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Changing Climate, Challenging Choices: Identifying and Evaluating Climate Change Adaptation Options for Protected Areas Management in Ontario, Canada

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Abstract Climate change will pose increasingly significant challenges to managers of parks and other forms of protected areas around the world. Over the past two decades, numerous scientific publications have identified potential adaptations, but their suitability from legal, policy, financial, internal capacity, and other management perspectives has not been evaluated for any protected area agency or organization. In this study, a panel of protected area experts applied a Policy Delphi methodology to identify and evaluate climate change adaptation options across the primary management areas of a protected area agency in Canada. The panel identified and evaluated one hundred and sixty five (165) adaptation options for their perceived desirability and feasibility. While the results revealed a high level of agreement with respect to the desirability of adaptation options and a moderate level of capacity pertaining to policy formulation and management direction, a perception of low capacity for implementation in most other program areas was identified. A separate panel of senior park agency decision-makers used a multiple criterion decision-facilitation matrix to further evaluate the institutional feasibility of the 56 most desirable adaptation options identified by the initial expert panel and to prioritize them for consideration in a climate change action plan. Critically, only two of the 56 adaptation options evaluated by senior decision-makers were deemed definitely implementable, due largely to fiscal and internal capacity limitations. These challenges are common to protected area agencies in developed countries and pervade those in developing countries, revealing that limited adaptive capacity represents a substantive barrier to biodiversity conservation and other protected area management objectives in an era of rapid climate change.

Keywords Climate change · Parks · Protected areas · Adaptation · Conservation · Management · Policy · Policy Delphi

Introduction

Among the many challenges confronting protected area agencies and organizations, climate change has emerged as a topic of international concern (e.g., Hannah and others 2002; Welch 2005; Lemieux and Scott 2005; Dunlop and Brown 2008; Heller and Zavaleta 2009; Baron and others 2009; Lemieux and others 2011a; Lindenmayer and others 2010). The global estate of protected areas has largely been justified based on the concepts of ecological representation and stable heritage assets. Such approaches to conservation, designed to protect specific natural features, species, and ecological communities and processes in-situ, have not taken into account potential shifts in ecosystem composition, structure, and function that are anticipated to occur as a result of global climate change.

While the body of research and discourse on biodiversity conservation, protected areas, and climate change

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adaptation has burgeoned in recent years (e.g., Scott and Lemieux 2005; Heller and Zavaleta 2009; Baron and others 2009; Lemieux and others 2011b), there continues to be a limited response from practitioners both in policy development and implementation of policy and management strategies (West and others 2009; Lawler and others 2009; Scott and Lemieux 2007; Lemieux and others 2011a). There are several possible explanations for this lack of action. First, the scientific literature on the subject has been dominated by ecology and has failed to integrate social science considerations (e.g., decision-making, policy formulation, etc.) (Heller and Zavaleta 2009; Lemieux and others 2010). Second, protected area management objectives that extend beyond the biological realm have been largely ignored in climate change impact assessments (e.g., tourism and recreation, ecosystem services, and human health and well-being) (Lemieux and others 2010). Third, the high degree of uncertainty in climate change impact assessments makes them difficult for managers to translate into practical management decisions (Dessai and others 2009; Lawler and others 2009). Finally, the protected area and climate change adaptation literature has not investigated the desirability or feasibility of adaptation options by those responsible for the planning and management of protected areas (Lemieux and others 2010). As Welch (2005) emphasized, this literature provides little guidance to the managers of already established protected areas.

Climate change adaptation planning by protected areas agencies is important for three main reasons: (1) climate change is already impacting protected areas ecosystems and other natural assets (e.g., the distribution and composition of species; landscape physiography; and the provision of recreational opportunities); (2) despite efforts to reduce greenhouse gas (GHG) emissions, some level of human-induced change will occur in the twenty-first century; and (3) proactive adaptation will be more cost effective and efficient than reactive responses in reducing the potential for irreversible impacts, such as species extinctions, and in exploiting potential benefits (Smit and others 1999; Thomas and others 2006; Stern 2006; IPCC 2007; Lemmen and others 2008; Lemieux and others 2010, 2011a).

Protected areas remain the fundamental building blocks of virtually all conservation strategies and are supported by governments and international institutions through various measures, including the *Convention on Biological Diversity* (Article 8). Climate change impacts will likely affect whether or not the goals of protected area agencies can be achieved, goals that universally include the permanent protection of representative ecosystems, the maintenance of ecological integrity, and the provision of opportunities for outdoor recreation. Accordingly, the objective of the research is to facilitate the process of climate change adaptation (mainstreaming) within a Canadian protected area agency, Ontario Parks. Mainstreaming refers to the integration of climate change adaptation considerations (or climate risks) such that they become part of policies, programs, and operations at all levels of decision-making (UNDP 2005). The mainstreaming of adaptation considerations into existing institutional decision-making processes can lead to policies that reduce vulnerability to climate change and better position agencies to exploit opportunities while simultaneously addressing other priorities (Lemmen and others 2008; Ogden and Innes 2009).

Study Area

The Canadian province of Ontario is home to more than 25,000 species of plants and animals (including invertebrates) located over 1.1 million square kilometers, 250,000 inland lakes, the Great Lakes, and countless watersheds (NHIC 2007). Ontario is also home to nearly 50% of Canada's endangered species. The institutional environment in which protected areas are embedded in Ontario is hierarchical and strongly compartmentalized. Two federal departments (Parks Canada Agency and Environment Canada), a provincial ministry [Ontario Parks, a branch of the Ontario Ministry of Natural Resources (MNR)], watershed management agencies (i.e., Ontario's 36 Conservation Authorities), municipalities, and a number of non-governmental organizations (e.g., The Nature Conservancy of Canada) operating at various and sometimes overlapping ecological and jurisdictional scales, are responsible for the province's protected area estate. Ontario Parks is the largest land manager, with 331 provincial parks, 303 conservation reserves, and 11 wilderness areas. Collectively, Ontario Parks protected areas cover 9.5 million ha (approximately 9%) of the province's terrestrial base (Ontario Parks 2009; Environment Canada 2010).

Methods

Climate Change Adaptation Planning Within Ontario Parks

The Ontario Ministry of Natural Resources (MNR) first recognized climate change as a vulnerability in its *Strategy and Action Plan on Climate Change* (MNR 2006). The action plan also recognized the need to begin implementing adaptation options. Accordingly, researchers at the University of Waterloo, the MNR, and Ontario Parks have engaged in scientist-stakeholder collaboration since 2004, using a seven-step climate change adaptation framework (Fig. 1). Step one, engaging stakeholders, began with an Ontario

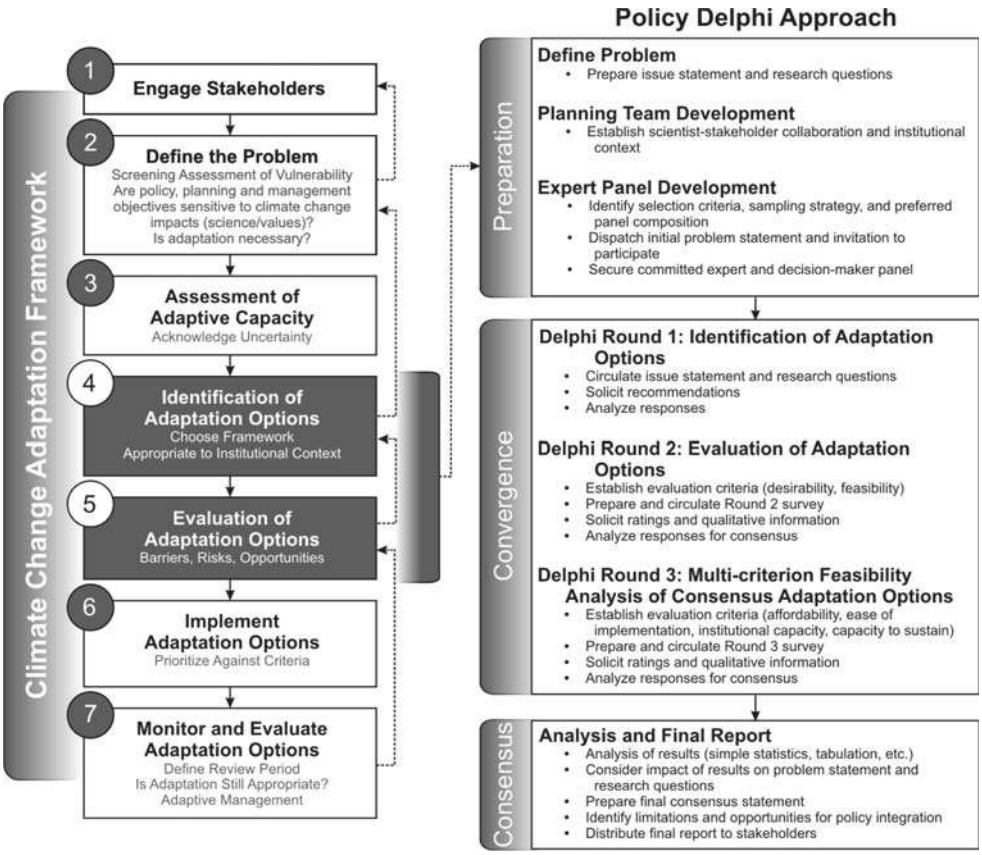

Fig. 1 The methodological approach used to identify and evaluate climate change adaptation options. The Policy Delphi approach detailed in this manuscript is nestled within the seven-step framework developed by Lemieux and others (2008) to facilitate climate change adaptation in Ontario Parks. The figure was developed using information from Lemieux and others (2008), UNEP (2008), and Donohoe and Needham (2009)

Parks manager workshop on climate change (Beveridge and others 2005). Steps five and six work towards identifying and evaluating adaptation options and are the objectives of the research presented here. The progression of the seven-step framework culminates with the implementation, monitoring, and evaluation of climate change adaptation options.

The Policy Delphi as an Idea Generation Strategy

There is no single correct procedure to undertake climate change adaptation (UNEP 2008), and various methodologies and decision-facilitation tools are applied to the identification and evaluation of climate change adaptation options. Examples include scenario planning (Peterson and others 2003), emerging issues analysis, multi-criterion analysis (UNDP 2005), and Idea Generation Strategies (IGSs) using expert judgment (e.g., workshops, focus groups, and the Policy Delphi) (Linstone and Turoff 2002; Donohoe and Needham 2009). No methodology, however, has been applied to the protected area sector. Each methodology has strengths and weaknesses and the utility of each depends on a number of factors, including the stakeholders involved (e.g., level of expertise, willingness to be engaged, etc.) and the availability of financial and other resources. After considering the availability of financial and human resources, the planning team selected the Policy Delphi as the most effective and efficient approach to address the research objectives.

In its broadest sense, a Policy Delphi is an iterative, group-oriented IGS that seeks to generate the strongest possible opposing views on the potential resolution of a policy issue (Turoff 1975; de Loë 1995; de Loë and Wojtanowski 2001; Donohoe and Needham 2009). The approach permits a diverse group of people, selected for their expertise, to interact anonymously on a defined policy issue and provides a constructive forum and a structured method for correlating views and information pertaining to a policy issue. By design, participants are afforded the freedom to present and challenge alternative viewpoints, and to think independently between iterations (Needham and de Loë 1990). Unlike the conventional Delphi, which explicitly seeks to create consensus, a Policy Delphi aims to uncover both consensus and disagreement on policy issues (Linstone and Turoff 2002; Donohoe and Needham 2009).

The Policy Delphi is a cost-effective way to engage stakeholders dispersed over large geographic regions and overcomes many of the limitations associated with committee or workshop processes, including dominating personalities, the awkwardness of taking positions that contradict individuals in higher positions, unwillingness to abandon a position, and fear of bringing up or supporting an uncertain idea that might result in loss of face. Because

a Policy Delphi is anonymous, it provides respondents with the opportunity to present innovative and sometimes controversial ideas to the panel without fear of repercussion. This freedom of expression is particularly important in the area of climate change adaptation in protected areas because some adaptations proposed in the conservation literature would require fundamental changes to how protected area agencies have traditionally planned and managed lands, and the adaptations may be controversial (e.g., conservation triage). Overall, the Policy Delphi approach is an effective tool for identifying solutions to complex policy problems characterized by significant uncertainty (Donohoe and Needham 2009). It is also suitable for situations where policy lacks historical precedent and exact knowledge is not available, such as climate change (UNDP 2005; Donohoe and Needham 2009).

The Policy Delphi approach adopted here used three survey iterations (Fig. 1). The first iteration presented a technical expert panel with climate change impacts and challenges related to Ontario Parks' six major program areas and solicited the panel's recommendations on possible adaptations. The second survey iteration focused on evaluating recommendations for their perceived desirability and feasibility. A separate panel of Ontario Parks senior decision-makers was established to further evaluate the feasibility of recommendations that the technical expert panel perceived to be the most desirable via a third survey iteration. A structured, multi-criterion feasibility matrix was developed and used to conduct the third survey evaluations.

Participants

Linstone and Turoff (2002) and de Loë (1995) recommended that a minimum of 10 and a maximum of 50 participants be included in a Policy Delphi exercise. After considering the complexity and novelty of the policy issue being examined, and to better ensure the solicitation of varying perspectives on climate change adaptation options, the research team attempted to achieve the higher range of this recommendation. Attempts were also made to engage experts with diverse professional backgrounds (e.g., ecologists, geographers, business administrators, political scientists, and communication and outreach coordinators) and with expertise representative of Ontario's diverse landscapes. Forty-five ($n = 45$) protected areas experts, including Ontario Parks practitioners ($n = 25$); Parks Canada Agency; Canadian Heritage Rivers and Canadian Wildlife Service practitioners ($n = 6$); academics ($n = 8$); non-governmental organizations ($n = 3$); and private agencies ($n = 3$), responded to the initial survey. Thirty-four ($n = 34$) individuals from the initial panel completed the second-round survey (76%).

To further evaluate the recommended adaptation options for their potential management applicability and to prioritize them for consideration in a climate change adaptation plan for Ontario's protected areas, a separate panel of 13 Ontario Parks senior decision-makers was established. The panel evaluated the adaptation options that were assessed to be "Very Desirable" and/or "Desirable" by at least 90% of the initial expert panel. Adaptation options that were assessed to be ambiguous were also included in the evaluation in case they become desirable in some future context.

Process and Results

Policy Delphi First Survey Iteration: Process and Results

The initial technical expert panel was asked to respond to eight questions structured according to Ontario Parks' major management program areas, using an electronic survey (Table 1). Collectively, 1,130 climate change adaptation options were identified. Recommendations were articulated very differently, ranging from brief sentences to detailed paragraphs expressing an adaptation option and its rationale. Recommendations also ranged from what may be considered fairly innocuous (e.g., "*A strategic and corporate policy on climate change and protected areas is needed to provide sufficient direction for planning and management*") to innovative (e.g., "*The establishment of new protected areas classes should be considered. Evolutionary baseline class parks, for example, could allow for natural evolution and be used to research, monitor, and demonstrate ecosystem changes*") to controversial and in direct conflict with current policy and management practice (e.g., "*Ecological representation should no longer be used as one of the five criteria for selecting and designing protected areas*"; "*Deregulating parks should be explored as an option should a protected area no longer achieve its original protection mandate*"). Because panelists provided very similar recommendations, a great deal of synthesis was required to condense the recommendations to 165 distinct adaptation options that would be evaluated in the second-round survey. The 165 recommended adaptation options organized by major program area are listed in Online Appendix 1.

Policy Delphi Second Survey Iteration: Process and Results

The initial technical expert panel used a five-point Likert scale (Fig. 2) to evaluate the 165 adaptation options identified in the first survey iteration for their level of

Table 1 Questions used to solicit adaptation options from the initial technical expert panel

Management area	Questions
Policy, System Planning and Legislation (PSPL)	How could Ontario Parks adapt current protected areas system planning to include climate change considerations? What are we trying to conserve? Is there a need to recalibrate conservation goals?
Management Direction (MD)	How could Ontario Parks adapt active management plans such as species-at-risk, fire management and invasive species, to include climate change considerations?
Operations and Development (OD)	What could Ontario Parks do 'in-house' to reduce GHG emissions?
Research, Monitoring and Reporting (RMR)	What are the research, monitoring and reporting priorities with regards to climate change?
Corporate Culture and Function (CCF)	How could Ontario Parks ensure that staff receives appropriate training with respect to climate change?
Education, Interpretation and Outreach (EIO)	How could climate change be more fully integrated into park interpretation programs to educate the public on climate change, biodiversity, and protected areas issues?

desirability and feasibility. Similar to de Loë and Wojtanowski (2001), for each adaptation option and criterion, the level of *consensus* (e.g., High, Medium, Low, None) among responses was established by determining the percentage of ratings in each evaluation class of the Likert scale (i.e., Desirability and Feasibility). A *point-of-agreement* (if such occurred) was identified when there was at least some consensus on the scoring (e.g., Very Desirable, Definitely Feasible, etc.). While non-responses and "Not Sure" responses were not included when calculating consensus, they were considered when evaluating the results of the analysis. Specifically, if more than one-third of respondents gave "No" or "Not Sure" responses, the evaluation of that criterion for that option was noted as unsatisfactory. Consensus was deemed as "Not Applicable" in these situations.

Tables 2 and 3 summarize consensus and points of agreement across the 165 climate change adaptation options for each evaluation criterion. Based on the thresholds noted in Fig. 2, consensus was assessed to be "High" within related categories (e.g., "Very Desirable to Desirable") for the majority of recommended adaptation options. The majority of recommendations were evaluated to be "Very Desirable" or "Desirable" (>80% of recommended adaptation options), and "Definitely Feasible" or "Possibly Feasible" (>85% of recommended adaptation options).

A high level of agreement was found among this diverse set of expert panelists and these diverse areas of conservation policy, planning, and management. The Policy Delphi process produced a large number of recommendations, but it is beyond the scope of this paper to discuss each individually. What follows is a selected but programmatically balanced discussion of options whose ratings generated agreement and/or disagreement within the expert panel or were in contrast with the expectations of the authors and/or the scientific literature on the subject. Evaluations are presented with a summary of qualitative responses that provide further insight into the diverse expert opinions.

Evaluation of Policy, System Planning and Legislation (PSPL) Adaptation Options

For the PSPL program area, a number of recommendations called for greater integration of climate change into Ontario Parks' management frameworks, management plans, principles, system planning approaches, and objectives. These recommendations were not surprising since many similar recommendations have appeared in the scientific literature over nearly two decades. However, a number of innovative adaptations were also identified. Only a single adaptation was evaluated as "Very Desirable to Desirable" and "Definitely Feasible" with "High" consensus. This statement recommended that, "*representation should continue to be used in protected areas system planning as a wider variety (diversity) of landform/vegetation associations being protected may increase the likelihood that different species and habitats will remain protected under climate change*" (PSPL.23). This result was somewhat unexpected given that the majority of the literature has emphasized that the ecological manifestations of climate change could render representation-based targets untenable over the long term (e.g., see Hannah and others 2002; Scott and others 2002; Araújo and others 2004) with only a limited number of assessments suggesting the contrary (e.g., Dunlop and Brown 2008; Lemieux and others 2011b).

Instead of eliminating the use of representation-based approaches, the panel stressed that persistence parameters should be incorporated into system planning and park establishment to better ensure the perpetual representation of species (PSPL.24). Panelists also believed strongly that policies should focus less on ecological pattern and more on ecological processes (PSPL.10) and that a unified policy on climate change was needed to provide clear direction for planning and management (PSPL.2). This recommendation

Example Recommendation

PSPL.2: A strategic and corporate policy on climate change and protected areas is needed to provide sufficient direction for planning and management.

Desirability

	VD	D	U	VU	Not Sure	CONSENSUS	DESIRABILITY
responses	25	6	0	1	2		
% with opinion	78.1%	18.8%	0.0%	3.1%	5.9%	**HIGH**	**Very Desirable**
% like categories	96.9%		3.1%				

VD=Very Desirable; D=Desirable; U=Undesirable; VU=Very Undesirable

Feasibility

	DF	PF	PU	DU	Not Sure	CONSENSUS	FEASIBILITY
responses	19	13	1	0	1		
% with opinion	57.6%	39.4%	3.0%	0.0%	2.9%	**HIGH**	**Definitely Feasible to Possibly Feasible**
% like categories	97.0%		3.0%				

DF=Definitely Feasible; PF=Possibly Feasible; PU= Possibly Unfeasible; DU= Definitely Unfeasible

= point of agreement

Fig. 2 Criteria used to evaluate recommended climate change adaptation options. *Consensus* is a measure of the degree to which the group agreed on the importance of the statement (e.g., Very Desirable, Definitely Feasible, etc.). The following categories are used: *High* 70% of ratings in 1 agreement category or 80% in 2 related categories[a]; *Medium* 60% of ratings in 1 agreement category or 70% in 2 related categories; *Low* 50% of ratings in 1 agreement category or 60% in 2 related categories; *None* less than 60% of ratings in 2 related categories[b]. [a] Related agreement categories for descriptors include: Desirability (Very Desirable to Desirable, Undesirable to Very Undesirable); and, Feasibility (Definitely Feasible to Possibly Feasible, Possibly Unfeasible to Definitely Unfeasible). [b] When consensus is 'None', agreement is always ambiguous ('None'). Thus, the respondent group is polarized on the assessment of the statement

Table 2 Consensus and desirability point-of-agreement matrix for 165 adaptation options

Consensus	Desirability									
	VD	D	VD to D	U	VU	U to VU	Not sure	None	Total	Total (%)
High	18	10	99	1	3	12	*0*	–	143	87.2
Medium	0	0	5	0	0	1	*0*	–	6	3.7
Low	0	0	2	0	0	2	*0*	–	4	2.4
N/A	–	–	–	–	–	–	*12*	–	12	7.3
None	0	0	0	0	0	0	*0*	–	0	0.0
Total	18	10	106	1	3	15	*12*	*0*		
Total (%)	11.0	6.1	64.6	0.6	1.8	9.1	*7.3*	*0.0*		

VD very desirable, *D* desirable, *VD to D* very desirable to desirable, *U* undesirable, *VU* very undesirable, *U to VU* undesirable to very undesirable

* An assessment was not applicable (N/A) in cases where 1/3 of the responses were either left blank and/or evaluated as 'not sure'

Italicized area ambiguity

supports previous findings that managers at the park level lack higher-level guidance in the implementation of adaptation options (Welch 2005; Dunlop and Brown 2008).

Finally, the recommendation that Ontario Parks should no longer attempt to protect highly vulnerable species and ecosystems (e.g., species at risk) and focus its limited resources instead on areas with a reasonable chance of

Table 3 Consensus and feasibility point-of-agreement matrix for 165 adaptation options

Consensus	Feasibility										
	DF	PF	PF to DF	PU	DU	PU to PF	Not sure	None	N/A	Total	Total (%)
High	4	13	101	0	0	0	*0*	–	0	118	72.0
Medium	0	0	16	0	0	0	*0*	–	0	16	9.8
Low	0	1	8	0	0	0	*0*	–	0	9	5.5
N/A	–	–	–	–	–	–	*3*	–	0	3	1.8
None	0	0	0	0	0	0	*0*	*1*	0	1	0.6
Total	4	14	125	0	0	0	*3*	*1*	0		
Total (%)	2.4	8.5	76.2	0.0	0.0	0.0	*1.8*	*0.6*	0.0		

DF definitely feasible, *PF* possibly feasible, *PF to DF* possibly feasible to definitely feasible, *PU* possibly unfeasible, *DU* definitely unfeasible, *PU to DU* possibly unfeasible to definitely unfeasible

* An assessment was not applicable (N/A) in cases where 1/3 of the responses were either left blank and/or evaluated as 'not sure'

Italicized area ambiguity

longer-term resilience was assessed to be "Undesirable to Very Undesirable" by the panel (64% of the panel with an opinion) (PSPL.40). However, a low consensus was revealed for this controversial recommendation: 47% of panelists with an opinion ($n = 16$) evaluated the recommendation as "Very Desirable to Desirable" or were "Not Sure" (18% of the entire panel) whether or not the recommendation was desirable. Similarly, when presented with the recommendation that highly vulnerable, disjunct/relict, and outlier species should receive higher protection in protected areas system planning, the panel was "Not Sure" (41% of the entire panel) whether it was desirable (PSPL.39). As one panelist explained, "*These questions are really about values. While I think that rare/relict species have intrinsic value and deserve attention and funding, I do not believe that a largely disproportionate amount of funding should be directed toward them to the detriment of species which hold more promise for persistence*." Conservation triage, i.e., the prioritization of conservation actions, may become more commonplace in an era of rapid climate change and Ontario Parks and other protected area agencies/organizations will need to consider many social and ethical issues in addition to the efficient allocation of financial resources.

Evaluation of Management Direction (MD) Adaptation Options

The majority of recommendations for the MD program area suggested the integration of climate change into management plans, such as those pertaining to invasive species, species at risk, ecosystem restoration, and visitor management. As in the PSPL program area, a number of recommendations within MD suggested that the role of protected areas in safeguarding valued ecosystems or species may have to be revised because of evolving ecological conditions. For example, while rejecting the elimination of the use of the representation principle in protected areas system planning, the panel did indicate that reassessing the role of individual protected areas at decadal intervals would be necessary under climate change (MD.3).

Similarly, the recommendation to incorporate climate change into protected area zoning [i.e., to recognize that park zones may need to shift across the landscape as (currently valued) species or ecosystems change, are lost, and new ones appear] was assessed as "Very Desirable to Desirable" with "High" consensus by the panel (MD.4). The acceptance of this recommendation by the panel suggests that the role of individual protected areas may have to change as Ontario's landscape changes. This recommendation was further supported in recommendation MD.5, where the panel deemed it both desirable and feasible to change park classifications (i.e., "Nature Reserve," "Natural Environment," and "Recreation" class parks) to accommodate protection values changing due to climate change (MD.5). For example, some protected areas originally established for recreation purposes may become more valuable in the protection of natural assets, such as species at risk, under changing ecological conditions. However, ironically, most panelists were not flexible on classification flexibility: while panelists deemed it acceptable to reclassify a "Recreation" class park as a "Nature Reserve" class park, they were less willing to accept the opposite (see MD.4).

The scientific literature has often suggested that operational definitions of "native" and "non-native" species and "species at risk" should be reassessed as the ecological manifestations of climate change begin to challenge their current operational definitions [see Scott and Lemieux (2005) and Hobbs and Cramer (2008) for discussions]. The position of the expert panel appears to be consistent with that of the scientific literature. Recommendation MD.10,

which suggests that the definitions of non-native, native species, and species at risk be re-evaluated with climate change considerations, was assessed by the panel as "Very Desirable to Desirable" and "Possibly Feasible."

The translocation of species at risk to areas of suitable habitat under changing climatic and ecological conditions has increasingly been debated in the conservation literature as an approach to assist species that are unable to adapt either in-situ or via self-migration (e.g., McLachlan and others 2007; Hoegh-Guldberg and others 2008; Carroll and others 2009; West and others 2009). When presented with the recommendation to consider species translocation, the panel was "Not Sure" of its desirability (MD.12). While a number of panelists indicated that translocation should be used to facilitate the migration of species at risk, others indicated that single-species management is often ineffective and expensive. However, a non-interventionist approach may not be politically feasible if the public objects to the potential loss of a highly valued species.

Evaluation of Operations and Development (OD) Adaptation Options

A number of recommendations for OD (i.e., management pertaining to infrastructure, business operations, transportation, and construction) suggested that it should be a priority for protected area agencies to become leaders in GHG reductions (e.g., showcase energy efficient technologies such as hybrid vehicles) (e.g., OD.2 and OD.3). Similarly, the panel believed strongly that the conservation sector should play an advocacy role in garnering widespread public support for GHG reductions (OD.3).

While the panel believed strongly that camping seasons should be extended in selected parks to take advantage of the potential increase in visitor use (OD.43) and that Ontario Parks should begin identifying staffing needs and challenges due to the possibility of an extended warm-season in the future (OD.44), the panel was "Not Sure" whether divesting winter programs was desirable despite the potential for a significant reduction in visitor use. A number of panelists indicated that extending camping seasons would place additional human resource and operational demands on parks.

Evaluation of Research, Monitoring and Reporting (RMR) Adaptation Options

The panel believed strongly that a climate change monitoring strategy should be developed in order to monitor trends and impacts, especially for regionally threatened species, extinction-prone species, and other target species (RMR.2 and RMR.3). The panel also believed strongly that Ontario Parks should begin establishing long-term monitoring sites on ecotones (i.e., species at the upper limits of their range) (recommendation RMR.5) and in non-disturbed protected areas (i.e., establish benchmarks for investigating climate change impacts) (RMR.13).

Evaluation of Corporate Culture and Function (CCF) Adaptation Options

With the exception of a single recommendation, all recommendations within the CCF program area were assessed to be "Very Desirable" or "Desirable" and "Definitely Feasible to Possibly Feasible." A number of recommendations suggested the need for internal capacity building, including the development of training sessions (CCF.2, CCF.3, and CCF.7), scientific workshops (CCF.8 and CCF.12), and orientation programs (CCF.9) to ensure that all staff understand and are capable of responding to climate change impacts.

Recommendations within the CCF program area also tended to target directly staff and internal capacity building (i.e., CCF recommendations were more tactical compared to recommendations in other program areas). For example, it was recommended that workshops should be developed for specific ecoregions and be geared to specific professionals (e.g., biologists, planners, mid- and upper-management, park interpreters, etc.) (CCF.4 and CCF.8).

Evaluation of Education, Interpretation and Outreach (EIO) Adaptation Options

As with the OD program area, the panel expressed the strong sentiment that Ontario Parks needs to be a leader in public interpretation and educational activities related to climate change (EIO.3). Specifically, the panel stressed that protected areas should be used to inform the public about climate change impacts and the implications for park features (EIO.3, EIO.4 and EIO.5).

The entire panel believed strongly that a national climate change working group with federal, provincial, and territorial representation should be established to address climate change (EIO.11). To avoid duplication of effort, the panel believed that it was desirable for protected area jurisdictions to seek partnership opportunities with research groups, such as the Canadian Council on Ecological Areas and the Canadian Parks Council, to stage workshops and to develop guidelines and strategies to help managers cope with the impacts of climate change (EIO.15).

Policy Delphi Third Survey Iteration: Senior Decision-Maker Feasibility Evaluation Process and Results

Four feasibility criteria were developed and used by a senior decision-making panel to evaluate the 56 most

desirable (i.e., first-order) adaptation options identified by the initial expert panel. The four criteria included (1) affordability, (2) ease of implementation, (3) institutional capacity, and, (4) capacity to sustain over time. A four-point Likert scale was developed to facilitate the rating of adaptation options (Table 4). Mean rankings across each criterion provided an overall evaluation rating of "Definitely Implementable", "Probably Implementable", "Probably Not Implementable", or "Definitely Not Implementable". Respondents were also asked to provide underlying assumptions or scientific evidence to support or contest positions and to identify the factors (e.g., economic, political, socio-cultural, technological, and informational) that ultimately constrain or enhance the implementation of each respective adaptation option.

The detailed feasibility evaluations for each of the first-order adaptation options can be found in Online Appendix 2, while a summary by program area is provided below (Tables 5, 6, 7, 8, 9). Overall, the feasibility evaluation by the senior decision-maker panel revealed a perception of low capacity within Ontario Parks to implement most of the first-order climate change adaptation options, despite the position of the original technical expert panel that collectively evaluated most recommendations as "Definitely Feasible" or "Possibly Feasible." Of the 56 recommendations evaluated by the panel, exactly half were evaluated to be "Definitely Not Implementable" to "Probably Not Implementable." Only two adaptation options were evaluated to be "Definitely Implementable," suggesting that that the overall capacity in Ontario Parks to implement climate change adaptation decisions is currently limited.

With respect to the Policy, System Planning and Legislation (PSPL) program area (Table 5), the panel believed strongly that Ontario Parks could develop a unified policy on climate change to provide sufficient direction for planning and management (PSPL.2). As one panelist emphasized, "*Development of policy and subsequent compliance monitoring should be easily achieved with current resources, with the possible requirement for limited updating of staff who might be involved. No new staff would be required, although some shifting of*

Table 4 Feasibility criterion used by Ontario Parks senior decision-makers to evaluate 56 'first order' adaptation options

Evaluation Criteria	Rating Scale			
	1	2	3	4
Affordability	Definitely affordable, can be implemented within current fiscal realities *AND/OR (please identify)* High cost-sharing possibilities	Some indication adaptation is affordable; possibility that adaptation can be implemented within current fiscal realities *AND/OR (please identify)* Some cost-sharing opportunities	Some indication adaptation is unaffordable; additional monetary resources, or re-allocation required to implement *AND/OR (please identify)* Low cost-sharing opportunities	Definitely unaffordable; adaptation cannot be implemented within current fiscal realities *AND/OR (please identify)* No cost-sharing opportunities
Ease of implementation	No identifiable internal or external barriers (e.g., legal, political, institutional, social, etc.); definitely can be implemented	Some identifiable internal or external barriers (e.g., legal, political, institutional, social, etc.); barriers most likely can be overcome (*please explain*)	Some identifiable internal or external barriers (e.g., legal, political, institutional, social, etc.); barriers may be too significant to overcome (*please explain*)	Obvious and significant internal and external barriers (e.g., legal, political, institutional, social, etc.); definitely cannot be implemented (*please explain*)
Institutional capacity	Capacity to implement and manage definitely exists No additional R&D, staff training and hiring, knowledge transfer and/or outsourcing required	Capacity to implement and manage exists or could be readily enhanced Some additional R&D, staff training and hiring, knowledge transfer and/or outsourcing required	Capacity to implement and manage does not exist and difficult to enhance Significant additional R&D, staff training and hiring, knowledge transfer and/or outsourcing required	Capacity to implement and manage definitely does not exist Additional R&D, staff training and/or hiring, knowledge transfer and/or outsourcing is required and probably not possible
Capacity to sustain over time	Capacity can definitely be sustained over time without additional resources (e.g., financial, staff, technological, etc.)	Capacity can be sustained over time with moderate additional resources (e.g., financial, staff, technological, etc.) (*please explain*)	Adaptation cannot be sustained over time without considerable additional resources (e.g., financial, staff, technological, etc.) (*please explain*)	Adaptation definitely cannot be sustained over time, additional resources required not accessible (e.g., financial, staff, technological, etc.) (*please explain*)

Table 5 Ontario Parks senior decision-maker feasibility results for climate change adaptation options evaluated to be desirable by 95% of the initial expert panel for the Policy, System Planning and Legislation (PSPL) program area

Recommended adaptation option	Feasibility evaluation
[PSPL.2] A strategic and corporate policy on climate change and protected areas is needed to provide sufficient direction for planning and management	Probably implementable
[PSPL.3] Ontario Parks should consult with protected area organizations in adjacent provinces and states to help anticipate, plan, and synergize cross-jurisdictional objectives to anticipate the "loss and gain" of species, communities and processes	Probably not implementable[a]
[PSPL.4] A national protected areas strategy should be developed to ensure that protected areas systems are integrated into a plan to achieve broad goals of biodiversity conservation and ecosystem health	Probably implementable
[PSPL.5] Policies for provincial parks and conservation reserves should embrace a science-based adaptive management approach to better deal with potential climate change impacts (i.e., acknowledgement of the dynamic nature of ecosystems and increased flexibility to better manage uncertainty)	Probably not implementable[a]
[PSPL.7] Climate change should be addressed in a review of policies for provincial parks and conservation reserves to ensure they consider climate change, biodiversity conservation, and ecological integrity goals	Probably not implementable[a]
[PSPL.8] Policies on modifying protected area boundaries should include climate change considerations in designing ecologically appropriate boundaries	Probably implementable
[PSPL.21&10] A multi-disciplinary team should be developed to examine the ecological representation criterion for selecting and designing protected areas, evaluate whether this approach is viable in protecting biodiversity under a changing climate, and examine alternative approaches (i.e., include spatial and temporal aspects of natural process, including population sizes, movements, disturbance regimes, ecological refugia, and adjustments to climate change)	Probably implementable
[PSPL.12] It is necessary to develop a more explicit mandate and policies for protected areas system design to enable better connectivity among protected areas through the protection of corridors, linkages, and functional ecology	Probably not implementable[a]
[PSPL.19] Many of the initiatives needed to enhance ecological integrity under the existing climate regime are the same as those under future climate scenarios. As such, climate change should be used to help rationalize and compel the implementation of ecological integrity objectives	Probably implementable
[PSPL.29] Land use activities adjacent to protected areas should allow for movement of wildlife and plants and help to "feather" protected areas into the working landscape	Probably not implementable[a]
[PSPL.30] Protected areas system planning should incorporate 'redundancy' into representation requirements to offset potential species losses resulting from climatic and ecological change (giving high priority to species at risk and highly threatened species)	Probably not implementable[a]
[PSPL.42] Ontario Parks' protected area selection criterion of "ecological functions" (i.e., processes) should receive greater emphasis in protected areas system design in order for protected areas to be sufficiently designed to better withstand increased natural disturbances and to help facilitate the movement of species in response to climate change	Probably implementable
[PSPL.44] Ontario Parks should anticipate locations that could serve as refugia for certain kinds of ecosystems and work to protect these sites in advance	Definitely not implementable[a]
Not sure	
[PSPL.33] "Floating protected areas", "temporal reserves" and protected areas "swapping" approaches (i.e., strategic de-regulation and establishment) should be explored as a planning option in order facilitate the movement of non-migratory species and increase the overall resiliency of the protected areas system to climate change related impacts	Probably not implementable[a]
[PSPL.37] Future protected area establishment should focus on species at the northern limits of their range as these may be the best adapted to adjust to changing climatic conditions	Probably implementable
[PSPL.39] Highly vulnerable, disjunct/relict, and outlier species should receive higher protection priority in system planning	Probably implementable

[a] Difference in opinion between initial expert panel and senior decision-maker panel

PSPL.28 was removed from the evaluation as it was deemed to be beyond the purview of Ontario Parks

priorities might be required." However, another panelist cautioned, "*…there is a significant backlog of high priority policy needs… A policy on climate change would need to be considered in light of these other needs*."

The senior panel believed strongly that Ontario Parks will definitely not be able to anticipate refugia for vulnerable species under changing climatic and ecological conditions nor could Ontario Parks work towards protecting these sites in advance (PSPL.44). As one panelist

Table 6 Ontario Parks senior decision-maker feasibility results for climate change adaptation options assessed to be desirable by 95% of the initial expert panel for the Management Direction (MD) program area

Recommended adaptation option	Feasibility evaluation
[MD.2] A corporate statement/position on climate change should be developed in order to help provide staff with direction and guidance on climate change-related planning and management issues	Probably implementable
[MD.6] Management plans should incorporate a long-term trends analysis to help guide longer-term actions and priorities	Probably implementable
[MD.8] "Clustered" management plans that would provide a generic management prescription for a series of protected areas having similar ecological management should be used to provide the flexibility needed to incorporate climate change considerations at local and regional levels for protected areas having similar environmental conditions	Definitely implementable
[MD.11] Management plans should acknowledge climate change as an ecological driver and should no longer focus on maintaining the "status quo" of flora and faunal composition	Probably implementable
[MD.13] Species at risk planning should include protection provisions for the range expansions and contractions of species	Probably implementable
[MD.15] Invasive species management direction should be "fluid" and include new and upcoming invasives that could expand their range and affect ecological integrity because of climate change	Probably implementable
[MD.17] Management direction should explicitly identify species, habitats, and ecosystems at risk due to possible climate change impacts	Probably implementable
[MD.18] The principles of "adaptive management" and the "ecosystem approach" should be incorporated into all management (e.g., preparing and implementing resource management plans and their subset of interventions) and planning (strategic/corporate, systems planning, site level management plans) directions of Ontario Parks	Probably implementable
[MD.20] Management direction for fisheries should place more emphasis on maintaining cold-water aquatic ecosystems and the species that depend on them. Areas adjacent to cold-water streams and lakes should generally not be developed, and natural vegetative cover should be maintained	Probably implementable
[MD.22] Climate change adaptation indicators need to be identified, defined and used to assess the successes and challenges of specific management plans	Probably not implementable[a]
Not sure	
[MD.12] Species translocation should be considered as an active management option when species are unable to migrate to suitable habitat naturally	Probably not implementable[a]

[a] Difference in opinion between initial expert panel and senior decision-maker panel

emphasized, "*Habitat supply and ecological function modelling expertise is required to predict such locations. Good idea, but additional resources and expertise would be required*." Similarly, the panel deemed that the establishment of floating protected areas or temporal reserves would probably not be implementable given current land tenure constraints (PSPL.33). One member, who was opposed to the recommendation, stated, "*I strongly disagree with this strategy. This would lead to the protected areas system representing a series of degraded sites that have been depleted of their previously existing resources, basically the "throw aways," and then, when ecosystems have been re-established, they would again be deregulated to be freed up for commodity extraction*."

Of the 11 recommended Management Direction (MD) adaptation options evaluated by the panel (Table 6), all but two were deemed "Definitely Implementable" or "Probably Implementable." The panel perceived as "Definitely Implementable" the recommendations to develop a unified position statement on climate change (MD.2) and to use clustered management plans for a series of protected areas to enhance the flexibility needed to incorporate climate change considerations (MD.8). The panel was also in agreement that management plans could begin acknowledging climate change as an ecological driver and move away from maintaining the status quo of floral and faunal composition (MD.11).

However, the panel evaluated the recommendation to use species translocation as "Probably Not Implementable" (MD.12). Common barriers to this option identified by the panel included lack of financial resources, lack of knowledge of persistence parameters, and unknown impacts on host species. As one panelist emphasized with respect to assisted migration in the initial evaluation, "*We cannot start compensating for climate change – it will never end*."

With respect to Research, Monitoring and Reporting (RMR) (Table 7), the panel strongly believed that most recommended adaptation options are not currently implementable. For example, the panel deemed as "Definitely Not Feasible" (RMR.15) the recommendation to assess major species, habitats, physical features, processes, and

Table 7 Ontario Parks senior decision-maker feasibility results for climate change adaptation options assessed to be desirable by 95% of the initial expert panel for the Research, Monitoring and Reporting (RMR) program area

Recommended adaptation option	Feasibility evaluation
[RMR.3] An integrated and cooperative monitoring strategy related to climate change to detect and monitor trends and impacts, especially for regionally threatened species, extinction prone species, and management target species, should be established and should be implemented at the ecoregional/system level. Such a monitoring program should also be used to document and assess the success/failure of remedial actions	Probably not implementable[a]
[RMR.5, RMR.12 & RMR.13] Ontario Parks should establish long-term research and monitoring sites against which to quantitatively measure climate change impacts (e.g., using permanent sample/systematic plots located at ecotones, established in the least disturbed protected areas in each ecodistrict)	Probably not implementable[a]
[RMR.6] Weather stations should be established and strategically located in protected areas to improve the grid of climate data in Ontario and to provide long-term climate information specifically relevant to protected areas	Probably not implementable[a]
[RMR.8] A comprehensive research strategy and monitoring framework with a defined set of measures (with sufficient spatial and temporal considerations) pertaining to climate change should be established (e.g., incorporated into Ontario Parks Comprehensive Monitoring Framework) at both the system and park level to track climate change and its effects and for comparative reporting	Probably not implementable[a]
[RMR.9 & RMR.24] Climate change impacts and actions should be explicitly recognized as an ecosystem management issue in state of the protected areas reporting and monitoring frameworks.	Definitely Implementable
[RMR.10] A research strategy should be developed on the role of protected areas and climate change (e.g., What are the looming questions needing answers necessary to address critical policy, planning, management and operation needs in protected areas? More broadly, what service roles can protected areas play as platforms for long-term time-trend research on climate change issues that transcend protected areas?)	Probably not implementable[a]
[RMR.14] Regional climate models should be used to predict current protected areas whose ecosystems will be most susceptible to alteration	Probably implementable
[RMR.15] Ontario Parks should assess major species, habitats, physical features, processes and other important ecosystem resources that are most likely to be impacted by climate change	Definitely not implementable[a]
[RMR.19] Monitoring efforts should be coordinated across jurisdictions and with other organizations and partners (i.e., standardize indicators, protocols, etc. to enable seamless roll-ups, assessment, and reporting of time-trend data)	Probably not implementable[a]
[RMR.25] Specific climate change indicators should be developed for each Ontario ecoregion (i.e., Hudson Bay Lowlands, Ontario Shield; Mixedwood Plains)	Probably not implementable[a]
[OD.19] A staff and public education program with standardized messaging should be implemented to help recognize, monitor and report on invasive species occurrences in protected areas	Probably implementable
[RMR.26] There needs to be a balance between climate (driver) and feature/species (responder) indicators, and a clear distinction between regions and parks	Probably not implementable[a]
Not sure	
[RMR.22] The assessment of ecological integrity should be made relative the to prevailing climate at the time of assessment and not a historical benchmark that no longer exists	Probably implementable

[a] Difference in opinion between initial expert panel and senior decision-maker panel

other important ecosystem resources that are most likely to be impacted by climate change. Moreover, the panel believed strongly that Ontario Parks would not be able to establish long-term monitoring sites against which to measure climate change impacts (RMR.5). Finally, the panel held the position that the development of climate change indicators (RMR.25) and a comprehensive research strategy on climate change at both the system and park levels to track climate change and its effects (RMR.8) are not currently feasible.

Overall, it appears that capacity is very limited with respect to the RMR program area. As one panelist emphasized, "*For the most part, Ontario Parks currently lacks the resources (funding, staff in general, and qualified staff) to conduct the types of monitoring proposed. I would not anticipate any change in this capacity in the near- to moderate-term. While I agree that protected areas will change and that they also have a role to play in terms of serving as benchmarks, extensive monitoring is largely out of the question due to capacity limitations*."

The senior panel was divided with respect to the feasibility of adaptation options recommended for the Corporate Culture and Function (CCF) and Education, Interpretation and Outreach (EIO) program areas (Tables 8, 9, respectively). On a positive note, the panel believed strongly that Ontario Parks could lead by example in climate change public interpretation and education activities (EIO.3) and could also begin providing visitors with climate change information and conservation-oriented activities aimed at reducing personal GHG emissions (EIO.4). The panel

Table 8 Ontario Parks senior decision-maker feasibility results for climate change adaptation options assessed to be desirable by 90% of the initial expert panel for the Corporate Culture and Function (CCF) program area

Recommended adaptation option	Feasibility evaluation
[CCF.2] Ontario Parks should ensure that all staff have a level of understanding of, and capacity to respond to, climate change impacts and adaptation appropriate to their mission	Probably implementable
[CCF.3] The Ontario Parks "Planning and Research Team" should develop a training session to address climate change and related topics for all levels of park staff	Probably implementable
[CCF.4] Staff orientation and training should be geared to occupation (e.g., biologists, planners, mid and upper management, interpreters, etc.) to ensure each understands the science of climate change, impacts, and potential adaptations. As such, training needs to be targeted, concise and directly relevant so employees so they can use it in their daily work	Probably not implementable[a]
[CCF.5] A system-wide "culture of conservation" needs to be cultivated in order to address activities that can reduce the effects of climate change. Ontario Parks should become a model of "low impact" and positive action	Probably not implementable[a]
[CCF.6] The contents of an education program could focus on: (1) current science; (2) potential impacts; (3) potential adaptations and limitations to response; (4) "the plan" on moving ahead; and (5) the role of employees in implementing "the plan"	Probably implementable
[CCF.7] A standardized educational package at the provincial level should be developed with regional specialists disseminating information and training staff at the park level	Probably not implementable[a]
[CCF.10] Ontario Parks should ensure that educational materials related to ecological integrity address climate change as one of the threats	Probably implementable
[CCF.11] A parks certificate course should be re-instated and the curriculum should include basic information and training on climate change	Probably not implementable[a]

[a] Difference in opinion between initial expert panel and senior decision-maker panel

believed that it would also be feasible for Ontario Parks to begin using protected areas to inform the public about climate change impacts and the implications of these impacts for park features (e.g., species, habitats, ecoregions, physiography, etc.).

Discussion

The research presented here introduces a methodology to facilitate both the identification and evaluation of climate change adaptation options tailored specifically to a protected area agency. One important advantage of the method is the inclusion of senior decision-makers in the feasibility evaluation of adaptation options. Such persons are in a position to implement the recommendations identified through this consensus building exercise. The research therefore focused on conditions important to the agency itself rather than those assumed in the literature. As did the findings of Ogden and Innes (2009), it is also likely that this study itself contributed to the adaptive capacity of the many practitioners, policy-makers, and decision-makers engaged in the research by increasing their awareness of adaptation options for protected area management. Overall, the long-standing scientist-stakeholder collaboration associated with the research has cultivated an enabling environment where stakeholders have assumed a great deal of ownership in the adaptation process. Continued scientist-stakeholder collaboration will play an important role in the research and monitoring of adaptation options within the purview of the MNR's greater adaptive management framework (MNR 2006).

The adaptation framework presented here has broad utility for the global protected area community who are also beginning to address the challenges posed by climate change. The primary advantage of the framework lies in its high transparency, its ability to solicit both quantitative and qualitative information to support decision-making, and in its flexibility to accommodate institutional-specific contexts and processes. The quantitative criteria included in this analysis can be adapted and weighted to suit the major determinants of adaptive capacity within other jurisdictions. Moreover, the portfolio of adaptation options, many of which are novel, and their respective quantitative and qualitative evaluations can be considered by other protected area agencies in addressing their own adaptation requirements.

Because of the uncertainties associated with climate change, it is important to emphasize that some of the adaptation options identified here may very well prove to be maladaptations in some future context. Perceptions of what will precisely enhance the ability to respond (i.e., appropriate adaptation options) are also likely to change. Accordingly, it is important to recognize that any capacity built or decision made can change in response to new information (i.e., recognize that adaptive management will be necessary) (Tompkins and Adger 2005). Additional work to test this framework in other land-management

Table 9 Ontario Parks senior decision-maker feasibility results for climate change adaptation options assessed to be desirable by 90% of the initial expert panel for the Education, Interpretation and Outreach (EIO) program area

Recommended adaptation option	Feasibility evaluation
[EIO.3 & EIO.6] Ontario Parks should be leading by example in public interpretation and education activities. Protected areas should be used to educate the public (e.g., through interpretation activities) about climate change impacts and the implications of these impacts for park features (e.g., species, habitats, ecoregions, physiography, etc.) and to build public support on climate change initiatives. Parks should be used to inform the public about climate change efforts to mitigate and adapt to it (e.g., energy conservation)	Probably implementable
[EIO.4] Ontario Parks should provide visitors with climate change ideas and conservation-oriented activities that they can act on themselves. As such, interpretation and outreach should play a role in encouraging personal responsibility in reducing emissions and making a difference	Probably implementable
[EIO.7] Interactive, hands-on displays, demonstration monitoring (demonstration sites, such as lake retreat), and mitigative/adaptive actions and techniques (e.g., ways to reduce emissions and conserve energy) should be used in protected areas to educate the public and engage multiple partners in climate change education and outreach	Probably not implementable[a]
[EIO.9] Protected areas organizations should work in cooperation with other organizations outside of protected area boundaries to help reduce the impacts of climate change through approaches such as protected area system design, ecological restoration, and compatible land uses adjacent to protected areas	Probably not implementable[a]
[EIO.11] A national climate change working group with provincial/territorial representation should be established to address climate change and protected areas issues including adaptation.	Probably not implementable[a]
[EIO.12] A "Partner Program" with government, NGOs, and other relevant organizations and individuals should be developed to address climate change and protected areas issues. Examples include: partners to reduce climate change (mitigation measures); partners to educate visitors; and, partner to educate staff	Probably not implementable[a]
[EIO.13] A conference or series of workshops across the country to bring together partners involved in conservation to discuss and learn from leading edge researchers and practitioners who have been considering climate change and how to integrate it into protected areas planning and management should be developed	Probably implementable
[EIO.15] In order to avoid duplication of effort and maximize efficiencies, protected areas jurisdictions should seek out partnership opportunities (e.g., with protected area research groups such as the Canadian Council on Ecological Areas (CCEA), the Canadian Parks Council (CPC), Science and the Management of Protected Areas Association (SAMPAA), the World Commission on Protected Areas (WCPA), the Centre for Applied Science in Ontario Protected Areas (CASIOPA), etc.) to stage workshops and develop guidelines, strategies, etc. to help management organizations cope with climate change	Probably not implementable[a]

[a] Difference in opinion between initial expert panel and senior decision-maker panel

contexts is needed to identify synergies and challenges. This additional work would also aid in the development of generalizations with respect to adaptation in the greater landscape context.

Conclusions

The impacts of anthropogenic climate change on biodiversity and the implications for protected area management have been discussed in the scientific literature for more than two decades. There is consensus that current conservation policies and practices are inadequate to cope with the challenges caused by even moderate climate change scenarios in the twenty-first century, let alone the minimum +4°C of warming that policies for adaptation should now be preparing for given current GHG emission trajectories (Anderson and Bows 2008; Parry and others 2009; Rogelj and others 2009). While most scientific literature on climate change adaptation suggests that adapting now will be more effective than adapting later (i.e., more cost effective and efficient in reducing the potential for irreversible impacts, such as species extinction), the results here indicate that Ontario Parks currently has a lack of capacity to implement a number of important adaptation options. This lack of adaptive capacity is very likely common to protected area jurisdictions around the world, as recent surveys and independent audits of a number of agencies responsible for protected areas in Canada and the United States have similarly revealed a minimal capacity to manage for climate change and ecological integrity (GAO 2007; OAGC 2008a, b); OAGBC 2010; Lemieux and others 2011a).

Climate change adaptation by protected area agencies can progress only by means of a more integrated approach within government, institutions and society, among sectors, and between a complex overlay of ecological and jurisdictional scales, from the international to the local. However, limited resources and limited internal capacity to implement adaptation options have resulted in adaptation paralysis at the decision-making level in many protected area agencies and may lead managers to continue to maintain the status-quo despite concerns about the long-term viability of current planning and management practices in an era of climate change.

In the wake of the Copenhagen Summit, there is a growing acceptance that much of the climate change response burden will fall on adaptation. Lack of action on climate change potentially could jeopardize the goals and objectives of protected areas, resulting in negative impacts on species and ecosystems targeted for conservation, and compromise over a century of investments made in conservation in Canada and elsewhere. The public is likely to place greater demands on agencies responsible for protected areas to conserve species and ecosystems under stress from climate change. If these agencies are to respond to the demands of the public, governments will need to make major new investments in protected areas establishment, personnel training, research, and monitoring.

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