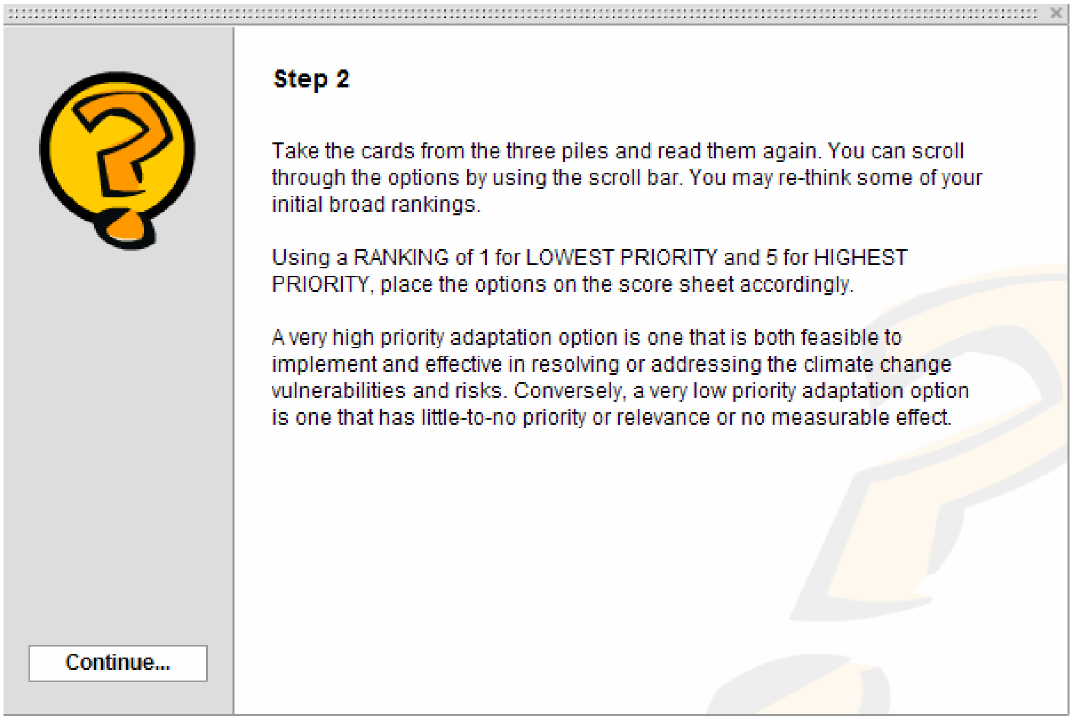
Step 1



Drag and Drop cards to 1 of 3 Piles



Step 2

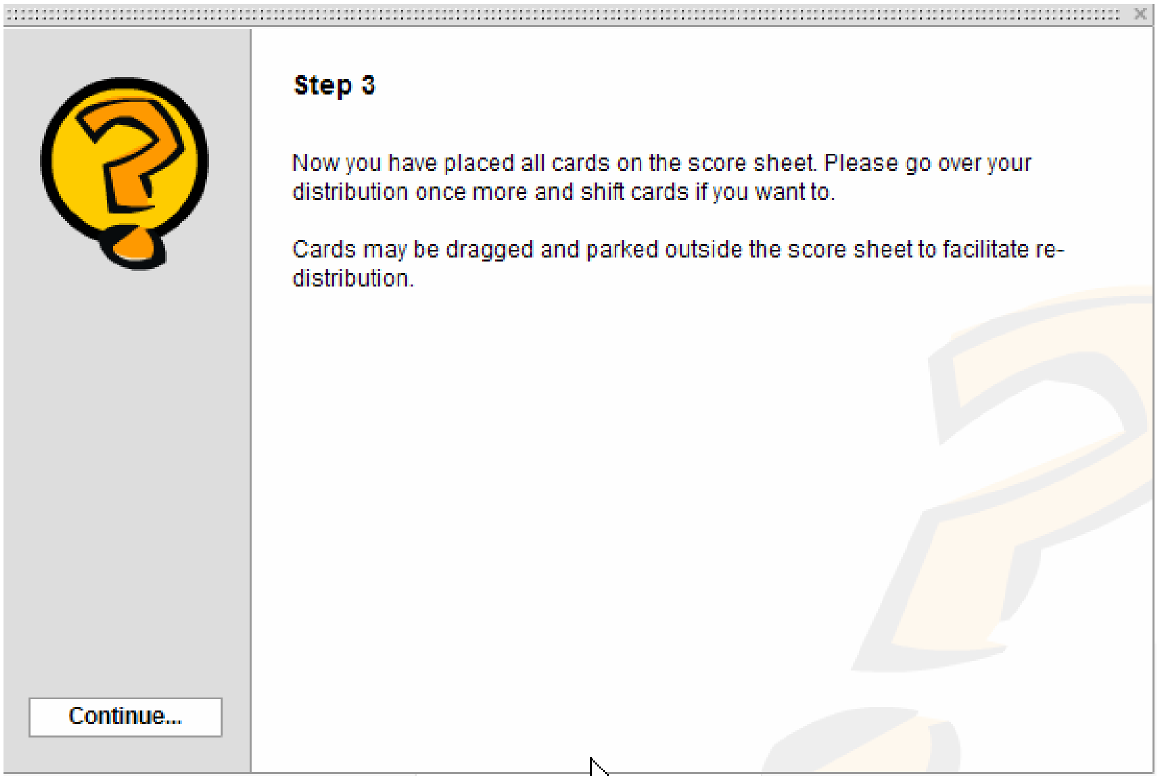


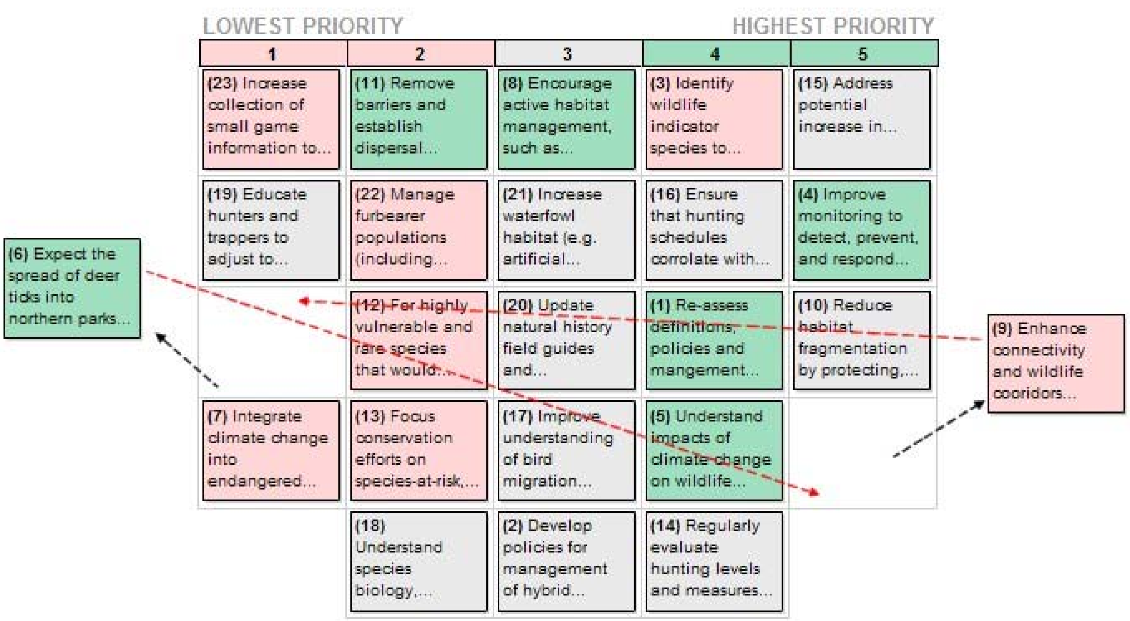
Drag and drop the Cards from the 3 Piles to the Grid

LOWEST PRIORITY — HIGHEST PRIORITY

1	2	3	4	5
(23) Increase collection of small game information to...	(11) Remove barriers and establish dispersal...	(8) Encourage active habitat management, such as...	(3) Identify wildlife indicator species to...	(15) Address potential increase in...
(19) Educate hunters and trappers to adjust to...	(22) Manage furbearer populations (including...	(21) Increase waterfowl habitat (e.g. artificial...	(16) Ensure that hunting schedules correlate with...	(4) Improve monitoring to detect, prevent, and respond...
(9) Enhance connectivity and wildlife cooridors...	(12) For highly vulnerable and rare species that would...	(20) Update natural history field guides and...	(1) Re-assess definitions, policies and mangement...	(10) Reduce habitat fragmentation by protecting,...
(7) Integrate climate change into endangered...	(13) Focus conservation efforts on species-at-risk,...	(17) Improve understanding of bird migration...	(5) Understand impacts of climate change on wildlife...	(6) Expect the spread of deer ticks into northern parks...
	(18) Understand species biology,...	(2) Develop policies for management of hybrid...	(14) Regularly evaluate hunting levels and measures...	

Step 3


Step 3
Now you have placed all cards on the score sheet. Please go over your distribution once more and shift cards if you want to.
Cards may be dragged and parked outside the score sheet to facilitate re-distribution.
Continue...


LOWEST PRIORITY
HIGHEST PRIORITY
1
2
3
4
5
(23) Increase collection of small game information to...
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(17) Improve understanding of bird migration...
(5) Understand impacts of climate change on wildlife...
(18) Understand species biology,...
(2) Develop policies for management of hybrid...
(14) Regularly evaluate hunting levels and measures...

Are there other options that you think should be considered? Please note them and explain why.

Are there options in the survey that are socially unacceptable or ecologically unsuitable and should not be pursued?

If so, describe issues that you may foresee.

Please select one area that best describes your background.

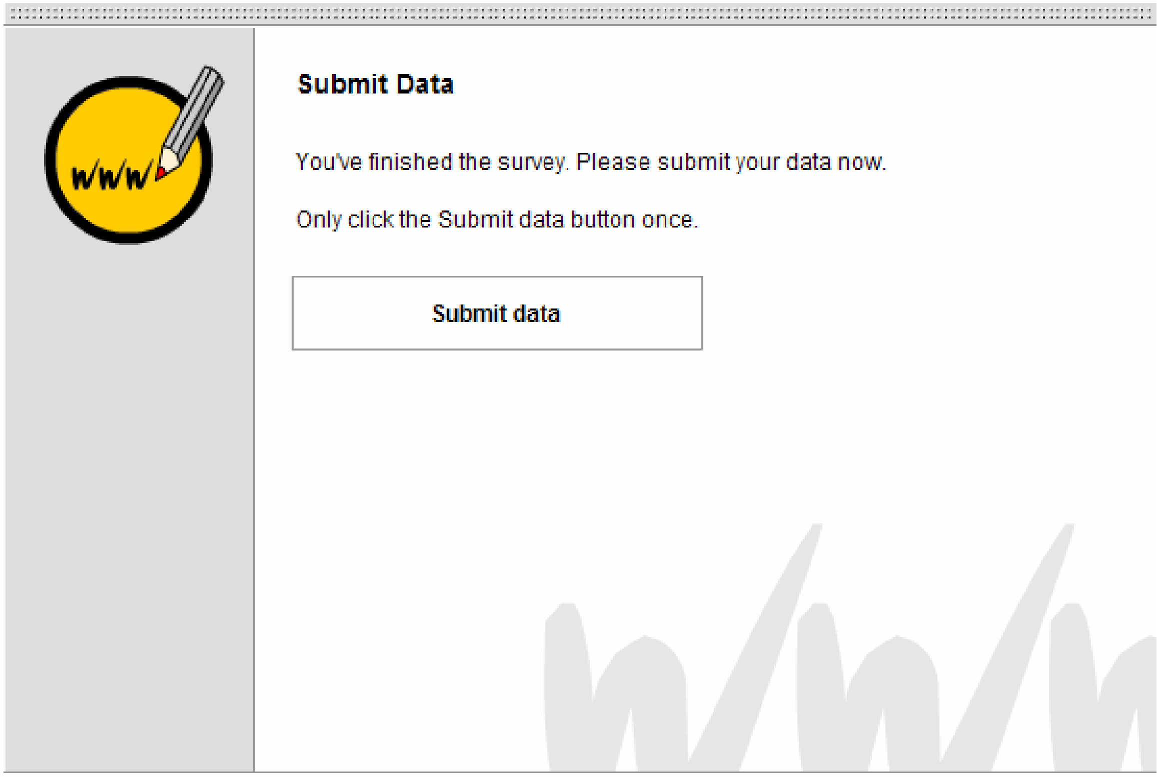
- ○ scientist or researcher
- ○ natural resource manager
- ○ natural resource technician
- ○ economic development
- ○ social services
- ○ community representative
- ○ other (please describe)

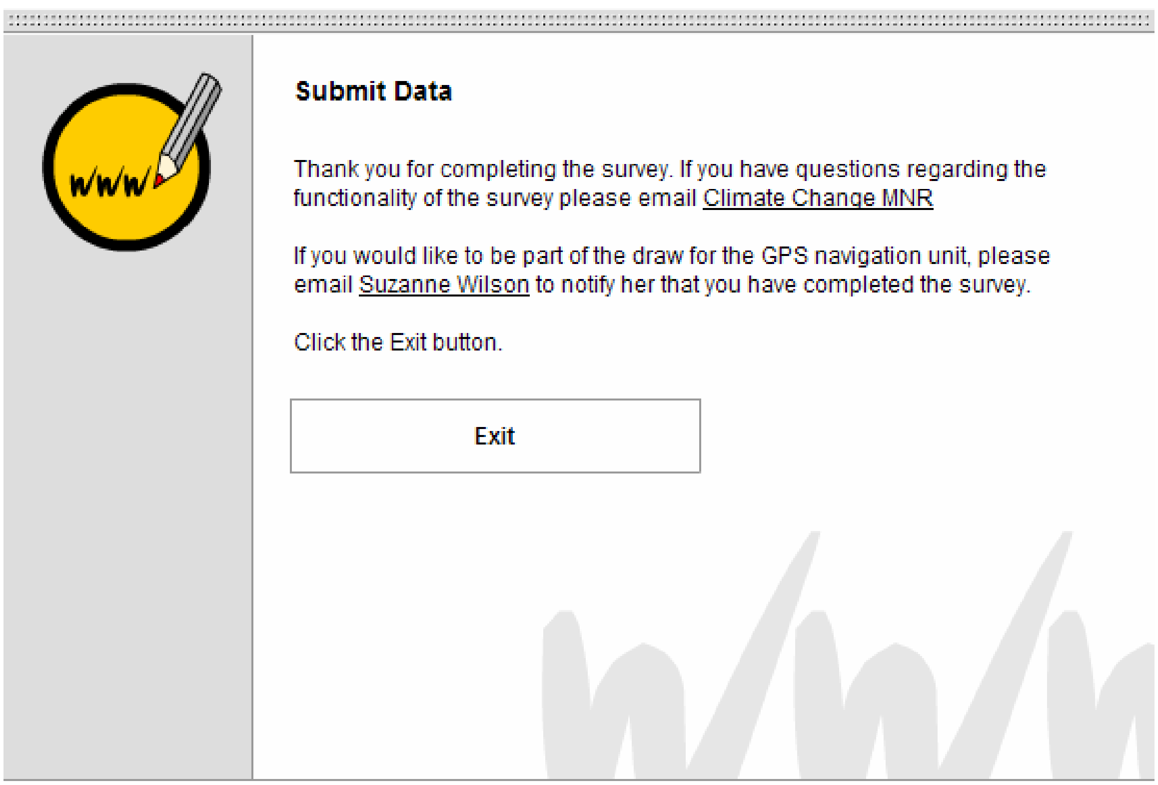
Please select one area that best describes your area of expertise and knowledge.

- ○ forests
- ○ aquatics
- ○ wildlife
- ○ socio-economics
- ○ other (please describe)

Continue...

Submit data and Exit





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