Threats, Monitoring, and Policy to Present and Future Climate Change from Algonquin Park (Ontario, Canada) to the Adirondack Park (New York, United States)

By

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A project submitted to the Graduate Program in Environmental Studies

In conformity with the requirements for the

Degree of Master of Environmental Studies

Queen’s University

Kingston, Ontario, Canada

May 2013

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Abstract

Anthropogenic greenhouse gas emissions have been steadily increasing since the Industrial Revolution. The release of greenhouse gases and the results in changes in global climate have made it a challenge for parks and protected areas to respond to the potential negative impacts to ecological integrity. The predicted rate of climate change is forecasted to be faster than the rate of deglacial warming and a fragmented landscape between large protected areas further contributes to our challenges. The Algonquin to Adirondack corridor provides a corridor for flora and fauna to migrate in the face of climate change. Assessing the perceived threats, current level of monitoring and assessment, and climate change policy provides the framework to assess our preparedness to adapt to climate change on study areas within the Algonquin to Adirondack corridor. To compile data, a literature review was completed and 8 individuals representing 7 governmental and non-governmental organizations were interviewed. The findings include: 1) there are concerns that climate change is affecting study areas, however, climate change is a large problem that many areas are not financially or capacity-wise able to deal with; 2) monitoring and assessment relevant to climate change is occurring within study areas but no standardized method is utilized; 3) budget cuts for all organizations is impacting the ability to accomplish continuous data collection, however, citizen science may potentially fill this gap; 4) there are no specific climate change policies for parks and adjacent regions. The main policy recommendation based on this research is to employ an adaptive management approach to take into account the unpredictable nature of our climate future. Additionally, given the broad range of climate change impacts, tackling this issue can be done quicker and more effectively when accomplished strategically and using partnerships across this region.
Acknowledgements

I would like to thank my advisor Dr. Brian Cumming for the continuous support during my research and writing. Thank you to my committee members, Dr. Ryan Danby and Graham Whitelaw who provided research support. I would like to thank the individuals and organizations who participated in interviews: Frontenac Arch Biosphere Reserve, Office of Climate Change in New York State, Nature Conservancy of Canada, St. Lawrence Islands National Park, Ontario Parks, Trees Ontario, and Parks Canada. Thank you to my family, friends, and Paul for supporting me while completing this degree. I could have not done any of this without your love.
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1.0 Introduction

This project identifies examples of actions that are actively being followed in various governmental documents and policies to address climate change, as well as other environmental problems that could be exacerbated by climate change, such as maintaining ecological integrity and biodiversity within parks and protected areas. While policy is being created to address the overarching issue of climate change at the international, national/provincial/state, and local levels (e.g. international agreements on emissions targets, carbon trading, and greening activities) there is currently no direct landscape-level policy for parks and protected areas.

Historically, Earth’s average temperature has fluctuated due to changes in the climate and environmental conditions. Periods of cooling and warming have been occurring for millions of years as Ice Ages and interglacial periods occurred (Balling & Hunt, 1998). The last Ice Age ended approximately 12,000 years ago (Balling, 2003). Even with the last interglacial period, there have been cycles of warming and cooling. However, since the late 1800s, human activities have accelerated the release of greenhouse gases, and future scenarios of rapid climate change that are unprecedented are predicted in the next 20-50 years (IPCC, 2007).

The global average and measured temperature data are fairly constant around -0.8 to -0.4 degrees Celsius from 1750 to 1900 (Luterbacher et al., 2004; Betts et al., 2007). Starting around 1900s the temperature begins to creep upwards to approximately -0.2 in 1950 (IPCC 2002; Parmesan & Yohe, 2003). In this time frame it is difficult to attribute anthropogenic greenhouse gas emissions to the increase in temperature. It was, however, during this time that the sales and fabrication of fossil fuel burning automobiles increased rapidly (Chapman, 2007). Around the 1960s there is a decrease in temperature; however, the numbers are still higher than they had been historically (Baines & Folland 2007). The decrease could be attributed to a natural cooling
period or cleaner burning fossil fuels and tighter environmental regulations (Environmental Protection Agency, 2012).

However, with these policy changes and technology innovations, there is still a rise in temperature. It is not until recently, 1980s and on, that the increase in temperature has become severe and rapid, climbing up to 0.4 degrees Celsius (Solomon et al., 2009). The predicted global temperature increase from 2000 and on is even higher, with increases projected to occur until 2100 between 1.1 and 6.4 Celsius (IPCC, 2007). The Intergovernmental Panel on Climate Change (2007) attributes contemporary temperature increase to human-induced climate change. It is no longer a natural, cycling occurring phenomenon.

![Figure 1: Concentration of Greenhouse Gases in the Past 2,000 Years](image-url)

**Figure 1**: Increases in concentrations of the heating trapping gases: carbon dioxide, methane, and nitrous oxide have occurred in the past 2,000 years. Starting in 1750 there is an observed increase in these gases due to human activities in the industrial era. Concentration units are shown in parts per million (ppm) and parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million and billion molecules of air respectively. (From Intergovernmental Panel on Climate Change, 2007).
Human activities result in emissions of three principal greenhouse gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) (Figure 1). Since the beginning of the industrial revolution, around 1750, human activities involving the release of carbon dioxide, methane, and nitrous oxide have had a warming effect on the globe (Figure 1). These three greenhouse gases are the main contributors to the global greenhouse warming. Table 1 shows the lifetime of each greenhouse gas in the atmosphere and its global warming potential (GWP).

Table 1: Global Warming Potential (GWP) Values and Lifetime of the Three Most Abundant Greenhouse Gases (Summarized from IPCC, 2007; EPA, 2012).

<table>
<thead>
<tr>
<th>Greenhouse Gas</th>
<th>100-year GWP</th>
<th>Lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>1</td>
<td>Complex</td>
</tr>
<tr>
<td>Methane</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>310</td>
<td>114</td>
</tr>
</tbody>
</table>

The largest known contribution to global warming comes from the burning of fossil fuels, which releases carbon dioxide gas to the atmosphere. The release of carbon dioxide is due to electricity generation, transportation, and industrial and household activities. Over the past several decades deforestation accounts for 20% of carbon dioxide emissions (Karl et al., 2009). Methane has increased in the atmosphere as it is released during agricultural activities, transportation, and decomposition of garbage in landfills. Global methane concentrations have been decreasing over the last two decades due to methane being captured and burned off at landfills and improved efficiency in the production and distribution systems for natural gas (IPCC 2007; EPA, 2010). Nitrous oxide concentration is increasing as a result of fertilizer use and fossil fuel burning (IPCC 2007).
The 100-year global warming potentials of greenhouse gases define the effects over a timeframe of 100 years after these gases have been emitted (IPCC, 2007). IPCC chose carbon dioxide as the reference gas and its GWP was set equal to one (1) and other GHGs are measured in comparison to carbon dioxide. After being released, these major greenhouse gases can remain in the atmosphere for decades, and the length of time a GHG remains in the atmosphere is known as its lifetime. Carbon dioxide has a complex lifetime as the gas is not destroyed over time but moves along different parts of the ocean-atmosphere-land system (Gillenwater, 2010). Different GHGs have varying global warming capacities. The release of these global warming gases could push ecosystems past tipping points that may create powerful negative feedback loops resulting in even larger increases in temperature (Solomon et al., 2009).

The world’s protected areas are valuable and critical sites for conservation and for climate monitoring. The volume of greenhouse gases already in the atmosphere means that Ontario and New York State will experience some of these effects of climate change no matter what mitigation strategies are put in place. Northern countries such as Canada are projected to warm more quickly than other countries. The Algonquin to Adirondack (A2A) corridor is partially located within Canada. If climate change occurs as swiftly and to the large magnitude as predicted (Balling, 2003), it will have significant consequences for Ontario and New York State (Scott & Lemieux, 2005).

Climate change is predicted to have broad effects on the level of biodiversity within ecosystems. The Millennium Ecosystem Assessment (MEA) was carried out from 2001 to 2005 to assess the state of the Earth’s ecosystems through synthesized scientific literature and relevant peer-reviewed datasets and models. The MEA (2005) found that the consequences of climate change over the next century are projected to affect both directly and indirectly, all aspects of
ecosystem services. The MEA (2005) ranked habitat loss as the fastest-growing threat to species and populations for the next several decades and noted the strong connection of habitat loss with climate change. Habitat loss negatively impacts biodiversity and leads to worsening ecosystem services (Thuiller, 2007).

The A2A corridor is an immense cross-border collage of ecological communities stretching from Algonquin Park in Ontario, Canada to Adirondack State Park in New York, United States (Figure 2). The purpose of the corridor is to provide enhanced connectivity throughout the landscape. The need for large-scale corridors is based on the theory of island biogeography that states that species richness is directly related to an island’s size and its level of isolation from other landforms. No parks in North America are large enough to sustain themselves unless they stay connected to each other (Noss et al., 1997).

Figure 2: Map of Algonquin to Adirondack Region (From: Canadian Parks and Wilderness Society, 2012).

Corridors that facilitate the movement of plant and wildlife species will help ecosystems adjust to the changing climate conditions. In a world that is projected to be increasingly warm,
entire biomes can shift locations with major shifts in climate (Beier & Noss, 1998). It is predicted that the increase in temperature will cause forest regions in North America to shift northward. Climate models predict shifting habitat at a rate of 40 kilometers north a decade and as much as 500 kilometers north over the next century (McKenney et al., 2007). This rate is much faster than flora and fauna have traditionally expanded their range in the past. Given the probable changes in climate, threats, monitoring, and policies to ensure the ecological integrity and biological diversity on landscape scale from the Adirondacks to Algonquin are examined in this project.

2.0 Literature Review

The purpose of the literature review is to provide a starting point to evaluate what has previously been done within the topic of climate change in protected areas. Early in the research of this project, a literature review of adaptive management, habitat fragmentation and corridors, ecological integrity, and the history of climate change in protect areas was undertaken. The literature review provided the context from this project and served as a guide for research process and informed the study’s findings.

2.1 Adaptive Management

Parks and protected areas are dynamic and complex ecosystems. To be properly managed, these systems need to be understood and managed to maintain long-term ecological integrity, and depending on the type of protected area integrated resource management (Suffling & Scott, 2002). In Holling’s (1978) seminal work entitled Adaptive Environmental Assessment and Management he states that adaptive assessment and management is a methodological
approach of learning-oriented policy experimentation to test management strategies, and with the goal of informing subsequent policy decisions.

A systematic approach for evaluating change within parks and protected areas is recommended, as managers of these lands cannot be expected to conserve the biodiversity and ecosystem processes (i.e. ecological integrity) within their borders if they are unaware of the ecological status of the park (Timko & Innes, 2009). This systematic approach would include monitoring, evaluation, and reporting into the cycle of park management, which in turn would generate informed feedback that would improve management approaches and progressively improve management effectiveness (Jones, 2005).

The traditional scientific method to problem solving involves isolating components from their larger context and understanding their specific mechanisms and processes. However, compartmentalizing of science does not adequately address complex environmental issues where a landscape-scale approach is required. Holling’s (1978) work uses management policies as experiments to test; conclusions are then reached that lead to modifications to future policies. The concept of adaptive management links cyclical learning with policy and assessment. Walters’ (1986) main argument is that for actions and policies will foster from the ongoing adaptive and experimental process rather than basic research.

Uncertainty is a characteristic of natural resource management due to dynamic and ever-changing ecosystems. The adaptive approach is the link between information and action following the best available knowledge. Walters (1986) states that it is important to create management objectives and a gauge to measure how policy choices affect the ability to attain those objectives. His findings were rooted in natural resource management and used statistical methods to manage uncertainty and risk in wildlife populations.
Uncertainty and risk in natural resource management are viewed as opportunities to build understanding within the adaptive management framework. Incorporation of risk and uncertainty into the evaluation of decision alternatives could ultimately reduce risk (McAllister & Peterman, 1992). Formal institutionalization and buy-in of adaptive management is critical, however, during times of uncertainty when institutions may choose to proceed with caution and do no action until more knowledge is known. Ironically, this risk-aversion method of waiting until more information is produced may suppress experimental policies and actions needed to produce the knowledge and understanding to reduce risk and uncertainty. Managers and policy makers should view errors through the lens of success and welcome this challenge as a part of the learning process. Information gathered during this process is to be collected and analyzed to redirect new objectives when old objectives are met or need re-working (Halbert, 1993).

Successful adaptive management plans involve the three following criteria (Walters, 1986; Halbert, 1993; McLain & Lee, 1996): creation of new understanding based on a systematic assessment of feedback on management policies; incorporation of new knowledge into succeeding actions and policies; and creation of opportunities for knowledge transfer and communication to occur. Use of adaptive management has a chance of greater success when the objectives of: connecting science with management and the applications of policy are viewed as an experiment.

Short-Fall of Adaptive Management

Within the literature the theoretical framework of adaptive management is well laid-out. There are issues with the framework, however, during on-the-ground implementation. For adaptive management to be successfully implemented, there needs to be agreed-upon definitions of this management style and goals need to be laid out in regards to how to reach objectives.
(Halbert, 1993). The cost of adaptive management and experimentation can be expensive and appear to be a very large up-front cost to pay (Halbert, 1993; Van Winkle, 1997). As well the benefits, far in the future and potentially problematic, can be factors to suppress investments in knowledge acquisition.

Adaptive management promotes system models to continuously create hypotheses and re-test hypotheses to create strong, accurate policy. In this system, it is assumed that managers, scientists and policy makers have agreed upon sets of “facts” (McAllister & Peterman, 1992). Different perspectives are exaggerated when the adaptive management cyclical process demands quantitative data to test hypotheses and establish policy (Pahl-Wostl et al., 2007).

If the results of an adaptive policy are to be believed, there needs to be clear criteria to measure based on a proposed basis for policy creation (Stankey et al., 2003). Adaptive management is probably the best approach available for addressing multifaceted problems in large systems such as the complex issue of climate change in parks and protected areas. Yosemite National Park has been managing forest fires through extensive prescriptive documents that describe where, when, and how to manage in specific locations. This method has been successful in the past, however, regular review of prescriptive methods are required as historic ranges of variability in natural disturbance cycles may not be appropriate targets in a different climate scenario (Baron et al., 2009).

2.2. Habitat Fragmentation and Corridors in Wildlife Management

Anthropogenic use of land threatens biodiversity in many ways, including habitat loss, introduction of non-native species, and pollution. Habitat loss leads to increased habitat fragmentation, resulting in smaller land sections and thereby increased isolation and proportion of edge habitat (Fletcher, 2005). Often urbanization has negative effects on the biodiversity and
ecological integrity of ecosystems through edge effects, fragmentation, and the introduction of non-native species. Conservation of large protected areas is critical for: species requiring large territories; conservation of a wide variety of habitats; and maintenance of viable populations (World Conservation Union, 2010).

Historically, park-system planning centered on capturing representative ecosystems of a certain region. Continuous habitat fragmentation by development decreases connectivity and the ability for species to migrate in the face of a changing climate (United Nations Environment Programme, 2006). The provision of corridors allows for the movement of organisms, maintenance of ecological integrity as well as human uses (Beier & Noss, 1998). Corridors are also needed for fully functioning ecosystems at the national, regional, and global scale (Bennett, 2003) and the stabilization of the effects of climate change (Bennett & Mulongoy, 2006).

Corridors may be affected, however, by encroachment of urbanization. The process of urbanization refers to the increased density of anthropogenic structures along a once rural or untouched landscape. One of the consequences of urbanization is the edge effect, altering the biodiversity of the given landscape (Ranney et al., 1981, Chen et al., 1992). The edge effect is a transitional zone between one type of vegetation to another. The transition could be from a natural edge area to an urbanized location, leading to an increasingly fragmented landscape (Molles, 2005). The negative consequences for biodiversity as edges increase along a habitat include changes in micro-climates, increased risk of invasive species, and changes in metapopulation dynamics (Fahrig, 2003).

The decrease in a particular landscape’s size through fragmentation affects many aspects of terrestrial vegetation including composition and diversity (Ranney et al., 1981; Brothers & Spingam 1992; Alberti 2005). As land becomes increasingly more fragmented, the adjacent plot
of land is affected by changes in the physical environment through a reduction in habitat area. Habitat fragmentation leads to increased habitat loss, resulting in smaller land sections and thereby increasing isolation of residual vegetation patches and increasing proportion of exposed edge habitat (Fletcher 2005). Fragmented vegetated areas can be too small or isolated to support an adequate number of species to protect ecological integrity (Savard et al., 2000). Development of natural areas creates high-contrast edges surrounding the natural area and can lead to a decrease in species diversity (Swenson & Franklin, 2000).

Island Biogeographic Theory

The concept of island biogeography originated from empirical research largely relating to islands isolated by water. Several studies demonstrated that small islands are unable to support the equivalent amount of species as larger islands of similar habitat (Simberloff, 1974; Diamond, 1975). Theoretically, the number of species on an island will be greatest when the island is larger and geographically located close to a source of immigration. However, the theory is not without criticisms.

The criticisms as outlined by Doak and Mills (1994) started in the 1980s and pertained to the statistical and ecological component of the island biogeography theory. Leading up to the 1980s, species-area curves were implemented to predict the number of species able to sustain in any given sized protected area. However, when these curves are applied, regression models are often inadequately selected giving way to lower explanatory power (Doak & Mills, 1994). Even if proper methodological and sampling statistical techniques are applied, there is the ecological assumption of applying island biogeography theory to conservation issues (Haila, 2002). Patch size is the central idea behind island biogeography, and has three assumptions with it: 1) habitat patches are perceived to be comparable to isolated oceanic islands, 2) certain species would find
the area outside the island to be hostile, and 3) natural pre-fragmentation conditions were uniform (Michael et. al., 2008).

Despite the controversy surrounding the theoretical basis of island biogeography theory, the analogy between oceanic islands and isolated terrestrial protected areas scattered in a sea of encroachment are strong. A park can be viewed as a large, single island of protected land. While a single large protected region is recommended, when this is not feasible several smaller, well annotated patches can be substituted (Odion & Sarr, 2007).

Impacts of climate change on parks are difficult to predict as it is hard to distinguish what environmental processes are actually being affected from climate change and what is a natural change. Climatically-driven biome changes will not likely be recognizable in small or isolated protected areas but rather at the landscape scale. The moving climatic envelopes highlight the need for large, contiguous areas that allow movement and flow at the regional scale (Hagerman et al., 2010).

Currently, the objective of establishing parks connected via corridors is vital for the maintenance of individual parks but also for the conservation of ecological functions along the border landscape. Successful projects like the Yellowstone to Yukon Conservation Initiative have established corridors to sufficiently maintain two-space demanding species, grizzly bears and wolves (Locke, 1998).

2.3 Ecological Integrity

Within parks and protected areas, there are two competing goals: one of use and enjoyment by humans, and one of conservation and preservation. The dual order inevitably leads
to tension between these two goals. For these goals to be achieved, there needs to be a management plan in place to optimize ecological integrity and visitor satisfaction.

Maintenance of biodiversity and ecological integrity are two main goals of protected areas. It is important to quantify these qualities because of the necessity to have evidence for the creation of parks and protection of areas. Biodiversity is defined in a multitude of ways in the literature (Noss & Cooperrider 1994; Baydack et al., 1999), which has inevitably led to a controversial definition. However, Marcot makes an effort to define biodiversity simply as “the variety of life and its processes” (Marcot, 2007). The broad concept of biological diversity has many implications because it is important for environmental research, regulatory and policy agendas (Angermeier & Karr 1994). The loss of biodiversity should be of importance to society because of its ethical, aesthetic, economic, and environmental implications (Noss & Cooperrider, 1994). One method to conserve biodiversity is the creation and management of protected parks and natural areas. Not all areas in this study were in protected parks, but these areas do contribute to the overall biodiversity of the local ecosystem. In a world of increasingly fragmented landscapes, protected areas have become vital in maintaining ecosystem services and enhancing biodiversity (Dearden & Dempsy, 2004).

This concept of diversity in biological systems is often thought to foster ecosystem health and ecological integrity. Biodiversity, and changes in biodiversity, are used as a measure of ecological integrity, which is a goal of protected area legislation (Zorn et al., 2001). As one of its founding principles and goals, the Canadian National Parks Act defines ecological integrity as “a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change, and supporting processes” (Canadian National Parks
Act, 2000). Again, this concept of ecological integrity and its relationship to tangible National Park practices and biodiversity is not simple (Parks Canada, 2000). There is, however, an intrinsic relationship between biodiversity and ecological integrity (Marcot, 2007).

Biodiversity studies attempt to look at ecosystems as a whole, but because these systems are complex and our knowledge of biodiversity is incomplete this is after not possible. Not all areas can be surveyed due to time and monetary constraints, so small biodiversity inventories are utilized to represent the entire area of interest. This approach makes the assumption that there will be similar trends in the un-surveyed portions of the protected area population (Reyers et al., 2000). Biodiversity can be measured on different scales and depending upon the scale of examination (e.g. ecoregion vs. watershed; community vs. species scales). This can result in different interpretations (Thompson & Starzomski 2007). Depending on the purpose of an assessment, an appropriate scale needs to be defined.

Biodiversity in terrestrial ecosystems has evolved over time as disturbances that have come into the realm of impacts on a given landscape, and forced species to adapt through natural selection (Sheil & Burslem, 2003). Because of the broad range of unique landscapes and disturbances or impacts on these terrestrial ecosystems across the province, country and world, each ecosystem has responded in a somewhat different way and this has led to the observed level of biodiversity. This statement parallels the intermediate disturbance hypothesis: the level of species diversity is maximized when disturbances in the form of selection pressures are not at an extremely slow or rapid pace, rather, an intermediate one (Jentsch et al., 2002; Sheil & Burslem, 2003)

The magnitude and scale of disturbance on an ecosystem has significant implications on the resistance and endurance of ecosystems. The diversity-stability hypothesis defines the
relationship between ecosystem stability and ecosystem diversity (Johnson et al., 1996; Sheil & Burslem, 2003; Weigelt et al., 2008). Within the literature, there are opposing views regarding the diversity-stability hypothesis; the directional relationship between stability and diversity is controversial (Johnson et al., 1996). However, the disturbance on various scales will have consequential effects on terrestrial biodiversity (Onaindia et al., 2004; Odion & Sarr, 2007). One such disturbance to ecosystems that is pertinent today is climate change.

Ecosystems typically have characteristic rates of change; however, climate change is altering this rate to unpredictable levels. It is important to study the effects and impacts of climate change on ecosystems to be able to anticipate how ecosystems and ecological integrity will change. Ecological integrity must be assessed and understood at a landscape scale. Ecosystems science has shown that ecosystems change over time as new communities form (Vaughan et al., 2001). Wildlife corridors enhance connectivity and contribute to maintaining the integrity of a system’s environmental processes (Bennett & Mulongoy, 2006). Stresses of a global nature, such as climate change, will affect ecological communities within parks.

2.4 Climate Change in Protected Areas

Historically, parks and protected areas are chosen based on their geographic, natural features, and ecosystems that they contain. Currently, in the face of climate change, these historically selected parks may no longer represent their chosen criteria due to rapidly changing environmental conditions (i.e. temperature and precipitation). As a consequence, ecosystems may not have the time to adapt as rapid climate change occurs resulting in much uncertainty. Past studies indicate that the impacts of climate change on biodiversity conservation in Canada will be extensive and have significant impacts (Scott et al., 2002; Scott & Lemieux, 2005;
Lemieux & Scott, 2005). In the past two decades, the impact of climate change on park planning, conservation, and adaptation has been developed (Scott et al.; Heller & Zavaleta, 2009). The overarching conclusion is that the future will be different from the past and that the undulating present will force us to manage parks in new ways requiring adaptation, monitoring, and new policies.

Adaptation requires: improved local institutional coordination among affected stakeholders; an expanded spatial and temporal viewpoint to take into consideration the long-time frame of climate change and its effect on landscape; the incorporation of climate modelling to predict impacts; and the inclusion of these and other threats into park planning. IUCN’s World Commission on Protected Areas has three recommendations for adapting protected areas to changing climatic conditions which are to: link isolated core areas by corridors; surround core areas with buffer zones; and surround clusters of core areas, corridors and buffer zones with sustainable land uses (World Commission on Protected Areas, 2003). Furthermore, there are uncertainties and gaps in our knowledge that are important to identify and research as organisms, populations, communities, and ecosystems respond to changes in climate.

Creating sufficient policy and park planning strategies will be required to manage parks and protected areas in the face of uncertainty regarding the effects of climate change. Scott et al. (2002) and Hannah et al. (2002) state that climate change has the potential to undermine more than a century of conservation efforts. Management techniques should include short-term and long-term strategies that focus on enhancing ecosystem resistance and resilience (Millar et al., 2007). Gaps in knowledge exist in practical operational principles for parks to follow and the lack of institutional buy-in (Hannah et al., 2002).
Identified in the literature as gaps in knowledge are examples of adaptation principles that take into account the documented uncertainty of climate change and it is suggested that uncertainty be coupled with ecosystem-climate models be used to predict future conditions. For parks and protected areas that would like to integrate these recommendations into their already existing policies, there is a need for a guiding how-to document. At the institutional level, there has been a lack of discussion of ecosystem impacts and management implications of climate change on protected areas (Scott et al., 2002). Additionally, a limited number of climate-change assessments and studies have utilized quantitative techniques to test the potential impacts on ecosystem structure and function (i.e. ecosystem integrity) due to climate projections in existing protected areas (Suffling & Scott, 2002; Hannah et al., 2005).

Climate change could amplify and accelerate major existing management problems such as species and habitat plans, resource extraction, inefficient site management and invasive species (Coenen et al, 2008). Many protected areas in the A2A corridor have high natural sensitivities and low capacities to cope with changing environmental impacts (UNESCO, 2012a). The degree to which ecological corridors can assist in minimizing the impacts of climate change remains an open question (Perterson et al., 1997). Corridors do offer populations an opportunity to move away from threatened habitats, but communities may not shift as quickly due primarily to limitations in their ability to disperse.

Within Ontario, the Protected Place and Conservation Reserves (PPCR) Act states that the objectives of Provincial Parks (i.e. Algonquin Park, Charleston Lake Park, and Frontenac Park) is to provide points of reference for monitoring of ecological change on the broader landscape, and to manage Parks to ensure that ecological integrity is maintained. Currently, this plan does not adequately monitor ecological integrity in the face of swift climate change. The
Department of Environmental Conservation (DEC, New York, USA) mandates conservation of Parks’ Forest Preserve lands, waters, and wildlife. The Adirondack Park Agency (APA) which is governed by the APA Act is charged with undertaking: comprehensive land use and development planning; supporting and enabling local planning; regulating all private land uses in the Park; and ultimately approving the DEC actions on lands designated as Forest Preserves.

The goals of this project include: assessing the perceived threats of climate change; investigating the current monitoring policies that are being used to evaluate climate change; and suggesting relevant policies and policy gaps to climate change through interviews and in the literature review. Parks are part of interconnected ecosystems and very much reflect the state of the larger regions where they are located. My study seeks to identify lessons learned from the case study of climate change adaptation planning in the Algonquin to Adirondack (A2A) corridor.

3.0 Methodology

3.1 Introduction

This project followed a multi-method approach that involved a literature review, semi-structured interviews, and document analysis. Several methods are utilized to produce robust findings and recommendations (Berg, 2001). The researcher gathered information during the literature review from books, journal articles, and from the internet to assess the background and understanding of climate change in protected areas. However, to establish the current situation within parks and protected areas, interviewing key stakeholders was imperative to capture the most up-to-date expert knowledge and opinions. Information and policy document recommendations from interviewees were included in a document analysis to assess if, and to
what extent, climate change was addressed in the documents. This project aimed is to explored perceived threats of climate change to study areas, current monitoring and assessment activities; and climate change policies.

3.2 Scholarly Literature Review

The scholarly literature review provided an overview of the significant literature published on the topic of climate change adaptation on a fragmented landscape. The review included a focus on: the strengths and weaknesses of adaptive management; habitat fragmentation and important of corridors in wildlife management; application of ecological integrity as a central theme for park management; and the consequences of climate change policies on protected areas. The literature review classified themes and also provided a chronological timeframe of theories and background information. Literature was found using the Queen’s University library, Queen’s University online databases, and Google Scholar. Gathered information was used to design and create interview questions.

3.3 Semi-Structured Interviews

The research project conducted qualitative interviews to provide a new insight into gaps in the climate change on parks and surrounding areas (Folkestad, 2008). Interview questions were designed using Kuter and Yilmaz’s (2001) methodology for obtaining interview data. The first step involves setting the goals of the interview and determining what information is sought from participants – in this case, detailed information regarding the specific threats of climate change, monitoring, and policy each park or natural area has in place, if any. For certain questions, a 1-10 scale was given to participants to indicate their thoughts on the subject. The 1-10 scale provided metric to measure responses from each participant. The researcher targeted individuals from each park or protected area knowledgeable to each specific area. Initially, to
select interview participants, individuals who create and utilize policy within the A2A study region were compiled. Initially, all sectors (Federal, Provincial, and local) facets of protected areas within the A2A study area and individual parks were included (Figure 2). All these participants were contacted via email. When an interview was not conducted, it was due to unwillingness or unavailability of the person to participate. Those who agreed to be interviewed, were interviewed in person, unless distance necessitated a phone interview.

Using Goodman’s (1961) snowball method, additional participants were contacted and asked to be interviewed. The snowballing method is a non-random sampling technique where existing project participants recruit future participants from among their acquaintances and is useful when potential participants are hard to locate. This is an appropriate recruiting technique as the A2A study area is relatively small and the individuals involved in protected area management are familiar with each other. Additionally, many of the study areas did not have a specific individual assigned to climate change policy development; it was useful to utilize the snowballing method as individuals within an organization know who is responsible for climate issue information that would not be known to the general public.

In total, seven interviews were completed with a total of eight participants. Participant seven and eight contributed during the same interview. Four interviews were face-to-face in office settings and three interviews were done over phone due to geographic constraints. Table 2 is the list of participants and the organization they represent. All participants were assigned a number that is referred to throughout this report.

Table 2: Interview Participation Code and Represented Organization

<table>
<thead>
<tr>
<th>Participant Code</th>
<th>Organization</th>
<th>Organization Level</th>
<th>Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frontenac Arch Biosphere Reserve</td>
<td>Non-Governmental Organization</td>
<td>Face-to-face</td>
</tr>
</tbody>
</table>
To gain access to individuals within the provincial park system, the researcher was required to complete a Research Authorization review process, which included filling out an application form to be granted a research permit. The complete procedure is attached in Appendix B. Although permission was not denied, it was not granted. Algonquin Provincial Park requested not to be included in the application, while Frontenac Provincial Park and Charleston Lake Provincial Park made no such requests. The Friends of Algonquin Park organization was also contacted via email for an interview; however, no response was received. In lieu of interviews with representatives from Provincial Parks, the researcher was able to secure an interview with a zone ecologist from Ontario Parks. A zone ecologist provides input in the areas of ecology, resource management and monitoring within Ontario Parks.

The interview questions were designed to be open-ended questions, requiring verbal responses (Appendix D). This allows for individual expression of existent values and feelings toward the environment and should present beneficial suggestions for the content of this report.
Leading questions were avoided to circumvent bias. To prepare for each interview, document analysis was performed on each of the parks’ management plans searching for existing policies on climate change or gaps where no policies exist. The document analysis was done to evaluate and compare with park management plans with the interviews. Within each question of the interview participants had the opportunity to state the current situation and research within their area but also the opportunity to suggest possible new policy directions. All questions were asked in the same order to each participant during interviews, but allowing for departure from this framework.

The application to the General Research Ethic’s Board (GREB) for this project was submitted on March 22nd 2012 and was granted approval for research on April 13th 2012. All participants were presented with a letter of information regarding the research and signed a consent form and a confidentiality agreement. (See Appendix A for the GREB Approval Letter and Letter of Information/Consent). The length of interview varied from 30 to 54 minutes, with the majority being 40 minutes. With permission from the participants, all interviews were audio recorded and fully transcribed. The researcher also took hand-written notes during the interview to record important points.

3.4 Analysis

An analysis on the interview data was done to provide insight into the research questions stated. Qualitative data of interviews need to be reduced and transformed from raw data into a more manageable form in order to make it accessible and understandable (Berg, 2001). All interviews were fully transcribed. The themes and patterns were then identified.
The researcher followed Berg’s (2001) standard analytical approaches to qualitative analysis with coding by categories to identify phrases, patterns, relationships, commonalities or differences. Themes that appeared were: budget (e.g. money, staff, employees, federal, budget); approach to climate change policy (e.g. top down, federal, municipal, community, park level, small scale); connectivity (e.g. land use, corridor, connection, urbanization, habitat, fragmentation); and citizen science programs (e.g. frog watch).

During interviews, the reoccurring climate change documents were recommended. A list of these government documents was created and the documents were analyzed. A quantitative content analysis is “any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings” (Patton, 2005, p.453) and is mainly an inductive process, grounded in the examination of topics and themes. Qualitative content analysis typically uses individual themes as the unit for analysis (Zhang & Wildemuth, 2009). Analysis of the interviews contributed significantly to understanding the threats, assessment and monitoring, and policy within the parks and conservation areas.

4.0 Study Area and Background

Parks and protected areas around the world are managed to satisfy numerous stakeholders. Dimensions of management include visitor and tourism management, financial, staff, legal, political management, and natural and cultural resource management. To provide context to the types of protected areas, a brief framework is provided below. Protected areas can be categorised into six types, according to their management objectives. All protected areas fall into one of the IUCN (International Union for Conservation of Nature) six categories. The six UNCN areas are each protected and managed for different reasons and purposes.
Table 3: International Union for Conservation of Nature Protected Area Categories and Descriptions (from IUCN, 1994).

<table>
<thead>
<tr>
<th>Number</th>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia)</td>
<td>Strict Nature</td>
<td>Strict Protection</td>
<td>Nature Reserve</td>
</tr>
<tr>
<td>Ib)</td>
<td>Wilderness Areas</td>
<td>Managed mainly for science or wilderness protection</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Ecosystem Conservation</td>
<td>Managed mainly for ecosystem protection and recreation</td>
<td>National Park</td>
</tr>
<tr>
<td>III</td>
<td>Conservation of Natural Features</td>
<td>Managed mainly for conservation of specific natural features</td>
<td>National Monument</td>
</tr>
<tr>
<td>IV</td>
<td>Active management Conservation</td>
<td>Managed mainly for conservation through management intervention</td>
<td>Species/habitat management area</td>
</tr>
<tr>
<td>V</td>
<td>Landscape Conservation</td>
<td>Managed mainly for landscape/seascape conservation and recreation</td>
<td>Protected Landscape</td>
</tr>
<tr>
<td>VI</td>
<td>Sustainable Use Area</td>
<td>Area managed mainly for the sustainable use of natural ecosystems</td>
<td>Resource Management Area</td>
</tr>
</tbody>
</table>

(IUCN, 1994)

Within Canada, legislation establishes basic responsibilities and rules governing parks (Dearden & Rollins, 2002). All parks are legal entities and planning and management occurring within park borders is directed by law. Within the United States, the Adirondack Park Agency (APA) is a New York State government agency. The Adirondack Park Agency administers its mission and responsibilities through The Adirondack Park Agency Act, The New York State Freshwater Wetlands Act, and The New York State Wild, Scenic, and Recreational Rivers System Act (APA, 2003).
4.1 National Parks

The Department of Justice Canada (2012) declares through The National Parks Act that the purposes of National Parks are for the “benefit, education, and enjoyment of Canadians and for future generations.” Inherently, National Parks have a dual and somewhat conflicting mandate: to provide outdoor experiences and education while preserving parks for the use and enjoyment of future generations. However, in 2000 an amendment in the National Parks Act declared the protection of park resources should be the driving mandate, stating that the “maintenance or restoration of ecological integrity, through the protection of natural resources and processes, shall be the first priority of the Minister when considering all aspects of the management of parks” (Section 8: (2)).

Management Plans are prepared for National Parks so that the long-term ecological vision, ecological integrity objectives, zoning, and performance evaluations. The Minister of the Environment reviews the management plan for each National Park every 10 years and any amendments are tabled in the House of Parliament (Section 11: (2)). Previously to the amendment, the Minister had to review management plans every 5 years.

St. Lawrence Islands National Park

Geographic information on St. Lawrence Islands National Park

St. Lawrence Islands National Park (SLINP) was created in 1904 and is located in Southeastern Ontario. The park connects the Northern Canadian Shield with the Adirondack Mountains in New York State. The park consists of 26 islands and 80 inlets as well as many mainland properties located on the St. Lawrence River (Parks Canada, 2012). SLINP is
positioned along the international border with the United States (Figure 3). Locally, there are six municipalities that have jurisdiction boundaries within the park area and the surrounding area has a total resident population of approximately 250,000 individuals (Parks Canada, 2010).

![Map of St. Lawrence Islands National Park](image)

**Figure 3**: Map of St. Lawrence Islands National Park (from Parks Canada, 2013a).

**Park Ecology**

SLINP is the third smallest National Park in Canada, holding a mere 24.4 square kilometres of land. Land within the park is physically separated and fragmented over the land-water-scape, making it difficult to maintain ecological integrity. Much of the area surrounding the park borders is in the Frontenac Arch Biosphere Reserve (FABR). FABR and its significance will be discussed later in this chapter. SLINP works collaboratively with FABR to sustain and improve ecological integrity. There is also an international role with the park’s proximity adjacent to the United States.
SLINP is located in a critical north-south and east-west axis that fosters the movement of flora and fauna. Many species within the region are at the limits of their range. The rugged topography of the region has produced micro-habitats for many species. The Great Lakes act as a heat sink and regulate the area surrounding the 1000 Islands Region (Lofgren & Zhu, 2000).

The State of the Park Report, St. Lawrence Islands National Park was completed in 2004 and used seven indicators of ecological integrity monitors to evaluate the overall environmental condition of the park. The report found that the overall ecological state of the Thousand Islands ecosystem and SLINP is fair, but in a condition of fragile stability (Figure 4).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxics and Pollutants</td>
<td>GOOD</td>
<td></td>
</tr>
<tr>
<td>Human Footprint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Park</td>
<td>FAIR</td>
<td></td>
</tr>
<tr>
<td>Outside Park</td>
<td>FAIR</td>
<td></td>
</tr>
<tr>
<td>Terrestrial Habitat Change</td>
<td>FAIR</td>
<td></td>
</tr>
<tr>
<td>Aquatic Habitat Change</td>
<td>FAIR</td>
<td></td>
</tr>
<tr>
<td>Wetland Habitat Change</td>
<td>FAIR</td>
<td></td>
</tr>
<tr>
<td>Condition of Biodiversity</td>
<td>FAIR</td>
<td></td>
</tr>
<tr>
<td>Stewardship</td>
<td>FAIR</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4: Ecological Integrity Indicator, Condition, and Trend of St. Lawrence Islands National Park – State of Environment (from Parks Canada, 2013b).

SLINP was also included in The State of Canada’s Natural and Historic Places (2011) report which provides an ecological, economical, and social snapshot of the state of Canada's national parks, national historic sites, and national marine conservation areas. The report fulfills the obligation in the Parks Canada Agency Act to report to the Minister on the state of Canada's
protected areas. A summary table for the ecological indicators for SLINP used in *The State of Canada’s Natural and Historic Places* (2011) report found that SLINP is in a good state with fairly stable conditions.

### National Park

<table>
<thead>
<tr>
<th>Ecological Integrity Indicators</th>
<th>Forests</th>
<th>Lakes</th>
<th>Streams</th>
<th>Wetlands</th>
<th>Tundra</th>
<th>Coastal</th>
<th>Glaciers</th>
<th>Grasslands</th>
</tr>
</thead>
<tbody>
<tr>
<td>St Lawrence</td>
<td>&lt;&gt;&lt;&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend

<table>
<thead>
<tr>
<th>State</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Green Circle" /></td>
<td>Good ←→ Stable</td>
</tr>
<tr>
<td><img src="image" alt="Yellow Triangle" /></td>
<td>Fair</td>
</tr>
</tbody>
</table>

**Figure 5**: SLINP Ecological Indicators States and Trends. (From Parks Canada, 2011).

### 4.2 Provincial Parks

Provincial Parks are governed by the *Provincial Parks and Conservation Reserves Act (2006)* which protects ecosystems that represent all of Ontario’s natural regions (natural and cultural) and maintains biodiversity and ecologically sustainable recreation. Provincial Parks are dedicated to the public and are assigned one of the six IUCN classifications above.

Within the *Provincial Parks and Conservation Reserves Act (2006)* there are two types of protected area management direction (Ontario Ministry of Natural Resources, 2006): 1) management statement - approved by the Minister of the Environment, the statement provides a policy and resource management framework for non-complex issues for limited infrastructure and resource management projects for one or more provincial park(s) or conservation reserve(s); and 2) management plan - approved by the Minister of Environment providing policy and
framework for resource management addressing complex issues for substantial infrastructure and resource management projects for one or more Provincial Park(s).

The management direction is written with a 20-year timeline in mind and the examination and review of the direction occurs every 10 years by the Ministry of Natural Resources (Ontario Ministry of Natural Resources, 2009).

There are predicted changes that will affect both the social and ecological components of provincial parks in the coming decades. Visitation to Ontario parks is projected to rise between 11-27% in the 2020s and 15-56% in 2050 (Jones and Scott, 2006). The majority of the surge in visitation surge would come outside the traditional peak summer season. Jones and Scott (2006) found that the combined influence of climate change and projected demographics would have a substantial impact on visitation as soon as the 2020s (+23% to 41%). Fire was identified as the major disturbing factor influencing the landscape structure of Ontario forests. Fires can affect forest structure through larger mean patch size, less old growth, more under growth, and smaller mean shape resulting in decreased patch diversity (Thompson et al., 1998). Central regions of the province are expected to have higher fire frequency, which will lead to more area burns and result in forest patches melding together (Thompson et al., 1998). The number of patches will decline and forests will become younger and more homogeneous (Onaindia et al., 2004).

Provincial Parks are ecologically representative areas of Ontario. Charleston Lake and Frontenac Provincial Parks are located within ecodistrict 6E-10 and serve to protect the natural environments’ representative of this ecodistrict. Algonquin Provincial Park straddles ecodistricts 5E-9 and 5E-10 (Ministry of Natural Resources, 2007).


Algonquin Provincial Park

Geographic Information

Algonquin Park is Ontario’s largest (772,500 ha) and oldest provincial park as it was established in 1893 (Strickland, 1989). Algonquin Provincial Park is situated between Georgian Bay and the Ottawa River in Southeastern Ontario and occupies 7,630 square kilometers (Ontario Parks, 2002). The park is multi-use with campers, paddlers, and loggers utilizing resources. There is a northern boreal and southern deciduous hardwood forest transitionary zone within the park’s borders. The park sits on Precambrian Canadian Shield bedrock. The forest type transitionary zone and bedrock have produced a unique ecosystem which results in rich biodiversity.

Park Ecology

There has been an observed decrease in forest fire frequencies in Algonquin Park, and Flannigan et al. (1998) found that this is likely climatically driven. However, they do note that Algonquin Provincial Park was an early adopter of fire suppression, so that could have contributed to the decrease. Boreal climate warming will probably increase fire incidences in north western Ontario (Thompson et al., 1998). The Canadian Forest Fire Weather Index (FWI) is predicted to increase in Algonquin Provincial Park from 8.0 to 12.0 in the next 50 years (Thompson et al., 1998).

Another impact of climate change is on fauna populations within the park. Loons, great blue herons, and American black ducks are returning to Algonquin Park in the spring one-week earlier when compared to 1970s arrival dates (The Friends of Algonquin Park, 2005). As the bird populations are arriving earlier in the spring season, they are also staying longer into the
fall/winter season because milder late fall conditions result in open water for longer. The warmer and milder seasons result in later ice formation and increased feeding habitats.

Climate change is making the lake system unpredictable in terms of water temperature, this making it difficult for fish species to adapt (Murdoch & Power, 2013). Within Algonquin Provincial Park, King et al. (1999) found that warmer air temperatures are producing an earlier onset of stratification, a warmer epilimnion, a greater thermal gradient, and a shallower thermocline in park lakes. There are species that benefit and lose from shifting water gradients. Smallmouth bass benefited from the longer and warmer water epilimnetric. Lake trout populations were smaller in years of early stratification but not affected by other variables (King et al., 1999). The young rainbow smelt population decreased as the epilimnion layer decreased, while the older rainbow smelt population grew as it occupied the hypolimnion. Stratification characteristics reflect the thermal and feeding habitats’ spatial or temporal boundaries of fish species and can be useful in forecasting how climate change indicators may influence thermal habitats and affect fish growth.

*Frontenac Provincial Park and Charleston Lake Provincial Park*

*Geographic information on Frontenac Provincial Park*

Frontenac Provincial Park was created in 1974 and is 5,214 hectares located on the Southern arm of the Canadian Shield north of Kingston, Ontario (Ontario Parks, 2010a). The park is situated in a semi-wilderness setting with granite outcrops, wetlands, and mixed forests. The park has many hiking trails, paddling routes, and campsites. Frontenac’s Master Plan from 1974 has guided park development and usage around the semi-wilderness theme. The Master Plan is currently under review and will be updated with a new management plan.
Frontenac Provincial Park is located on the Frontenac Arch, which is a portion of the Precambrian Shield extending from Algonquin Provincial Park located further north to the Adirondack Mountains in New York State (Ontario Parks, 2010b).

Geographic information on Charleston Lake Provincial Park

Charleston Lake Provincial Park is located 15 kilometers north of the St Lawrence River and includes the western and eastern shores of Charleston Lake and the 46 islands within the lake (Ontario Parks, 2007). The park is classified as a natural environment park, which integrates recreational landscapes with representative natural features. Within the park is a provincial significant landscape of the Blue Mountain Area of Natural and Scientific Interest and this park also lies within the Frontenac Arch. The park borders encompass provincially significant wetlands, 13 species at risk, and at least 27 provincially significant species (Ontario Parks, 2007). The park has two bedrock types: granite and sandstone, which contributes to the diversity of its’ ecologically characteristics.

The two distinct bedrock types of Charleston Lake have increased the parks’ biodiversity, as flora and fauna have adapted to flourish along the border of the two bedrocks. The park is situated within the Frontenac Biosphere Reserve and is intersected between the boreal northland, the Atlantic coast, the continental heartland, the Appalachian Mountains and the Carolinian forests (Friends of Charleston Lake, 2012). The intersection has created a diverse ecosystem, however, there is not an accurate survey of what flora and fauna are within the park’s borders.

Frontenac and Charleston Lake Provincial Park Ecology

Frontenac and Charleston Lake Provincial Park has high flora biodiversity due to its location situated on then Frontenac Arch. There is 650 (Ontario Parks, 2010b) and 750 (Friends
of Frontenac Provincial Park, 2013) plant species within the Frontenac parks’ borders with four species listed as endangered and one species designated as special concern in Canada (Ontario Parks, 2010b). There has not been an in-depth fauna survey completed within the park, however, Friends of Frontenac Provincial Park (2013) published a check list with 38 mammals, 197 birds, 15 reptiles, 15 amphibians, and 45 fish species. As the park is situated within the Frontenac Arch, many of the flora and fauna species are at their range limits. Change in climate envelop is not known how it will affect these species as there is inadequate research on this topic.

4.3 Biosphere Reserve

There are many global institutions that promote conservation around the world, including: Ramsar (treaty protecting wetlands), Biosphere Reserve Designation, and World Heritage designation. United Nations Educational, Scientific and Cultural Organization’s (UNESCO) Biosphere Reserve Designation program promotes terrestrial and coastal conservation of biodiversity with sustainable use (Ishwaran, Persic & Tri, 2008). The designation has three main functions: conservation, sustainable development, and research and monitoring (UNESCO, 2012a). Biosphere Reserves are not an international convention, but for an area to be deemed a UNESCO Biosphere Reserve, it must fulfill the above three functions.

Biosphere reserves represent many different ecosystem types across the world. For land to be designated a UNESCO biosphere reserve, the area should be: representative of the biogeographic region; contain landscape feature, ecosystem, flora/fauna, or a mixture of each to be conserved; and have an appropriate zoning system in place (Frontenac Arch Biosphere Reserve, n.d.). Biosphere reserves also need proper planning including: core area(s), buffer zone(s), and transition area(s). This system of integrated and collaborative zoning is to ensure that the reserves can maintain three main functions: conservation, sustainable development, and
research and monitoring. There are 16 biosphere reserves in Canada; the Frontenac Arch Biosphere Reserve is the only reserve in this study (UNESCO, 2012b).

**Frontenac Arch Biosphere Reserve**

*Geographic information on Frontenac Arch Biosphere Reserve*

The Frontenac Arch Biosphere Reserve is located in southeastern Ontario, occupies 2,700 square kilometers, and was designated in November 2002 (UNESCO, 2012b). The area comprises the two provincial parks (Frontenac and Charleston Lake) and the national park (St. Lawrence Islands) in this study, as well as the terrestrial and riverine ecosystems of the St. Lawrence River. The area is given its name for the arching granite landform crossing beneath the St. Lawrence and connecting the Precambrian Canadian Shield to the Adirondack Mountains (UNESCO, 2012b). The reserve is at the boundaries of the Atlantic coastal ecosystem, the Appalachian forest, the northern boreal forest, the southern deciduous forests, and the St Lawrence lowland forests (Canadian Biosphere Reserves Association, 2009).

**Biosphere Reserve Ecology**

As the Frontenac Arch Biosphere Reserve is situated between Algonquin Provincial Park and Adirondack State Park and at the interface of multiple ecosystems, the reserve acts as a corridor for flora and fauna. With two major ecosystem types (temperate needleleaf forests and woodlands) and three major habitats and land-cover types (Bras d’Or Lake, bras d’Or Forests, and subwatersheds), the Frontenac Arch Biosphere Reserve is the most biodiverse region in Canada (UNESCO, 2012b). Global climate change can affect the distribution and abundance of organisms (Hansen et al., 2001). Changes in future climate will likely occur at a rapid rate and current biodiversity levels will change (Luterbacher et al., 2002). To manage for this uncertainty, it is imperative to invest in research and assessment on a landscape scale.
4.4 State Park

The concept of state parks and protected lands managed by state government agencies started in the late 19th century. State parks within the United States of America are managed at the state level. There are 7,804 state parks units and covers 14 million acres of land (America’s State Parks, 2013). New York State set up the Adirondack Park in 1892 and proclaimed that the land would remain forever wild (Walls, 2009). The New York State Department of Environmental Conservation’s (DEC) mission is to conserve, improve, and protect approximately four million acres of land including the Adirondacks and Catskill Forest Preserve, State Forests, Unique Areas and the State Nature and Historic Preserves (Department of Environmental Conservation, 2013a). The Adirondack Park Agency (APA) was created in 1971 and promotes wise-use planning for this region. The APA is governed by the APA Act (Adirondack Region, 2011) is charged with undertaking: comprehensive land use and development planning; supporting and enabling local planning; regulating all private land use in the Park; and ultimately approving the DEC actions on the Forest Preserve.

Adirondack State Park

Geographic information on Adirondack State Park

Adirondack Park was created in 1892 by the State of New York and is located in northeastern New York (Adirondack Region, 2011). The park is the largest protected area in the United States, covering an area of 6.1 million acres (9,375 square miles) and is graced with approximately 3,000 lakes and ponds, and 30,000 miles of rivers and streams (Adirondack Region, 2011). Figure 6 represents the Adirondack Park borders, and shows lakes (in blue), major roadways, and state lines. The park is the largest contiguous protected land in the United States and contains a mix of forests, wetlands, rivers, streams, and varying sizes of human
settlement (Department of Environmental Conservation, 2013b). The Adirondack region is blessed with undeveloped elevated High Peaks, high rainfall, and igneous bedrock, resulting in breathtaking scenery (Driscoll et al., 1980).

![Map of Adirondack State Park](image)

**Figure 6**: Map of Adirondack State Park (From Gates, 2011).

**Park Ecology**

Adirondack Park has alpine lakes and ecosystems, however, with a more erratic but general warming climate, the alpine areas are vulnerable to disappearing. Historically, the ice-cover of alpine lakes starts in the fall and is maintained throughout the winter season. Beier et al. (2012) found that since 1975, five alpine lakes in the Adirondacks have had rapid decline in the duration of ice-cover and are now frozen for 7 to 21 fewer days on average. The lack of ice coverage and the lack of ice cover days have impacted the life cycles of animals in the area. The Adirondacks is home to the endangered native brook trout, which thrives in cold water. Brook trout are stressed by warming water and could face increased competition by other fish species.
adapted to warm water conditions (Meisner, 1990). As the temperatures of lakes are predicted to rise, this will likely affect the distribution of brook trout.

One-to-three month droughts are projected to occur as frequently as once a summer in the Adirondack Mountains (U.S. Global Change Research Program, 2009). Droughts effect forest growth through diversity, distribution, and growth responses. Different conifer tree species in the Adirondack Mountains have varying drought tolerance which will result in species segregation along moisture gradients throughout the landscape (Pan & Raynal, 1995). Tree-growth patterns will respond to changes in climate. Forests, alpine tundra, snowpack, birds, and fish are all at risk as climate change alters the landscape of the park.

5.0 Findings, Discussion, and Recommendations/Future Direction

5.1 Introduction

Analysis of eight interviews, academic literature, and federal, state, and provincial policy documents revealed many interesting trends that help draw conclusions on the research questions. Findings on the perceived threats of climate change, state of current and in-progress monitoring and assessment, and policy findings are presented. Analyses of policy documents support the findings from the interviews. This chapter presents my research findings, a discussion on the research findings, as well as suggestions for future direction of research.

5.2 Findings

5.2.1 Perceived Threats of Climate Change

Amongst the participants, there is variance in the perceived threat that climate change has affected parks and protected areas within the A2A corridor (Table 4). The variance ranges from a
10 given by Participant 2 of the Office of Climate Change in New York State, to a 2 given by Participant 5 from Ontario Parks.

Participant 2 states that climate change is affecting the Adirondack State Park, however, there is a lack of information on how climate change affects resources within the park to date. They are concerned for how the Adirondack State Park will be affected into the future. They marked it a 10 as they are “….concerned about climate change affecting the park. We don’t have a lot of information on how climate change has affected the resources in the park to date. When we project, what was likely to happen, the effects could be quite severe to natural resources in the park.” As Participant 2 works very closely with the issues of climate change as their main job focus, this could explain his/her high level of concern for climate change. Participant 2 believes that climate change is affecting the Adirondack State Park, however, indicates there is no adequate information on how climate change affects resources within the park to date.

Participant 3 rated the effects of climate change on the A2A as a 7 and stated that climate change “is a great concern…. I have learned from experience that outcomes are not fairly predictable. So it’s one thing to be concerned and another thing to plan.” They are concerned with the effects of climate change, however, feels that there is a lack of planning for management in the face of this issue.

Participant 5 of Ontario Parks stated that they could not “think of any obvious examples of things we’ve seen that we can attribute directly to climate change. If I were to give a number it would be low at this point and a total guess at a 2 but that is very subjective.” Participant 5 is an ecologist with Ontario Parks and states that climate change “is going to affect us and everything, but we really don’t know (how). It’s nothing that we can see directly, we assume it’s going to and what we are going to have to answer is that given that the whole planet is dynamic what does
ecological integrity mean in a climate change scenario?” As a scientist they realize that climate change is occurring, however, as an ecologist with Ontario Parks they are not certain what will be the biotic ramifications of changing climate.

Participants 4, 6, 7, and 8 did not give a numerical answer. Participant 4 of St. Lawrence Islands National Park states that “it’s the biotic response to climate change that is the concern, not necessarily climate change.” They are not concerned if climate change has affected SLINP, rather what the biotic responses within the park boarders are. Participant 6 of Trees Ontario states that they could not “honestly answer… I think it might be premature because it requires good ongoing monitoring and data to look at the storm conditions versus today….my guess is we are already witnessing shifts in species distribution that are likely correlated with changes in climate and weather patterns over time.” Participant 6’s view on monitoring will be examined in greater depth later in this chapter. Participant 7 of SLINP states that climate change is in the top five stressors affecting the park, and this stressor is derived from well beyond the park borders. Participant 7 states that “… it’s hard to say what the impacts have been already” and therefore could not give a numerical answer. Participant 8 represents Parks Canada and deals with parks in the Arctic.

Table 4: Participant response on a scale of 1 to 10 if climate change has affected the area they represent to date (1 being no affect to 10 being extreme affect)

<table>
<thead>
<tr>
<th>Participant Code</th>
<th>Organization</th>
<th>Response Scale (1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frontenac Arch Biosphere Reserve</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Office of Climate Change in New York State</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Nature Conservancy of Canada</td>
<td>6</td>
</tr>
</tbody>
</table>
With the issue of potential impacts of climate change, the participants’ responses to the potential impacts indicated that all participants thought that various biotic responses on the ecosystem as well as increasing floods, droughts, fires, and invasive species (Table 5). Participant 1 states that a milder climate will allow for invasive species to survive better, but views species regime as the biggest concern. The forest stands are going to gradually change over with “sugar maple, not doing as well because of the milder climate and red maple doing better.” There will be changes with fauna regimes as previously there were “just northern flying squirrels and now we have both southern and northern flying squirrels (in the FABR region). There is a habitat change going on.” There is concern for changing flora and fauna species regimes. Participant 2 was not concerned with a shift of forest types, but a reshuffling of species with “projections to include more oak and hickory competing with the sugar maple and birch trees that have been more typical of the Adirondack forest.” Bauce and Allen (1991) found a decline of sugar maples during the previous 30 years of the study and this was significantly correlated with adverse climatic conditions. Climate change can disrupt ecosystems, and Participant 2 stated that invasive species, such as Japanese honeysuckle, are successful at colonizing disturbed or stressful environments. Participant 2 was the only participant to highlight
environmental refugees as a potential impact from climate change; sea level rise along the lower Hudson River could displace people in the next century or two. Participant 2 was concerned with the social aspect of climate change and the impact of environmental refugees moving to the Adirondacks from other areas of the United States. All participants stated three or more negative impacts of climate change and also stated that with climate change, it will become harder to predict ecosystem tipping points. Climate change is a process and its implications on biodiversity; and is it in itself a stressor and can exacerbate other ecosystem stressors.

Participant 3 was concerned with pest species such as poison ivy, deer ticks, and the associated Lyme disease, and emerald bore ash thriving in a warmer climate. Many pest species and “a lot of other weeds are going to push north and that (were) inhibited by climate.” Human impacts affect this region through land development, roads, sprawl, and cottage shore hardening; all of these impacts have an immediate and direct impact on biodiversity. Climate change affects the ecosystem at a much slower rate; however, the changes will be catastrophic for entire ecosystems. Participant 4 views the biotic responses to climate change as a main impact on biodiversity within SLINP. Invasive species are occurring and moving independently from climate change. Global environmental change makes it difficult to predict how the movement of invasive species will affect ecosystems (Hellmann et al., 2008). Participant 4 states that “climate change is process but it has implications on biodiversity and it is in itself stressor and it exacerbates some other stressors.” Climate change is a stressor on its own and also contributes pressure on multiple other stressors. Participant 5 states that climate change is disrupting ecosystems and asks questions such as “what does ecological integrity mean in a climate change scenario?” and “with the landscaping so fragmented, where would they (flora and fauna) move?” Participant 5 is unsure how Ontario Parks will be able to fulfill their ecological integrity mandate.
in the face of changing ecosystems. There is also questions regarding the need for species to migrate as the climate changes, however, this movement would be difficult in a fragmented landscape. Climate change and habitat fragmentation are considered key pressures on biodiversity (Opdam & Wascher, 2004). Participant 6 stated that there are “shifts in species distribution that are likely correlated with changes in climate and weather patterns over time.” Climate change has produced shifts in species distribution through the organizational hierarchies from the species to the community levels (Walther et al., 2002). Participant 7 stated that main biotic impacts will derive from warmer climate and will result in changing species regimes. Participant 7 states that “most of the focus for climate change planning in the park is to maintain level, recognizing that we have 37 species at risk occurring on our property which 90% are out there northern tips of their range.” SLINP is concerned with managing for species at risk when the habitat needed for survival is likely to change due to moving climatic envelopes. Participant 8 views dispersal or movement patterns of species being affected by climate change, they state “if it is anticipated that St. Lawrence National Park will get hotter and drier, how do we think some ecosystems will adapt to that, so for talking about how it will change their dispersal or movement patterns.”
Table 5: Summary of participant responses on potential impacts of climate change on areas they represent

<table>
<thead>
<tr>
<th>Potential Impacts</th>
<th>Frontenac Arch Biosphere Reserve (1)</th>
<th>Office of Climate Change in New York State (2)</th>
<th>Nature Conservancy of Canada (3)</th>
<th>St. Lawrence Islands National Park (4)</th>
<th>Ontario Parks (5)</th>
<th>Trees Ontario (6)</th>
<th>St. Lawrence Islands National Park (7)</th>
<th>Parks Canada (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotic Response</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
</tr>
<tr>
<td>Changing species regimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reshuffling of species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pests (deer ticks, emerald ash borer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Biotic responses to climate change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species migration in a fragmented landscape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shifts in species distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing species regimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in dispersal or movement patterns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unpredictable weather events</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
</tr>
<tr>
<td>Flood</td>
<td>[✓]</td>
<td></td>
<td>[✓]</td>
<td></td>
<td>[✓]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought</td>
<td>[✓]</td>
<td></td>
<td>[✓]</td>
<td></td>
<td>[✓]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest Fire</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[✓]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invasive Species</td>
<td>[✓]</td>
<td>[✓]</td>
<td></td>
<td></td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
<td>[✓]</td>
</tr>
</tbody>
</table>
5.2.2 State of Monitoring and Assessment

Monitoring and assessment is essential to evaluate ecosystem change. FABR has done work to establish a trend line and the effects of climate change in the area by utilizing the nine weather stations in the region. Office of Climate Change produced *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation* (2011) which is an integrated vulnerability assessment and relied on IPCC assessment reports for the information. The Office relies on information from the larger state, national, and international research bodies. The Nature Conservancy of Canada (NCC) does not specifically monitor for climate change, however, the organization does forest inventories and forest habitat characterization on all properties when they acquire it, with the goal of repeating this method every five years.

Ecosystem monitoring is done to gage ecological integrity within national parks. *State of Environment* (SOE) reports monitor ecological integrity through forests, wetlands, streams/rivers, and species at risk. The 1997 SOE reported the highest levels of impairment to ecological integrity within 4 national parks across Canada: Point Pelee National Park, Prince Edward Island National Park, Pacific Rim National Park and St. Lawrence Islands National Park. In 1998, Parks Canada sent out a questionnaire to park officials to determine anthropogenic threats to SLINP. Of the nine threats that were deemed of particular interest from the questionnaire, climate change is number 6 (Parks Canada, 2013d) *State of the Park Report, St. Lawrence Islands National Park* (2004) is a detailed review of board-scale stressors of the Greater Park Ecosystem, analysis of park-based indicators and measures that shape the condition of ecological integrity within the park.
Participant 5 stated that the Ministry of Natural Resources has the SNOW station network, which monitors snow depth over the winter and one of those stations is located at Charleston Lake Provincial Park. The snow monitoring could be used to represent climatic variation over the landscape. As an agency, Parks Canada is involved in a climate change vulnerability assessment initiative which examines how susceptible a park ecosystem will be under different climate change scenarios. As of March 2013, Parks Canada has draft climate change vulnerability assessments for Wapusk National Park in north-east Manitoba and Ivvavik National Park in the Yukon (Parks Canada, 2013c). Participant 8 states that “…we are starting this climate change vulnerability program, starting to look at different climate change scenarios, likely Park-level ecological responses to those and then what are some of the management issues that derive out of that.” The vulnerability assessments can be used to make decisions on what indicators to monitor, where the monitoring should be done, and developing adaptation strategies for certain species. There is no integrated monitoring being done over the A2A landscape. As indicated by participants there are several different methods of monitoring occurring, however, many are using different indicators and data sources.

5.2.3 Policy

Climate change is a top stressor and policies need to address climatic impacts on the environment. Table 6 are participants responses to what is needed in policies to address climate impacts on the environment within their protected area and what they view as potential barriers to the implementation of policy suggestions. Generally, participants felt that policies need to exist at a higher level than at the local landscape to push for carbon trading to aid with climate mitigation. Locally, players can push for changes in higher-level policies.
Within the Adirondack Park, Participant 2, states that “silvacultural techniques be adjusted to encourage those trees/plants that are here now that we want to try to maintain for as long as possible, such as the sugar maple, the yellow birch. (We need) to adjust our silvaculture so we don’t leave seed beds that are more likely to colonize by oaks and hickories. Silvacultural practices be adjusted to encourage tree and plant species that are currently exist within the park and to maintain the populations for as long as possible and redefine what is (now) classified as an invasive species (to re-classify) as new species colonize.” With unpredictable weather events occurring, there is need for continued improvement in the way riparian areas are managed and what uses are permitted in riparian zones.

Participant 3 stated that increased economic incentives will increase buy-in of carbon banking. Participant 4 and 7 represented SLINP. Participant 4 stated that climate change policy could determine key priorities using the SOE and consultation with the public. As SLINP is embedded in a fragmented landscape of different partners and surrounding landowners, public support is very important to maintain corridors and linkages as reiterated by Participant 7. Participant 5 states that climate change should always be in the background of management planning for protected areas and included climate scenarios to plan accordingly. Participant 6 states that assisting natural migration can be done by ensuring there are enough habitat islands that species can colonize and move naturally by their own mechanisms in a northward movement. Participant 8 states that as there is uncertainty around the ecological effects of climate change, vulnerability assessments are important. However, as an agency, Parks Canada is focusing more on the north because it is really only the Arctic national parks that have a projected higher rate of climate change than southern parks. There is no over-arching landscape
policy development in regards to climate change. Adaptive management is a possible approach to take in the face of an unpredictable, changing ecosystem.

Table 6: Participants' response to what is needed in policies to address climate impacts on the environment within the study areas. What are potential barriers to the implementation of policy suggestions?

<table>
<thead>
<tr>
<th>Participant Code</th>
<th>Organization</th>
<th>Elements Needed in Policy</th>
<th>Potential Barriers to Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frontenac Arch Biosphere Reserve</td>
<td>-Higher than local landscape policy</td>
<td>-Staffing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Financial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Behavioural</td>
</tr>
<tr>
<td>2</td>
<td>Office of Climate Change in New York State</td>
<td>-Improve riparian zone management</td>
<td>- Staffing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Invasive species management</td>
<td>- Financial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Storm water runoff management</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Nature Conservancy of Canada</td>
<td>-Economic incentives</td>
<td>- Financial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Behavioural</td>
</tr>
<tr>
<td>4</td>
<td>St. Lawrence Islands National Park</td>
<td>-Mix of public consultation with identified key issues from State of Environment reports</td>
<td>-Behavioural</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Local adaptation strategies</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Ontario Parks</td>
<td>-Manage with different climate scenarios in mind</td>
<td>- Intellectual</td>
</tr>
<tr>
<td>6</td>
<td>Trees Ontario</td>
<td>-Enhanced connectivity over the landscape</td>
<td>- Intellectual</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Assisted migration</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>St. Lawrence Islands National Park</td>
<td>-Maintenance of linkages and promote wildlife movement</td>
<td>-Behavioural</td>
</tr>
<tr>
<td>8</td>
<td>Parks Canada</td>
<td>-Vulnerability assessment</td>
<td>-Intellectual</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Institutional</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Financial</td>
</tr>
</tbody>
</table>
5.3 Discussion and Recommendations

Natural resources management in the face of a shifting climate is a complex issue that makes parks and protected areas integral components in the struggle to maintain biodiversity maintenance. Ecological-resources management is critical to the success of a park. Parks provide many services, including: ecosystem services, habitat for wildlife, recreational outlets for humans, and resource extraction to name but a few. Of that short list of park activities, it is already apparent that certain uses conflict with one another. The ecological issue of providing habitat for species in a changing climate is an environmental management problem facing all protected areas.

5.3.1 Perceived Threats of Climate Change

From the interview responses, climate change is viewed as a high concern for many of the protected areas within the A2A corridor. Participants state that they are aware that climate change is altering the landscape, but the effects are at such a large scale and over a relatively slow time scale; that they have more pressing management issues that need their attention. Climate change has been a driving factor for many conservation scientists to start developing methods to anticipating impacts and identify priority places to protect in order to maintain biodiversity (Young et al., 2005; Department of Environment and Climate Change NSW, 2007). Suffling and Scott (2002) paper entitled Assessment of Climate Change Effects on Canada's National Park System examined the magnitude of climate change predicted for National Parks in Canada. The paper includes regional climate change impacts in the Great Lakes – St. Lawrence Basin Parks, which is located in the middle of the A2A corridor, and includes impacts comprising of: lower average Great Lake water levels and less summer stream flow; increased lake and stream water temperatures; reduced lake ice-cover and earlier spring freshet, later
freeze-up in fall; less cold-water fish habitat; altered breeding/spawning and migration patterns (especially fish); reduced significant wetland areas; increased forest fire occurrence and intensity (more early successional ecosystems); altered successional trajectories; exacerbated acid rain stress; increased forest disease and insect outbreaks; increased mixed and deciduous forest, less boreal forest; and expansion of southern exotics (Suffling and Scott, 2002).

Climate change is an important environmental issue and is considered by many to be one of the most important issues in the future (Millennium Ecosystem Assessment, 2005; IPCC 2007). The global climate has been shifting since the industrial era and this change is projected to continue throughout the twenty-first century. Climate change has lasting effects on species distributions, population sizes, disrupting effects on reproduction and/or migration events, and increases the frequency of pest and disease outbreaks in forested systems (Millennium Ecosystem Assessment, 2005). The possible consequences of climate change in terrestrial ecosystems are likely to be changes in precipitation and warming in various ways (Thuiller, 2007). Sala et al. (2000) found that for terrestrial ecosystems under the stress of climate change, coupled with changes in land-use will have the largest effect. It is important to conserve habitat and corridors.

According to the World Conservation Union (2010), habitat loss and degradation and invasive alien species have been identified as stressors for most protected areas. These threats are exacerbated by other factors over which protected area managements have no control, such as the emerging effects of climate change. By minimizing habitat loss and invasive species stressors, ecosystems are less susceptible and more resilient to the increasing threat posed by climate change.
5.3.2 Assessment and Monitoring

A major inhibiting factor in making appropriate management decisions is the lack of data from which to make decisions. The problem originates with the lack of money and resources allocated to the proper collection of this data. For example, the Environmental Monitoring and Assessment Network (EMAN), which observes changes in ecosystems, lost 80 per cent of its budget in the 2007 (CBC, 2007) and is now totally gone. Canada’s version of the UNESCO Programme on Man and the Biosphere (MAB) is located within EMAN (Environment Canada, 2003). The MAB program originated from one of the Biosphere Conferences held in Paris in 1968, which concluded that countries must develop greater capabilities for undertaking cross-disciplinary research linked to policy and management issues for environmental conservation (Environment Canada, 2003).

Long-term observations and monitoring of previously sampled areas can observe changes in biodiversity. Climate change and other environmental stressors interact together over the landscape. An example of climate change compounding an additional stressor is invasive species. Change in climate can trigger alterations in biodiversity by creating opportunities for alien species by potentially enhancing their reproductive capacity, their survival and their competitive power against the native flora and fauna (Thuiller, 2007). Reduced areas of natural habitat and corridors linking such habitats are likely to promote biotic homogenization in biodiversity hotspots (i.e. the Frontenac Axis), and to foster unpredictable interactions between flora and fauna. Park managers need to forecast potential impacts of climate change on biodiversity. There are possible solutions to the decrease in funding to monitoring and research organizations.
Citizen science is a form of data collection that trains and involves community volunteers in local resource management issues (Carr, 2004). This form of data collection has its advantages and disadvantages. The advantage of using citizen science includes the low cost collection of large amounts of data over a large spatial scale, as well as educating the public about certain resource management issues (Carr, 2004). The limitations to using citizen science are that: methodology has to be simplified; work must be enjoyable for the volunteers (data collection can often be boring and tedious); there is the risk that the data won’t be useful; and that the data may not be reliable (Carr, 2004; Ferrer et al., 2006). Given these drawbacks, it is apparent that more resources need to be allocated to proper research and data collection techniques in order for sustainable land use and management for the future.

Along the Appalachian Trail Cohn (2008) stated that protocols should set parameters that limit the complexity of data collection by citizen scientists. Citizen scientists identify, document, and count 5 to 10 easily recognized indicator species rather than be expected to recognize all species in a given area. Guide books and other printed materials can be made available to help volunteers with data collection. To avoid weak data, the selection of ecological indicators, the development of robust study design, and the establishment of monitoring thresholds and targets are needed (Yeates & Zorn, 2005).

Citizen science can be a reliable method of gathering data and conducting research. Delaney et al. (2008) found that the establishment of an accurate monitoring network to assess the presence of invasive and native crab species was feasible with the assistance of citizen scientists. During data collection Delaney et al. (2008) created and enforced eligibility criteria for the citizen sciences. Data collected in such a manner can be added to large-scale, standardized database that could fill in gaps in current monitoring systems across the landscape.
It is crucial for this database be made available to managers of parks and protected areas across the landscape via the World Wide Web and geographical information systems as a means for data entry and sharing. Given the large scope and complexity of global climate change, no single agency or organization can manage for the landscape alone. Therefore, partnership is a fundamental prerequisite to adaptive management.

5.3.3 Policy

None of the parks or protected areas within the study area has any specific policy regarding climate change. State of Environment reporting is localized in park level issues and utilizes data from park on these conditions. Some of the concerns are tied to climate change but not exclusively. When starting this research, I expected that climate change would be a high priority concern due to its possible effects on ecosystem services and landscape function; however, from reading over interview transcriptions and coding, it appears as though there is very little priority being given to this issue. There needs to be dedicated research underway regarding the effects of climate change on the A2A corridor and political support needs to be mobilized.

Maintenance of corridors with a diversity of habitat types is critical to the resiliency of substantial number of bird and mammal species. Climate change policy within the A2A could benefit by taking an adaptive approach. There are numerous ecological uncertainties surrounding global climate change that knowledge and research needs to be systematically updated through policy development (Peterson et al., 1997). While climate change occurs on a global scale, this approach could occur on a regional level to assess opportunities and then adjust policies. The most important factor is to push for is clarity in policy.
There is a trend of increasing levels of visitation to park areas while there is a simultaneous decrease in tax-based budget resulting in lowered management effectiveness relating to many policies including climate mitigation. If climate change policy is not quickly recognized in policy there will be a biodiversity loss that may obstruct protected areas to maintain overall ecosystem services and functions. The vast majority of the proposed strategies for managing resources in a changing climate are general concepts. These concepts can be loosely grouped into three basic types of strategies: those promoting resistance, resilience, and change (Miller et al., 2007). Multiple levels of information are needed to make effective decisions, and the ideal indicators for measuring ecosystem integrity need to incorporate information from multiple scales (Andreasen et al., 2001).

Such a monitoring system would be comprehensive and multi-scale, relevant and helpful, and is flexible and measurable (Jones, 2005). This feedback system is demonstrated in Figure 7. The adaptive management cycle includes studying, monitoring and managing ecosystems to providing scientific based information for decision-making. The adaptive management cycle presented by Jones (2005) supports evidence based adaptive management by following four basic steps: Firstly, there needs to be a plan where management objectives are determined and clear management goals and desired outcomes and indicators are established. Only when outcomes and indicators are articulated, management strategies and actions can be developed. Secondly, monitoring programs need to be established to track how management is progressing towards desired outcomes. Thirdly, findings need to be evaluated and recommendations from evaluation to guide future management plan development, and lastly management performance should be adjusted and incorporated into future management plan.
Fleming and Baker (2002) state that the cycle of adaptation management is most useful when there are significant uncertainties regarding the effects of potential management policies. Adaptive management includes vulnerability (the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change) and uncertainties into the design of policy and management direction through continuous evaluation and adjustments (Yeates & Zorn, 2005).

6.0 Conclusion:

Climate change is ecologically intertwined with other forms of large-scale change such as invasive species movement and habitat loss leading to areas of decreased biodiversity. Study area representatives in the A2A corridor were interviewed to assess their perceived threats induced by climate change, state of current monitoring and assessment regime, and to gage the existence or
creation of new policy relating to climate change. Across the A2A landscape the various
government and non-governmental organizations have not been interview to assess what
individual organizations and areas are doing to conserve biodiversity. This is important work as
the future will become more erratic, the A2A corridor can remain intact to allow for migration. If
not parks and protected areas within the corridor are not managed correctly, biodiversity will
decline as will ecological integrity.

Study area participants perceived the threats of climate change as a high concern for many of
the protected areas within the A2A corridor. Participants state that they are aware that climate
change is altering the landscape through biotic responses to climate change and impacting the
ability of species to move across a fragmented landscape. The effects of global climate change
are at such an immense scale and have occurred over a relatively slow time scale, most
participants believed there were more immediate management issues which required their
attention. Climate change is an accelerating environmental issue that can interact with other
environmental stressors such as invasive species, habitat loss, and increased extreme weather
events.

Monitoring and assessment is an essential tool to protect and conserve biodiversity. Within
the study areas, there is no integrated or consistent standardized monitoring or assessment being
done. There is monitoring and assessment projects being completed within the study areas,
however, each are using dissimilar indicators and data sources. All participants stated a financial
barrier to completing timely and consistent monitoring. Citizen science is extremely important in
the current climate of budget cuts and partnerships act to distribute knowledge across the
landscape. Citizen science can aid organizations within the A2A corridor with smaller operating
budgets gather and distribute data when common ecological factors are decided upon.
Protected areas are susceptible to climate change and need strategic policies to aid in their conservation. There exists no specific climate change policy for each of the study areas. Adaptive management is one strategy to improve our understanding of the likely effects of future climate on biodiversity. The acknowledgement of the impact of climate change on the A2A corridor into an adaptive management cycle will allow for policy to be updated as data and research becomes available.

Possible areas for future research would be to interview the missing stakeholders (Algonquin Provincial Park, Charleston Lake Provincial Park, Frontenac Provincial Park, and Adirondack State Park) to gain further in-depth views on the threats, monitoring and assessment, and policy development in those parks.
7.0 Work Cited


Appendix A – Consent Form and Letter of Information Used in this Study

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Samantha Tavenor of the School of Environmental Studies at Queen’s University. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher.

This project has been reviewed by, and received ethics clearance through, the Office of Research Ethics at Queen’s University. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Director, Office of Research Ethics at (613) 533-6081

If you have any questions, concerns or complaints about the research you may contact:

Dr. Joan Stevenson, Research Ethics Board, Professor, School of Kinesiology & Health Studies Queen’s University Email: chair.GREB@queensu.ca Phone: (613) 533-6081

Prof Brian Cumming, Advisor, 3134A Bioscience Complex, 116 Barrie St, Queen's University Email: cummingb@queensu.ca Phone: 613-533-6153

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☐ YES ☐ NO

I agree to have my interview audio recorded.

68
I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

Participant Name: ____________________________ (Please print)

Participant Signature: __________________________

Witness Name: ________________________________ (Please print)

Witness Signature: _____________________________

Date: ____________________________

Letter of Information

Department Letterhead

Queen’s University

October 20th 2012

This letter is an invitation to consider participating in a study I am conducting as part of my Master’s degree in the School of Environmental Studies at Queen’s University under the supervision of Professor Brian Cumming. I would like to provide you with more information about this project and what your involvement would entail if you decide to take part.

My research of interest for my Master’s of Environmental Studies is climate change policy in protected natural areas in the Algonquin to Adirondack (A2A) corridor. The A2A corridor is an immense cross-border collage of ecological communities stretching from Algonquin Park in Ontario, Canada to Adirondack Park in New York, United States. The purpose of the research is to determine what is happening in the A2A corridor caused by climate change, how it is projected to change and to identify what policies currently exist at the park level.
This study will focus on interviewing Park Rangers and park managers on what climate change policies and mandates currently exist within the A2A corridor at the park level. Stresses of a global nature, such as climate change, affect ecological integrity within parks. Parks are part of interconnected ecosystems and very much reflect the state of the larger regions where they are located. My study can identify lessons that can be learned from the case study of climate change adaptation planning in the A2A corridor. I believe that because you are actively involved in the management and operation of (insert park name), you are best suited to speak to the various issues, such as climate change policy.

Participation in this study is voluntary. It will involve an interview of approximately (1 hour) in length to take place in a mutually agreed upon location. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. Shortly after the interview has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. All information you provide is considered completely confidential. Your name will not appear in any thesis or report resulting from this study, however, with your permission anonymous quotations may be used. Data collected during this study will be retained for (insert time period) in a locked office in my supervisor's lab. Only researchers associated with this project will have access. There are no known or anticipated risks to you as a participant in this study.

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact me at 613-888-1593 or by email at 11st33@queensu.ca. You can also contact my supervisor, Professor Brian Cumming at 613-533-6153 or email cummingb@queensu.ca

I would like to assure you that this study has been reviewed and received ethics clearance through the General Research Ethics Board at Queen’s University. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Joan Stevenson of this office at chair.GREB@queensu.ca or (613) 533-6081.

I hope that the results of my study will be of benefit to those organizations directly involved in the study, other voluntary recreation organizations not directly involved in the study, as well as to the broader research community.

I very much look forward to speaking with you and thank you in advance for your assistance in this project.

Yours Sincerely, Samantha Tavenor
CONSENT FORM

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Samantha Tavenor of the School of Environmental Studies at Queen’s University. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher.

This project has been reviewed by, and received ethics clearance through, the Office of Research Ethics at Queen’s University. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Director, Office of Research Ethics at (613) 533-6081

If you have any questions, concerns or complaints about the research you may contact:

Dr. Joan Stevenson  
Research Ethics Board, Professor, School of Kinesiology & Health Studies Queen’s University  
Email: chair.GREB@queensu.ca Phone: (613) 533-6081

Prof Brian Cumming  
Advisor, 3134A Bioscience Complex, 116 Barrie St, Queen's University  
Email: cummingb@queensu.ca Phone: 613-533-6153

<table>
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<tr>
<th>Responsibility</th>
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<tbody>
<tr>
<td>Researcher</td>
<td>1. Submit the online Ontario Protected Areas Research Application</td>
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<td>Protected Area Research Analyst</td>
<td>2. Acknowledge receipt of the application to the Researcher</td>
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<td>3. Enter the research application into the database</td>
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<td>4. Ensure the researcher has met the previous research authorization requirements (e.g., submission of all required data and reports)</td>
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<td>5. Forward the research application to Review Coordinator</td>
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<tr>
<td>Review Coordinator</td>
<td>6. Advise the researcher that the authorization under the PPCRA may be held until other required authorizations (e.g., Endangered Species Act Permits, Animal Care Committee, Wildlife Scientific Collectors Authorization) are issued</td>
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<td>7. Forward the research application to the Reviewers</td>
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<td>Researcher</td>
<td>8. Submit any other authorizations or permits required (e.g, Animal Care Protocol; First Nation discussions; etc) to the Review Coordinator</td>
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<td>Reviewers</td>
<td>9. Consider the criteria provided in the Research Authorization Policy and provide comment on the research application, posing questions for the researcher as appropriate, recommending Class EA screening, where appropriate, and providing specific wording for project specific conditions to the Review Coordinator</td>
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<td>Review Coordinator</td>
<td>10. Coordinate the review, questions and discussions between MNR and Researcher</td>
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<td>• Attempt to clarify/adjust the project with the researcher to address the concerns raised. Some overlap with Steps 8 and 9 may occur.</td>
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<td>11. Draft the authorization letter and send it to the reviewers</td>
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<td>Reviewers</td>
<td>12. Comment on the draft authorization letter to the Review Coordinator, providing specific changes where appropriate</td>
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<td>Review Coordinator</td>
<td>13. Submit the revised authorization letter to Park Superintendent(s) and Conservation Reserve Manager(s) for review</td>
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<td>Park Superintendent(s) and/or Conservation Reserve Manager(s)</td>
<td>14. Review the authorization letter</td>
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<td>15. Submit the written recommendation for approval or denial to the Review Coordinator. An email from their account is acceptable.</td>
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<td>Review Coordinator</td>
<td>16. Receive the written approval or denial from all the affected Park Superintendents and Conservation Reserve Managers</td>
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<td>17. Submit the authorization letter to Responsible Manager for signature</td>
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<td>Responsible Manager</td>
<td>18. Inspect and sign the authorization letter</td>
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<tr>
<td>Review Coordinator</td>
<td>19. Send a copy of signed authorization letter to the Researcher, with copies to:</td>
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<td>• Affected Provincial Park Superintendents</td>
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- Affected Conservation Reserve Managers
- Affected Zone Managers
- Affected District Managers
- Protected Area Research Analyst

| Researcher | 20. Sign and return a copy of the authorization letter to the Review Coordinator
21. Conduct the research
22. Submit the data and the reports to the Review Coordinator and copies to the Protected Area Research Analyst |

| Protected Area Research Analyst | 23. Ensure the receipt of data and reports1
24. Upon receipt of the data and reports, send copies to the appropriate staff and then place it in Ontario Parks library and MNR library
25. If necessary, process the requests for research extensions
   - Extension reviews should be considered and conducted by assigned review coordinators.
   - If application is less than three years old:
     i. if no methodological changes, the Responsible Manager may issue the extension without review
     ii. if the methodological changes, review will be undertaken with focus on changes by those involved in the initial review
   - If application is three years old or more a new application and full review is required |
Appendix C – General Research Ethics Board Approval Letter for this Study

April 13, 2012

Ms. Samantha Tavener
Master’s Student
School of Environmental Studies
Queen’s University
Kingston, ON K7L 3N6

GREB Ref #: GENC-049-12; Romeo # 6006746
Title: “GENSC-049-12 Climate change policy in protected natural areas in the Algonquin to Adirondack (AD) corridor”

Dear Ms. Tavener:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled “GENSC-049-11 Climate change policy in protected natural areas in the Algonquin to Adirondack (AD) corridor” for ethical compliance with the Tri-Council Guidelines (TCPS) and Queen’s ethics policies. In accordance with the Tri-Council Guidelines (article D.1.6) and Senate Terms of Reference (article G), your project has been cleared for one year. At the end of each year, the GREB will ask if your project has been completed and if not, what changes have occurred or will occur in the next year.

You are reminded of your obligation to advise the GREB, with a copy to your unit REB, of any adverse event(s) that occur during this one year period (access this form at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Adverse Event Report). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes to the level of risk, applicant characteristics, and implementations of new procedures. To make an amendment, access the application at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Amendment to Approved Study Form. These changes will automatically be sent to the Ethics Coordinator, Gail Irving, at the Office of Research Services or girving@queensu.ca for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

Joan Stevenson, Ph.D.
Professor and Chair
General Research Ethics Board

cc: Dr. Brian Cumming, Faculty
Appendix D – Interview Questions for this Study

Threats of Climate

1. Has climate change affected name of Park? Or perhaps, are you concerned about climate change affecting this region? (Please circle answer on scale below, 1 being not a concern and 10 being of extreme concern)

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2. In regards to what you are mandated to do, where do you place climate change as a driving force affecting name of Park?

3. What potential positive and/or negative impacts do you view climate change possessing on name of Park?

4. What encouragement have you received to consider climate change into your management?

5. Where do you see name of Park fitting into the landscape in 20-50 years in the short term and 100 years in the long term? What alterations could you see happening as a result of climate change?

Monitoring and Assessment

6. Are you monitoring climate change at name of Park? What indicators are you using?

7. How might you use models to determine the impact of climate change on name of Park?

8. What management options are required or already available to reduce climate change or already identified indicators of climate change?

Policy

9. What steps towards an adaptation strategy are you taking at name of Park?

10. What are the potential barriers to the implementation of this plan?

11. How well do natural resource managers at name of Park define climate change and how does that affect the region? (Please circle answer on scale below, 1 being no understanding of the concept and 10 being in-depth, academic understanding)

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12. Which species in name of Park will adapt naturally and which species might require active management in the face of climate change?
13. What existing park policies will have to evolve to include climatic impacts on the environment? What policies that should exist to address the issue of climate change, and its subsequent effects on *name of Park*?

14. Is there anything else you would like to add?