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Expert views on biodiversity conservation in an era of climate change

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ABSTRACT

Adapting conservation policy to the impacts of climate change has emerged as a central and unresolved challenge. In this paper, we report on the results of 21 in-depth interviews with biodiversity and climate change adaptation experts on their views of the implications of climate change for conservation policy. We find a diversity of views across a set of topics that included: changing conservation objectives, conservation triage and its criteria, increased management interventions in protected areas, the role of uncertainty in decision-making, and evolving standards of conservation success. Notably, our findings reveal active consideration among experts with some more controversial elements of policy adaptation (including the role of disturbance in facilitating species transitions, and changing standards of conservation success), despite a comparative silence on these topics in the published literature. Implications of these findings are discussed with respect to: (a) identifying future research and integration needs and (b) providing insight into the process of policy adaptation in the context of biodiversity conservation.

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1. Introduction

Conservation policy has evolved through time – changing for example from the goal of preserving iconic places, to maintaining biodiversity across scales. By 'policy' we mean collections of objectives (statements of a fundamental desired endpoint, goal or something that matters to the actors in a given decision context), and means (specific methods or management strategies designed to achieve a specific objective), that together reflect values, knowledge, and expectations of control at a given point in time. Today, the impacts of climate change prompt consideration of further revisions both for conservation means and objectives.

With respect to impacts, the challenge for conservation is that changing temperature and precipitation regimes (IPCC, 2007) are expected to interact with other drivers (e.g. habitat destruction) to influence a range of biological processes and ultimately species distributions (Thomas et al., 2004; Parmesan, 2006) (Fig. 1). Indeed, a growing collection of empirical evidence now documents a range of climate-change-attributed changes in biological processes, including phenology (Parmesan and Yohe, 2003; Root et al., 2003; Menzel et al., 2006), net primary production (Nemani et al., 2003), and inter-specific interactions (Suttle et al., 2007). Changes in species distributions have also been observed in both above-ground (Walther et al., 2002; Parmesan, 2006; Pounds et al., 2006; Lenoir et al., 2008), and below-ground biotic communities (Rinnan et al., 2007).

These system dynamics are at odds with established conservation approaches, which rest on assumptions of stable biodiversity targets, and that seek to protect biological targets within static protected areas (e.g. Margules and Pressey, 2000). The consequence and recognized challenge is that some target species or ecosystems will no longer be viable in reserve areas created for their protection (Peters and Darling, 1985; Hannah et al., 2002; Araujo et al., 2004; Pressey et al., 2007).

Conservation scientists have responded with a range of adaptive conservation strategies. These include proposals for dynamic protected areas[1] (Bengtsson et al., 2003; Rayfield et al., 2008) assisted migration[2] (McLachlan et al., 2007; Hoegh-Guldberg et al., 2008; Richardson et al., 2009), and most

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[1] Areas whose locations and levels of protection change through time and space.
[2] The deliberate introduction of species into areas where they have not existed in recent history. Also referred to as assisted colonization, and managed relocation.

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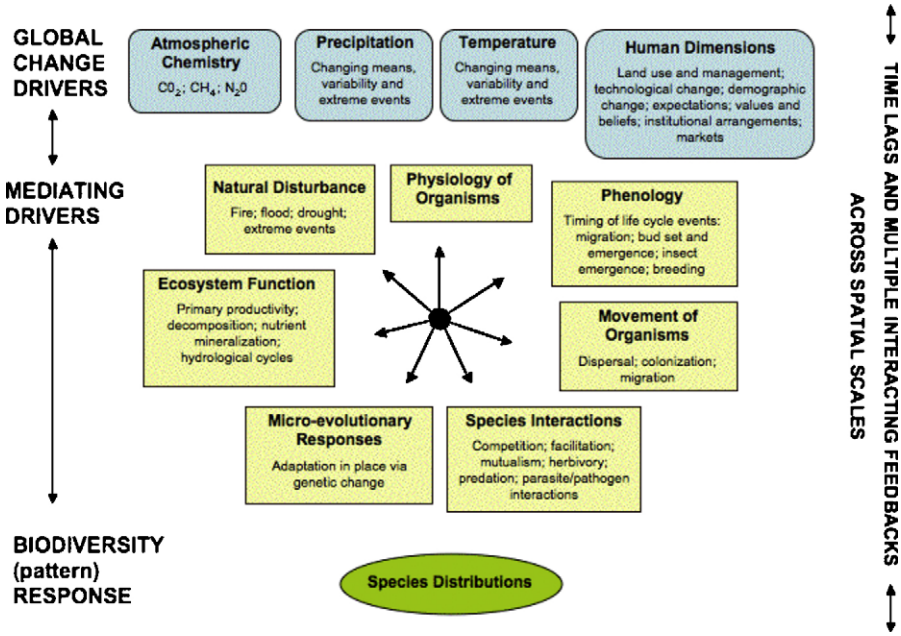

Fig. 1. Diagrammatic representation of some of the global change drivers, mediating drivers and biodiversity (pattern) responses in terrestrial ecosystems. From Hagerman and Chan (2009).

prominently, the expansion of linked networks of static protected areas (e.g. Hannah et al., 2002; Hannah, 2008). At the same time, other studies have highlighted the human dimensions of addressing this challenge such as the need to integrate livelihoods, property rights and governance considerations into the current suite of more ecologically focused proposals (Hagerman and Chan, 2009; Heller and Zavaleta, 2009). Moreover, recent work based on a synthesis of existing data and observations at professional meetings suggests the presence of additional problem dimensions that have not been publicly expressed or systematically examined (Hagerman and Dowlatabadi, 2006). Examples of these under-examined topics include the role of disturbance in mediating species transitions, the potential revision of conservation objectives, and changing standards of conservation success. These apparent discrepancies suggest that the challenge of adapting conservation policy to the impacts of climate change is even more complex than has been articulated by more disciplinary-focused examinations.

1.1. Objectives

The purpose of this paper is to better understand the ecological and social challenges of adapting conservation policy to the impacts of climate change. We do so by systematically examining the views of experts on the impacts of climate change for biodiversity and implications for conservation policy. Specifically, this paper aims to: (a) provide in-depth understanding of the diversity of expert views that currently exists on this topic (with a focus on conservation objectives and means), (b) highlight some potential implementation challenges, and (c) identify key unresolved topics and areas for future research. This paper proceeds from here in four parts. First we outline the key concepts that shape our analysis of policy change and adaptation in linked social–ecological systems, this is followed by a description of the methods, we then report on the views of experts, lastly, we discuss the implications of our findings for understanding the challenge of adapting conservation policy specifically, and how this relates to theories of policy change more broadly.

2. Concepts in policy change in linked social–ecological systems

In this section we outline the concepts and theoretical insights that shape our analysis. This work adopts the perspective that social–ecological systems (SESs) (Berkes and Folke, 1998) are linked, co-produced entities that display multi-scalar, historically contingent, non-linear change dynamics shaped by ecological and social drivers (Crumley, 1994; Gunderson and Holling, 2002; Walker et al., 2004; Reynolds et al., 2007). This view derives jointly from Holling's seminal work on multiple stable states and non-equilibrium behavior of ecological systems (Holling, 1973), and related insights on non-linearity and path dependence in policy-related fields (e.g. Pierson, 2004). More specifically, this work is situated and interpreted in the context of theories of policy change, including *integrated* theories of change such as developed by resilience scholars (e.g. Gunderson and Holling, 2002). We discuss these below.

2.1. Policy change and adaptation – patterns of change

As noted in the opening paragraph of this paper, policy in any sector is made and re-made over time in response to interacting human and environmental drivers and this pattern is similarly true for conservation (Wynn, 2004; Loo, 2006). Some scholars in the policy sciences see policy change as an 'incremental' process (Lindblom, 1959) that occurs for intrinsic (that is the way the world works), and strategic reasons (cf. Kingdon, 1995).[3] Other scholars, some adopting Stephen Gould's punctuated equilibrium metaphor from evolutionary biology, argue that patterns of change are more accurately described as punctuated spurts of substantive and infrequent change that follow prolonged periods of relative constancy and stasis (e.g. Baumgartner and Jones, 1991; Kingdon, 1995; Howlett and Ramesh, 2003; Repetto, 2006). Similarly, resilience scholars invoke a punctuated equilibrium understanding

[3] More specifically, that incrementalism applies to some aspects of policy change (e.g. the generation of new alternatives), but not to the larger process of agenda setting (Kingdon, 1995).

of policy change as part of the predicted dynamics of the adaptive cycle (Gunderson and Holling, 2002; Walker et al., 2004). For example, Gunderson and Holling describe the dynamics of adaptive cycles as: "cycles of slow accumulation of natural and cultural capital – in an ecosystem, an institution, or a society – interspersed with rapid phases of reorganization where, for transient moments, novelty can emerge to become subsequently entrained" (2002).

2.2. Policy change and adaptation – contributing triggers of change

Scholars working from the perspective of policy sciences and resilience theory have sought to identify the underlying mechanisms and determinants of non-equilibrium dynamics either for specific policies, or SESs more broadly. In the policy sciences, the social variables commonly identified as contributing triggers of change include various combinations of the role and history of ideas, beliefs, technology, the interests of key actors, institutions, market forces, learning, and scientific information (e.g. Sabatier and Jenkins-Smith, 1993; Hajer, 1995; Kingdon, 1995; Howlett, 2001; Sabatier, 2007). For resilience scholars, non-equilibrium dynamics of change are understood as driven by slow (e.g. soil development; cultural change) and fast variables (e.g. forest fires; market collapse), from *both* biophysical and social domains (Gunderson and Holling, 2002; Walker et al., 2006).

Drawing on the insights above, and because the purpose of this paper is to better understand the challenge of adaptation in the domain of conservation policy (in this case to the impacts of climate change), we pay particular attention to the interacting roles of (i) the history of debate about new policy proposals, (ii) the state of the science including uncertainty, (iii) the role of values and beliefs and (iv) policy windows. Below, we detail why these particular variables matter in this problem context and with respect to the purpose of this paper.[4]

History of debate of new proposals. Kingdon (1995) has shown that while new policy ideas may appear to emerge suddenly, they often have a lengthy history of debate. Further a 'gestation period' (and, commonly previous, rejection), is often required for ultimate acceptance: "... without the preliminary work, a proposal sprung even at a propitious time is likely to fall on deaf ears" (Kingdon, 1995, p. 128). This observation matters in the context of understanding policy change in the domain of conservation because previously rejected ideas may eventually be seen as acceptable, or even required, given biophysical and other forces of change (discussed below).

The role of science. In some cases new scientific information can be an important contributing factor of policy change (Ingram and Fraser, 2006). In other cases, new scientific information may be a necessary, but insufficient ingredient for policy change. Moreover, while scientific uncertainty is sometimes cited as a barrier to adaptation (e.g. we don't have enough information and knowledge to act), or mobilized by special interests to delay the development of new policies, there is little evidence from historical case studies to suggest that the presence of uncertainty in and of itself is a barrier when empowered actors are motivated to change (Oreskes, 2004). Lastly, non-equilibrium dynamics create irreducible system uncertainties in SESs, which implies that decision-making can only proceed in the face of uncertainty in any case. By irreducible uncertainties we mean uncertainties that are perpetuated by the properties and dynamics of linked SESs.

The role of values. The acceptance of new policy proposals tends to occur when they reinforce pre-existing values (Kingdon, 1995; Sabatier, 2007). As Kingdon argues: "proposals that survive ... are compatible with the values of the specialists" (1995, p. 132). By values we mean held beliefs and preferences about what is desirable and important at a given point in time. Risk and decision scientists use the term 'mental models' to describe a similar concept for collections of assumptions, evidence, experience, morality and cultural norms that form conceptions of how the world works, or ought to work (Morgan et al., 2002). Scholars using either concept make the point that in combination with other social and ecological factors, values have material policy consequences in that they can prevent or catalyze change, and contribute to shaping the nature of change when it occurs. Thus new proposals that challenge held values (that are not yet ready to yield to change) are unlikely to gain support. On this last point, we know from the work of environmental historians (e.g. Cronon, 1996) that values, and their expression in policy objectives that were suitable for the social, ecological and technological context of one time period, may be either ill-suited, not desired or untenable in a different time period and context.

The role of policy windows. Lastly, when new policy ideas do emerge, research has shown that it is often the result of the confluence of previous conditions (e.g. the passage of time) facilitated by an (punctuated and temporary) opportunity, or 'policy window' (cf. Kingdon, 1995). A policy window may be predictable (e.g. scheduled policy review) or unpredictable (an extreme event, a real or perceived crisis). Importantly, policy windows can close with the *perception* that the challenge has been addressed, even if it has not (Kingdon, 1995). In his opening address to the World Conservation Congress (2008), Valli Moosa, outgoing president of the International Union for Conservation of Nature (IUCN), adopted a now common phrase, proclaiming that climate change was a "crisis that would be a terrible thing to waste". The implication being that the climate crisis can be used to lobby for change and expand the conservation madate.

3. Methods

3.1. Modified qualitative expert elicitation

This paper is based on a modified qualitative expert elicitation with 21 biodiversity and climate adaptation scientists. By 'expert' we mean individuals with specialized knowledge, in this case on topics relating to the impacts of climate change on biodiversity pattern and process, with demonstrated experience and involvement in climate-change-related projects and/or publications.

In general, expert elicitation uses structured interviews (or questionnaires) to assess the subjective judgments of experts on technical topics at a given point in time (Morgan and Henrion, 1990). The method can yield quantitative or qualitative results and is well suited to topics where scientific uncertainty is high, and unlikely to be reduced on a time scale relevant for decision-making (e.g. Morgan et al., 2006; Kandlikar et al., 2007). A key strength of expert elicitation with respect to aiding decision-making and identifying future research needs is that it does not seek to identify consensus within a group. Rather, it highlights the current diversity (and locus) of agreement *and disagreement* within an expert community that may not be voiced in more public fora (Morgan and Keith, 1995).

These features implicated expert elicitation as an appropriate methodology for our study precisely because we were interested in the views of experts on technical topics (the potential impacts of climate change on patterns and processes of biodiversity), under conditions of irreducible uncertainty. At the same time, given that biodiversity conservation is seen by conservationists as "a mission

[4] Adaptation and policy change result from a multitude of factors beyond that which we examine here. At the same time, research from both the policy sciences and resilience theory has converged on the observation that a small set of key variables tend to govern the dynamics of change in a given system. We have provided our logic for examining this particular set of factors above.

oriented discipline" (Meine et al., 2006) we simultaneously sought to leave open the possibility to examine potential interactions between technical judgment and held values in shaping expressed preferences.[5] As a result, our methodology consisted of semi-structured (not structured) interviews with attention to technical concepts as well as expressed value positions, where they were offered.

Specifically, the interview protocol involved beginning each discussion topic with an open-ended question (e.g. "Tell me about your views on topic X."). Clarifying questions were then asked throughout the relatively unconstrained discussions that followed (e.g. "Can you give me an example?" Or, "Is that the same concept as ...?" Or, "Why is this important?"). While we had a predetermined interview schedule of topics to cover (Appendix A), in practice, we followed the natural flow of conversation and explored deeply the concepts that were raised by participants. This contrasts with a rigid 'keep to the schedule' approach, which carries with it the risk of gaining a peripheral and potentially inaccurate understanding of an individual's views.

Thus, our approach departs from conventional quantitative expert elicitations where systematic effort is made to reduce the influence of values, biases and other cognitive heuristics (Kahneman et al., 1982). At the same time, we were vigilant in our attempts to apply the sensibilities of expert elicitation with respect to seeking to minimize overt biases. For example, beginning with open-ended questions followed by more specific probes (as outlined above), by asking experts to give reasons for and against a given response, by asking participants to imagine scenarios which might yield answers outside of their initial responses, and by ensuring anonymity in effort to reduce motivational bias.

3.2. Participant selection

We purposively sought individuals from academic, non-governmental organizations (NGO) and government perspectives. Criteria for inclusion were both substantive and practical. Substantive criteria included demonstrated expertise and involvement in climate change and biodiversity research (as indicated by academic publications, involvement in global or regional scale climate change and/or conservation policy development, inclusion of climate change as agency mandate). Individuals were identified through a review of the literature on climate change adaptation, involvement of the authors in biodiversity management initiatives, and through agency directories. Because the majority of interviews were conducted in person, practical criteria for inclusion included resources for travel, which ultimately involved attendance at three major biodiversity meetings (two in North America and one in the United Kingdom) as well as numerous regional (British Columbia) workshops and planning meetings.[6]

Thirty-six individuals were invited to participate in this study. Of these, 33 agreed and 3 did not respond. The total number of interviews ultimately completed was 21.[7] Interviews were conducted between December 2007 and December 2008 and lasted from 45 to 120 min. Participants and their affiliations are listed in Table 1. Although this paper is primarily based on data obtained through these formal interviews, this data is supplemented by dozens of informal discussions and extensive systematic observations at biodiversity meetings and workshops between 2005 and 2008.

3.3. Interview protocol and analysis

The interview design, developed over a period of 2 years, was rigorously reviewed by domain experts to reflect the current thinking in conservation and climate change impacts, and pilot-tested with three ecologists. The first author conducted all interviews. Following some general questions about an interviewee's expertise in the context of conservation the interview schedule addressed topics including: (1) drivers of ecosystem change, (2) conservation objectives, (3) conservation means including interventions, (4) uncertainties and decision-making, (5) implementation and governance, (6) and criteria for success. Due to each individual's particular expertise and variable time constraints, the degree to which specific topics were discussed varied across participants.

Interviews were audio-recorded, transcribed verbatim, and systematically coded using qualitative data analysis software (HyperRESEARCH 2.8, 2007). Fig. 2 illustrates that our sample size was sufficient to achieve saturation of concepts. By saturation we mean that additional interviews did not yield new concepts, or perspectives within the context of the topics being discussed (Charmaz, 2006). We do not mean that we have captured all potential views from all potential perspectives on this topic. Rather that we determined and qualified the perspectives that currently exist (e.g. Morgan et al., 2002), on topics arising from a core set of questions within this interview schedule, among the domains of academic, NGO and agency scientists.

Due to the purposive selection of participants this sample is not representative of all individuals with relevant expertise. While our small sample necessarily limits quantified frequencies of agreement or disagreement, we do nonetheless indicate a coarse measure of commonality for some key topics by indicating how many experts expressed a given view (Table 2).[8] Expert views are reported anonymously, but numbers in parentheses at the end of excerpted interview quotes indicate the response of a specific interviewee. These numbers to do not correspond with the order of experts as listed in Table 1.

4. Findings: expert views

In this section we report on the views of experts. Our findings are organized by perspectives on: (1) policy frameworks (including means and objectives); (2) perceived relationship between uncertainty and decision-making; and (3) governance and implementation. Practical and theoretical implications of these findings are discussed in Section 5.

4.1. Potential elements of a new framework for conservation policy

All interviewees expressed the view that a paradigm shift in conservation practice was required to adapt to the impacts of climate change.

(11) We talk about paradigm shifts all the time but this actually is. What should our position be on threatened species and translocation? What are we trying to conserve, or preserve ... [what] is the right word? We are doing climate change impact assessments, but what does this really mean?

(18) Nothing is as simple as space anymore. It never was a simple as space – but now we are not going to get away with it.

[5] In recognition of the difficulty of separating values from scientific judgments, the first elicitation of experts designed by Morgan and Keith only explored climate change dynamics. As they grew more confident in the potential for this method, they attempted an elicitation of ecological impacts of climate change. The responses from that study highlighted the challenges in intertwined values and interpretation of evidence.

[6] In a few cases where last minute scheduling changes did not allow for in-person interviews, interviews were conducted over the phone.

[7] Unfortunately, we were only able to schedule interviews with 2/3 of the pool of experts due to time and resource constraints.

[8] Noting both that the absence of expression does not indicate disagreement, and that commonality of a view may not necessarily equate with technical accuracy.

Table 1
Experts whose views are reported on in this paper ($N = 21$).

Name	Affiliation	Role
NGO		
Geoffrey Blate	WWF – World Wide Fund for Nature	Climate Change Coordinator
Cassandra Brooke	WWF – Australia	Senior Climate Change Adaptation Scientist
Rhadika Dave	Conservation International	Climate Change Adaptation Manager
Lee Hannah	Conservation International, Center for Applied Biodiversity Science	Senior Scientist, Climate Change Biology
Lara Hansen	EcoAdapt	Chief Scientist and Executive Director
Michael Harley	AEA	Principal Consultant/Climate Change and Biodiversity
Jody Holmes	Rainforest Solutions Project	Senior Scientist, EBM and Conservation Science Advisor
Pierre Iachetti	Nature Conservancy of Canada, BC Region	Director of Conservation Science and Planning
Tony Janetos	Joint Global Change Research Institute	Director
Wendy Foden	International Union for the Conservation of Nature	Programme Officer: Climate Change IUCN Species Programme
Academic		
Andrew Dobson	Princeton University, Department of Ecology and Evolutionary Biology	Professor
Lance Gunderson	Emory University, Department of Environmental Studies	Associate Professor
Paul Ehrlich	Stanford University, Centre for Conservation Biology	Professor
Jennifer Martiny	University of California Irvine, Department of Ecology & Evolutionary Biology	Associate Professor
Guy Midgley	South African National Biodiversity Institute	Chief Director, Climate Change and Bioadaptation Division
Dov Sax	Brown University, Ecology and Evolutionary Biology	Assistant Professor
J. Michael Scott	University of Idaho, College of Natural Resources	Professor
Government		
Andy MacKinnon	Research Branch, British Columbia Ministry of Forests and Range	Senior Scientist, Research Ecologist
Del Meidinger	Research Branch, British Columbia Ministry of Forests and Range	Senior Scientist, Research Ecologist
Dave Spittlehouse	Research Branch, British Columbia Ministry of Forests and Range	Senior Research Climatologist
Tory Stevens	British Columbia Ministry of the Environment	Protected Areas Ecologist

(4) There are clearly some rules that we thought were hard and fast, that won't be anymore. Definitions of native species are not going to work because species may undergo complete natural range migrations and show up in places they haven't been in human history. Parks that have couched their reason for existence ... their entire management goal ... to protect a certain species or vegetation type, may no longer be there in the future. It doesn't mean that we don't need that protected area, we have too few protected areas, it means [we are] going to have to completely rethink its *raison d'être*.

4.1.1. Conservation means (management strategies)

Expert opinion varied with regard to the specific attributes (here distinguished as means and objectives) that a climate-change-motivated paradigm shift or a new conservation framework would entail. When asked about potential adaptive conservation means (management strategies), most experts echoed the suite of strategies commonly proposed in the literature, including expanding protected areas, migration corridors, and making matrix areas (areas adjacent and between protected areas) more hospitable to change (Table 2).

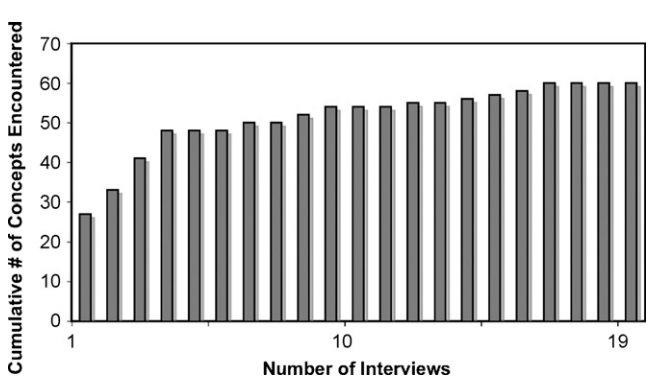

Fig. 2. Cumulative number of concepts encountered with increasing interviews (total formal interviews, $n = 21$).

(4) We are going to lose representation of species. Some species are going to move out of protected areas, and that means we need to add more protected areas to compensate.

(8) One of the best things we can do is to protect big landscapes – keeping in mind movement corridors.

(16) It would be sensible to have a sequence of land acquisitions along a corridor where things are likely to move – and to select these areas based on their present as much as their potential future value.

(13) One of the major challenges is to make the intervening landscape less inhospitable to species so that they can actually track the climate change through the landscapes.

Similarly, one participant attending a regional climate-change-planning meeting summarized the primary means to respond to climate change as to: "save more [area] and save aggressively".

Other views were less commonly volunteered. One expert identified the need to integrate the role of disturbance processes in facilitating the species/population transitions that the above-mentioned strategies are designed to accommodate.

(15) What [conservation organizations] want to think about, is how do [species] get from here to there? If you force the [bioclimate envelope] models with the same climate forcing, they will all produce similar endpoints. But it is the transition that you have to manage through. The species or assemblage replacements scenarios imply some kind of disturbance or series of disturbances – something that makes the space. From a manager's perspective, [managing] through the transition, is at least as important, maybe more directly important, as thinking about the endpoints from the models.

Another expert similarly noted the importance of available niche space for migrating species. During a discussion of the utility of corridors as a strategy to enable range shifts, expert (17) asserted, "the trouble with [that is], are there really empty niches?"

Table 2
Summary of views on recurrent topics across total expert sample: (✓) indicates that this view was stated during the elicitation, (–) indicates that this topic was not discussed (e.g. because it was outside the realm of a respondent's expertise), ( ) boxes without any marker indicate the absence of expressed view for the theme in that column. It does not mean that the general topic was not discussed, just that the themes listed here were not expressed. For example, Expert 2 shows three empty boxes under 'Success and objectives'. In this case, this individual discussed other (procedural) metrics of success (e.g. monitoring programs), but not the three themes listed here. The total number of experts who expressed a given view on a particular topic is summed along the bottom row.

Expert no.	Means	Interventions		Triage and prioritization			Success and objectives			Uncertainties and decision-making		Implementation	
	New protected areas and migration corridors	Opposed	Necessary	Implicit already	Undesirable but necessary	Opposed – slippery slope	Revise objectives	Focus on process and function not pattern	Gradients	No experimenting without prior evidence	Action/experiment in the face of uncertainty	Jurisdictional and livelihoods	Institutional barriers
1	✓		✓	✓	✓		✓	✓	✓		✓	–	–
2	✓		✓	✓	✓						✓	–	–
3	✓		✓	–	–	–	✓				✓	✓	
4	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓
5	–		✓		✓		✓				✓		✓
6	–		✓	–	–	–	✓				✓	✓	✓
7	✓		✓	–	–	–	✓				✓	–	–
8	✓		✓	✓	✓			✓	✓		✓	✓	
9	✓		✓	✓					✓	–	–	✓	–
10	✓		✓	–	–	–				–	–	✓	✓
11	–	✓				✓	✓	✓			✓	✓	✓
12	✓	✓	✓	✓	✓		✓	✓	✓	–	–	✓	
13	✓		✓		✓		–	–	–	–	–	✓	
14	–		✓	–	–	–	✓				✓	✓	✓
15	–		✓	–	–	–	✓	✓			✓	✓	✓
16	✓	✓	✓	–	–	–	–	–	–		✓	✓	
17	✓	✓	✓		✓		–	–	–		✓	✓	
18	✓	✓	✓		✓		✓	✓			✓		✓
19	✓	✓	✓	✓					✓			✓	✓
20			✓		✓		✓	✓			✓	✓	✓
21	✓	✓	✓	✓		✓	✓		✓		✓	–	–
TOT.	15	8	20	7	10	3	13	7	6	1	16	15	10

While only two experts in this study highlighted the role of disturbance and the availability of niche space in facilitating/enabling range shifts, natural disturbance processes including fire, grazing, floods and wind are widely recognized for their importance in determining patterns of biodiversity (e.g. Hobbs and Huenneke, 1992). It is highly likely both that climate change impacts will be mediated through disturbance processes (e.g. altered fire frequency and intensity) (Littell et al., 2009), and that deliberate disturbance may be required to achieve some specified goals. The current and potentially increased role of management interventions including disturbance, underpinned more commonly discussed themes relating to interventions or active management in conservation adaptation more broadly. On this topic, some experts expressed a preference for minimum intervention in conservation areas.

(16) It is best to let things work its natural way ... we tend not to do a particularly good job when we intervene.

(21) We should be helping species adapt and ... not interfering, letting them stay natural and letting the processes go as they will.

(19) Nature can handle things better than we can. We just don't know enough.

At the same time, all but one respondent (including individuals with an initial no intervention preference) (Table 2), agreed not only that interventions were already central to conservation, but that in many cases they would come to be more systematically realized and increasingly necessary to achieving conservation goals given climate change and other interacting drivers of change.

(9) We've been messing with nature for a long time – now we have to do it in a more formalized way. The first time I learned that wasn't going work [lack of human intervention in conservation] was when the Nature Conservancy purchased [conservation area]. The first thing they did was to close it to ... hunters [thinking] that would benefit everything. Well, it benefited the [animal which] started thriving ... and rather than benefiting [the ecosystem] by locking it up, it was a negative.

(6) I remember ... a nature reserve that was established in India because it was the breeding or overwintering site of a [species of] swan. And the international NGOs, got together ... to buy this area and the first thing they did was to kick people off, whom had been farming the area. Well, in doing that the habitat changed, and it no longer became an overwintering area.

Considering interventions in light of climate change some experts expressed the following:

(13) It [lack of intervention] wouldn't work. It wouldn't work in fragmented landscapes.

(21) I have seen the devastation of ... invasive species [that] come in and destroy everything else. If an alien species comes in and wipes out [native vegetation], I don't think that's okay just because they are the winners.

(2) Subtle or creative intervention, in other words the forces of nature will allow things to adapt, but because of the rate of change, we can help accelerate the effectiveness of some of those natural forces. [But] I am not sure how effective major interventions are going to be. Like translocating all the world amphibians ... we've got to learn how to do this. There is a learning by doing element.

(15) If there are assemblages that [conservation organizations] particularly care about, I think you're going to have to advise some active management strategy to keep them. I just don't see any other way realistically that that is going to happen.

Others argued with distinction that intervention was inevitably necessary, but necessarily site-specific.

(19) If it is a large contiguous system of conservation areas then I think you ... let nature take care of itself. If it is small and isolated and you have relatively little in the matrix ... then you have to have more intervention.

(6) It is site-specific. There are areas where people have been so involved in altering and changing systems for years that there has to be a lot of active management.

Almost all of the participants in this study demonstrated active engagement (even if with reluctance) with the concept of increased interventions, as being a necessary component of conservation strategies adapted to the impacts of climate change. Yet the complexity of views and depth of discussion on interventions in our interviews does not neatly correspond with the degree and nature of consideration given to this topic in the literature on adapting conservation policy to the impacts of climate change (Fig. 3), where the focus has centered on advocating for additional strategically located protected areas.

Assisted migration the deliberate translocation of an imperiled species from one location to another where it has not existed in recent history, is a notable relative exception (e.g. McLachlan et al., 2007; Richardson et al., 2009). When initially asked about their views on this (emerging at the time) topic, at least eight experts expressed skepticism towards assisted migration-type proposals.

(11) Our [conservation NGO] view is that it's too risky at this point.

(4) I'm not a big fan [of assisted migration]. People have a great nurturing tendency ... [but] we really need to keep [these efforts] in perspective and not have people's desire to help out, get us into a situation where we are intervening, without any guidelines or principles, in a system that we don't understand.

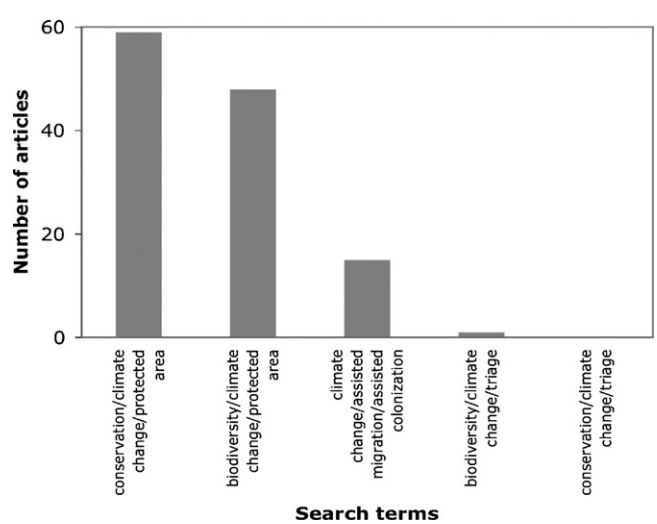

Fig. 3. Number of papers published on a range of strategies for adapting conservation policy to the impacts of climate change. Web of Science search Dec. 17.08 (1965–2008).

(19) My opinion is – wow – ain't that [assisted migration] tragic. Isn't that the canary in the coal mine that should be getting all of us to take notice and ask whether we want to be in that situation, because that is incredibly expensive ... you would rather be doing preventative medicine ... than paying for it afterwards.

(18) [assisted migration-like interventions] are ... I don't want to say doomed to failure, but they are doomed to failure! Conservation doesn't get much money, and it isn't about to get a lot of money. [assisted migration] is very expensive. Additionally, [we will] select for species that we think are important. And moving species to new locations will further challenge the species that are being challenged in those systems that may have some important function. [We] will select for the charismatic, we may not select for the functionally important. And if you look at our past history in biological manipulation, it doesn't ever go well.

On the one hand, the cautious and skeptical perspectives towards deliberate biological manipulation as expressed above are well founded. In many cases, deliberately translocating organisms has resulted in unintended and negative consequences, both for native species and human communities that rely on natural resources: the introduction of Nile Perch to Lake Victoria being a dramatic case in point (e.g. Mack et al., 2000). At the same time, other intentional introductions can be viewed as relative successes: the introduction of symbiotic mycorrhizal fungi (see Mack et al., 2000), or the introduction of crop species including cereals and rice, and livestock to North America centuries ago (Crosby, 2004).

Whether or not a given biological manipulation 'goes well' or is considered a success, is arguably influenced by both perspective and time. Perspective matters because some groups may see the introduction of a given species as providing certain benefits (agriculture and production), while others may view an introduction in terms of incurred losses (biodiversity). The temporal dimension matters because perspectives themselves change over time.

In spite of a general reluctance towards the idea of assisted migration, all but one expert acknowledged that it would be a necessary strategy in some cases (Table 2).

(18) I certainly think there is a place for moving some things. Moving some coastal plant species farther north isn't a bad idea. But moving species without a bigger functional plan, and having thought out what the unintended consequences might be, makes me nervous. It also seems like a tremendous use of resources.

(16) For some species it is going to work tremendously well – the reason we have such trouble with invasive plant and animal species is that some species are easy to move around and then take off. But I think we need to use as large a diversity of management tools as we have available.

As with discussions surrounding interventions more broadly, some experts similarly recalled the history of deliberate species translocations.

(9) We've already done it! We are there. We just haven't had the ethical conversation about what this really means when you do it on a large scale. Doing it for a handful of species is one thing doing it for several hundred or thousand species is another.

(1) We are going to end up moving species around intentionally to save them – obviously we already do that. Climate change is going to force our hand and we are going to end up moving species that can't get around urban and agricultural barriers – to get them to places where they are going to be more likely to persist.

Indeed, some respondents referenced their practical experience with translocation (albeit motivated by impacts other than climate change).

(8) We are ... moving [plant communities] ... farther north ... but that is not [because of] climate change. It is [because] this piece [of land] is being destroyed and houses are being put up, and we are going to save what we can of the native vegetation and move it somewhere else.

4.1.2. Conservation objectives and success

The findings above describe a range of potential pathways (means) to achieve a specific end (objective). For conservation biologists, the fundamental objective can be summarized as "the protection and perpetuation of the Earth's biological diversity" (Meine et al., 2006). As noted in the introduction, the primary means to achieve this end over the past 3–4 decades has been the establishment of protected areas that seek to separate valued ecosystem attributes from proximate anthropogenic stressors. The management (or means) objectives that currently guide these efforts are the representation and persistence of *a priori* identified species biodiversity targets (Margules and Pressey, 2000). Thus conservation success is currently measured in terms of hectares protected from proximate stressors; representation of ecosystems or ecosections; and the persistence of viable populations of specific species in specific places.

Some respondents argued that conservation success in an era of climate change could be evaluated using this same general approach (a focus on biodiversity patterns), recognizing that these patterns would inevitably change through time.

(5) Right now, our success is judged by our ability to maintain the species and ecosystems that we have ... right now. Under a new climate, we would have new ecosystems and new species lists. The way of evaluating success would be the same but the list would be different. We are going to see whole new assemblages of plants and animals that we have never seen before. We are going to lose some species and ecosystem-types ... just because of climate change. And we have to realize that there is not a darn thing we can do about that. You ... have to accept that [is] the case ... we have to adapt to a new reality. It means that our entire ecosystem classification that we have been working on for thirty years will be useless ... well, it will be of historical interest, it won't be useless, pardon me (laughing).

(12) The target is allowing evolution to happen. We will have completely reorganized ecosystems at all levels – we have to allow species to move ... to evolve. And if they can't ... then they are going to go extinct. That is the way the cookie crumbles.

Others argued that the only realistic approach to measuring conservation success in an era of climate change is by ecosystem function, because we "can't control species composition" (18).

(15) What it might mean is to change the goal. People have said we want ... the actual assemblage of what we have now [to persist]. Maybe what you want to have to persist are the natural processes, recognizing that this will [result in] different assemblages. [Standards of success] might need to evolve.

(6) [The goal] is trying to conserve the capacity of the system to adapt. So it is not a static view of structures, but much more subtle, and more about latent properties of resilience, adaptive capacity and evolutionary potential. I prefer very broad [objectives] like functioning landscapes, not specific kinds of age structure, or compositional features. Those are way too detailed targets. It's one of those things that can easily get over defined.

(18) [We need to] leave [behind] the spatial model of conservation and start thinking more about large scale conservation that is not based on creating protected barriers. So you no longer have as your conservation goal a protected area or a species. Rather your goal is how do you sustain a functional landscape ... or resource. Function is what it gets down to ... that is a great metric. It's asking what are the functions you want to preserve, rather than what is the place or ... species you want to preserve – and how do we get to that? For some places it may be asking how do you maintain water, the most robust run-off and flow given snow is changing to rain and disappearing ... as opposed to saying this is a great river because it has salmon in it! So we are no longer doing conservation for conservation sake – with the awareness that we do not have a static status quo.

Other interviewees expressed complex views regarding the prospect of changing objectives and expectations in the ways described above. In particular, we observed tension between a technical understanding of climate change impacts on ecosystem dynamics, and personal value preferences for existing patterns of biodiversity. This tension is encapsulated in the response of an adaptation scientist who specializes in ecosystem dynamics and managing ecological change.

(11) I still think that I am stuck on some sort of preservation paradigm. Although regions should be sustainably managing change, I don't want to see some of those things change! Because if you give up on [specific species and ecosystems], it's hard if you give up on that. Then what are you trying to achieve? [Adaptation] is full of all sorts of contradictory stuff.

Another conservation scientist echoed this resistance to change.

(12) We are going to go through a period of intense discomfort as species go extinct and we don't recognize the ecosystems that are being reassembled.

Similarly, a prominent conservation scientist responding to a statement from the audience during a seminar at the World Conservation Congress that there will be conservation 'winners and losers' and some species will stay in the 'game of life' and some won't, stated: "We have to be very careful about being sanguine – developing parts of the world are going to suffer ... we like the world as it is". This response reflects concern about failing to take the potential impacts of climate-change-related extinctions seriously, in tandem with the stated preference for minimal change with respect to species patterns.

Still others underscored the potential social implications of adapting conservation policy objectives.

(15) It is a very dangerous thing for the conservation community to think about changing its goals in this way – but it may be something that some of them are going to have to have the courage to think about. It is dangerous in a number ways. First, it could be perceived as a slippery slope. That, oh well, we're not going to succeed so we are going to change the rules. Second, is that it will endanger their support: if you give up on sphagnum bogs ... and someone really cares about sphagnum bogs, they might say, 'I will give my money to someone who is going to do the job if you're not going to do it'. Third, the conservation movement for the last hundred years has been predicated on preserving places. We can argue about whether that was realistic or not, or whether their notion of pristine was correct, but it has a lot of appeal for people who care about the outdoors. The notion that you are going to preserve processes, that then shape places can be appealing to a bunch of academics who understand that things weren't in equilibrium anyways, but is that going to have the same degree of popular appeal? How do you tell people that?

In fact, the practical experience of other respondents confirms some of the anticipated barriers to changing objectives as expressed in the quote above. When asked how conservation NGO's respond in practice to suggestions to manage for functioning landscapes rather than specific biodiversity targets, one participant explained that:

(18) ... people don't respond terribly well to it because it means changing the way they do business. The conservation paradigm is very entrenched ... this spatial idea is at the base of what conservation has been and it is hard to get people to think beyond that. It makes people feel uncomfortable to think beyond [the spatial] because protected areas or species numbers are very definable metrics. You can say we have protected x-number of hectares, or we have protected 500 Ibises. People can count it, and they feel like they can say they've succeeded. The conservation community has gotten very locked into this idea of being able to say that they have succeeded.

4.1.3. Conservation triage

Discussions about standards of conservation success and revising conservation objectives given climate change impacts were often linked with the concept of conservation triage. Triage for conservation derives from its application in medicine where it is a strategy for priority setting in urgent situations when it is not possible to save all patients due to resource limitations (time, supplies, medical personnel, alternatives) at a given point in time. Insofar as conservation priorities are set amidst social and spatial constraints, conservation activities (e.g. the siting of protected areas or the listing of endangered species) are ranked and prioritized all the time.[9] Conservation triage is different from prioritization because the former includes the explicit decision not to treat a given individual (protect a given population/species), knowing that a lack of effort (or an intervention applied in effort to protect another species) will likely lead to death/possible extinction of the first population/species. Triage for conservation involves making an assessment of the viability of a given population, species or ecosystem at a given place, point in time, and with some degree and type of intervention and probability of success. It means explicitly diverting resources away from targets assessed to be non-viable (by some criteria), in favor of efforts that are focused on targets assessed as being more viable given a set of conditions and interventions at a given point in time.

Historically, the concept of triage for conservation has been met with harsh criticism (e.g. Pimm, 2000) and described as "ethically pernicious and politically defeatist when applied to biological conservation" (Noss, 1996). At the same time scientists in the allied field of restoration ecology are actively engaged with developing this concept for ecosystem management (e.g. Hobbs and Kristjanson, 2003); consideration of triage concepts for conservation given climate change are increasingly found in the literature associated with government resource management agencies (e.g. Dunlop and Brown, 2008; Baron et al., 2008); and recent consideration has been given to triage in the peer-reviewed literature (e.g. Bottrill et al., 2008). Additionally, personal observations at key biodiversity and conservation meetings over the past 6 years indicate that consideration of triage principles is a topic at the forefront of the minds of many conservation specialists, even if not expressed in print.

In light of recent nascent discussions of triage for conservation and ecosystem management as outlined above, it was not entirely surprising that some respondents voluntarily raised the concept in the process of evaluating adaptation options for conservation policy. The following scientists affiliated with two different NGO's noted the following:

[9] Current prioritization schemes include species-based (e.g. taxonomic distinctness, keystone or focal species) and landscape-based approaches (e.g. hotspots, cold-spots, cost–benefit analysis over time).

(13) Inevitably one has to make some harsh decisions such as what you give up on. No doubt there will be species that we give up on. If you have a species with weak populations that has no hope in hell of surviving ... we would say [to policymakers], unless there is available climate space and suitable habitat ... one would have to question the value of investing large sums of limited resource in protecting that species, when that resource could go into protecting other species that would benefit.

(8) I'm all for it [triage]. It's a reality ... one of the sorts of decisions that can be made is that that [species x] is not able to be saved and to just let it go. I'm not against those kinds of decisions.

A similar view was voiced during a panel session on climate change and biological adaptation at a major science conference in 2007. In this instance, a participant asked about "abandoning place-based conservation". The session moderator directed the question to the panel by asking, "are we thinking about triage?" A panelist and IPCC lead author responded: "we are going to have to make hard ethical choices for species and habitats that have so little hope that they are not worth trying to save. I hate to say this, but this is the reality of the situation. The flip side of this is that it frees up more money to buy up more reserve land".

As with discussions on interventions including assisted migration, some experts argued that we already engage in a form of (implicit) triage in the form of the various priority-setting schemes used by conservation NGOs (e.g. hotspots and Conservation International). For these respondents, existing prioritization schemes are seen as essentially the same as conservation triage in response to climate change impacts.

(9) I think we have to start talking about triage. I don't see how you can walk away from it – we do it now. We [have] just elected not to have the conversation.

(2) Focusing on a certain set of issues inevitably excludes another set. Which is the bang for buck story ... you know, what can you do to get the maximum benefit? They [existing prioritization schemes] are all guides – they are all a desperate attempts to make trade-offs palatable.

Both echoing the history of discussion on conservation triage as "ethically pernicious and politically defeatist" (Noss, 1996), and reflecting the different ways in which the concept of triage can be interpreted, another respondent noted:

(1) I can imagine that there are people out there that are not willing to give up on any species and they would think that conservation triage is offensive, but they might think that conservation prioritization is reasonable.

Irrespective of the potential differences and similarities of conservation prioritization as currently practiced, vs. conservation triage considering climate change impacts, the challenge of designing the basis and criteria for explicit (and active) triage-like assessment for conservation decision-making in response to climate change and other interacting impacts emerged as a key (if uncomfortable) challenge.

(17) We used the concept of triage ... and I was really uncomfortable with it. But ... since species and ecosystems are going to unravel, it is important that we as a conservation community, and other stakeholders, have a conversation about the criteria for making decisions about what ecosystems we save. If we don't talk about the criteria ... it is going to be ad hoc, which could be even worse.

(2) It is assessing where we can afford to let go ... *de facto* species will go. We don't have the framework for tolerating loss. We have to figure out, for critical ecosystems to start with, what are the minimum sets of species within functional groups that are essential for [ecosystem] function? And then build up from there to not tolerate the loss of the raw scaffolding.

(9) It is a tough conversation, and one that I think we need to have openly. But I think you would want to try to ensure that at least one member of every genus survived – to try to maintain evolutionary options ... but that is arbitrary and capricious, and you could come up with another strategy.

Echoing the ambivalence of the last respondent, another expert noted:

(6) [Triage] opens up a whole other set of issues and problems. How do you define who is worse off? By whose metrics? What sort of indicators do you use?

Directly related to the challenges associated with defining metrics and indicators as noted above are the decision processes that flow from the indicators however defined. Consider the following example of a discussion between regional conservation scientists during a planning session on how to interpret the results of a climate change vulnerability assessment. "What if these species don't have a hope in hell? How do we handle this?" asked one scientist. This question sparked a lively discussion of whether more or less resources should be directed towards identified vulnerable species. Some argued the latter, that the most vulnerable species should be taken out of the assessment. Others felt that extra measures and resources should be put towards keeping them in the assessment precisely because of their vulnerability. In the end, the tension was displaced with the unanimously agreed upon comment that "the trouble with these conversations is the data gaps that exist".

Other interview participants questioned the transferability of the concept of triage to the realm of conservation – both in terms of species-level dynamics and resource availability.

(1) I don't see any problem with it [triage]. The trouble is that the units we are trying to save aren't usually individuals – there is a point of no return with individuals. I am not as convinced that there is a point of no return with species. So it seems reasonable to do conservation triage on the one hand, on the other hand given how little money is invested in conservation, I am not convinced that is the best way to go about things. So the California Condor – we have spent tons of money trying to save the species and the question is if we went from a purely triage point of view we would have let it go extinct and spent our money on other species. But it is not clear to me that we would have had the money to spend on other species. People rally around the Condor and attract money for it – so then the question is, if you are attracting money for it, is it taking away from money that could be attracted for other conservation programs?

A similar concern was expressed during a panel session on climate change and species extinctions at the World Conservation Congress. There, a panelist and IPCC author stated: "I am really concerned that policy makers are going to start asking questions about why we are investing money on wimpy species and huge dollars fighting species that are doing very well, [this represents] an awful nexus of problems".

While the quotes above reflect active consideration of the concept of triage (if not reluctance) a minority few expressed more absolute resistance that often centered on the social context of conservation decision-making. For example, some experts argued that explicit triage in objective setting would set a dangerous precedent and slippery slope on the path to "letting go".

(21) It [triage] just makes it so easy – the same with commoditization and being able to pay offsets – it is a completely slippery slope ... how in the world do you put a value on something? What if [developers] come up with the money? [Say] it is going to cost 4 billion to trash an area, and someone says, here it is. But, it was irreplaceable!

This quote reflects the view that associates the trade-offs inherent in triage-like prioritization with mechanisms for biodiversity offsets (conservation actions designed to compensate for adverse impacts on biodiversity by development in one location by protecting "equivalent" biodiversity values in another area with the desired end as "no net biodiversity loss") (see ten Kate et al., 2004). One of the central concerns regarding this approach is that in many cases, the damage incurred by development would incur losses to biodiversity values that were "irreplaceable".

For others, resistance to implementing the concept of triage derives from the view that it would problematically alter the focus away from increasing resources.

(4) I think that there is little question that we will have to be doing triage. The reality is that if you devote yourself entirely to triage and none to increasing the amount of resources available to deal with a problem – well then you'll wind up doing triage. Whereas if you put effort into increasing the amount of resources that you have to deal with the problem, that minimizes the amount of triage that you have to do. Sure you have to worry about triage a little bit but that is not where we want to put our main focus. You don't want to give people the impression that triage is the solution to the problem.

When asked if the conservation community needed nonetheless to start thinking about criteria and decision process for triage considering climate change impacts the same expert replied:

(4) Yes, I think that is quite reasonable. But, there is a social context to this and you need to make sure that you're not giving people the idea that you are just going to do triage. You need to emphasize that hopefully we will get funding in place to deal with this in a much broader way. We may have to do a little triage, but the message would be, we don't want to be in a position of doing a lot of triage. ... At the same time in the long term you want to have intelligent triage, so that you are a maximizing the positive impact of what resources you do have.

Perhaps not surprisingly, the experts who expressed the strongest rejection of triage principles were associated with major conservation NGO's. In partial contrast, those expressing the view that triage principles were undesirable but necessary were associated with affiliations spread equally across conservation NGO's (4); academic institutions (3) and government agencies (3).

4.1.4. Playing God, nature designers and ecosystem engineers

Combined, discussions on conservation means (namely active interventions), and changing conservation objectives including triage, often raised the notion (with both reluctance and matter-of-factness) of humans as playing God, nature designers, or ecosystem engineers.

(9) Assisted migration raises huge ethical issues ... basically you are ... in charge of nature at that point. We are nature designers.

(17) I'm not a great fan of this [assisted migration]. Maybe for species of a particular concern or that has some special value from a cultural standpoint. But ... I don't want to play God. If species are going to blink out, we have to accept that. I hate to accept that, I don't want to lose any species.

(2) What it means [conservation in an era of climate change], is an ecosystem engineering approach. We need more ecosystem engineers.

(13) Some conservationists [are] locked into a mindset that doesn't respect the dynamics of nature. It is easy for [me] to say that – less easy for a deep conservationist who has for all of their life worked on one set of reserves – to be told that you are going to have to give up on some of these things. They would say, 'I've spent 50 years of my life doing this – how can you tell me that?' [But] the reality is, you will have to give up on some of those things – unless you create artificial conditions. It is moving away from nature conservation ... to wildlife gardening.

Overall, eight respondents initially expressed opposition to assisted migration interventions (six affiliated with NGO, one government and one academic). However, over the course of discussion, all but one respondent noted that interventions such as assisted migration would be necessary given the impacts of climate change.

The tension surrounding discussions both about assisted migration and triage principles for management and objective setting arguably reflect different perspectives on "nature" and the role of humans within/outside of "it". On the one hand, the statement above by Expert 17 reflects the view that true 'nature' is something 'out there', and separate from human influence. By this framing, all human manipulation is 'intervention', seen as unnatural and potentially unethical. On the other hand, the statements of Experts 2 and 13 above reflect the perspective that nature is a co-produced, integral and linked component of society. Viewed through the lens of linked SESs, so-called 'interventions' such as assisted migration can be viewed as part of the evolution of management and changing means and objectives through time (however undesirable this may seem and noting the need for great caution in potential implementation). Combined, these responses reveal how different perspectives on nature can shape expressed preferences for management, which have the potential to influence policy design and implementation.

4.2. Basis for informing new conservation means: science, uncertainty and decision-making

In considering the criteria and basis for implementing new means such as assisted migration or new objectives including triage, some experts highlighted lack of knowledge as a key barrier to new policy design.

(21) I don't think that we can justify major [triage-type] choices. We don't know the role of species in ecosystems. There was a conference this year [2008], where they discussed these things. The conclusion was that we just don't know enough to say that we don't need that species. We can't tell you that – we don't know ... we can't make those decisions.

Without question, the scientific uncertainties associated with understanding the impacts of climate change on biodiversity (e.g. both process and pattern) are daunting. There are, for instance, uncertainties relating to biotic interactions including inter-specific competition, facilitation and mutualism (Pearson and Dawson, 2003; Guisan and Thuiller, 2005); dispersal dynamics (Pearson, 2006); colonization dynamics (Carmel and Flather, 2006; Ibanez et al., 2006); rapid evolutionary change (Gienapp et al., 2008); and interactions between these and other dynamics across scales. Additional layers of scientific uncertainties arise from future patterns of land use, changing carbon dioxide concentrations, how the climate will actually change and interactions between climate and other drivers.

Ongoing research will improve the richness of our understanding of these dynamics and resolve some current modeling challenges. At the same time, new insights will just as likely raise more questions, and may even increase uncertainty (cf. Yohe,

2006). Moreover, adopting the perspective of SESs as linked, dynamic and co-adapting systems, uncertainties are inherent and perpetuating in any case. Exemplifying this last point, other experts (again invoking history), highlighted that conservation decisions are currently, and have historically been based on uncertain and partial information.

(15) There is a mismatch – if you ask [conservation and resource managers] what they need [to manage resources given climate change impacts], you get back specifics. If you look at what they do today, they don't use any of those specifics anyways! I don't believe they need them to think about the future. They're not using them now, I don't understand why they think they need them to think about the future. If I thought it was true that you need 10 km scale climate predictions that were 90% accurate for the next 40 years I would be really depressed because we're not going to get that in the next 10 years ... If we really needed that, we might as well just start flipping coins. [But] I don't think we need that to make urgent decisions.

(17) [I disagree with those] who say we shouldn't go forward with adaptation because there is still too much uncertainty. We need to start testing ideas and do it in a way that has flexibility for us to change course if it's obvious that we've made mistakes. But to be willing to make mistakes – because if we are so overly cautious, we are going to be waiting until we have perfect data, and then it will be too late.

(6) I am a firm proponent of the latter argument [decision-making under uncertainty]. If you wait until you know enough to act with certainty it's going to be too late. The other side of it is that I believe really strongly, that what ever we do, whether we are transplanting species across ranges ... or trying to change drivers, we are going to make a hell of a lot of mistakes. It is a question how we deal with those mistakes.

4.3. Implementation and governance

Discussions surrounding new management strategies implemented in the face of irreducible uncertainty were commonly associated with arguments in favour of adaptive management. These arguments were simultaneously linked with discussions about the barriers to implementing adaptive management in practice and the importance of appropriate institutions.

4.3.1. Institutional dimensions and barriers

(15) We need the capacity to recognize that some of those early decisions won't work out. Adaptive management sounds great in theory, but in practice you don't want to be the guy that is wrong first, because you don't get a chance to be wrong twice. [Adaptive management] is clearly the philosophy that you need for these conservation decisions [considering climate change impacts], [but] there has to be a way for the ones that don't work out not to end people's careers.

(6) It is a very conservative system. There are lots of disincentives for [innovation] at the research level, at the applied level and the management level. There are lots ... of disincentives for doing things differently.

(4) There are regulations that codify [invasive species] and that means that they have a pretty long regulatory process to go through to get it fixed. So while I don't think there are any huge intellectual barriers, it may well take years to change it.

Others observed that it takes time for a change in perspective to set in.

(19) It takes a while for a paradigm shift ... to walk in. I have noticed in the last year that people are saying things that they weren't saying five years ago. So there is a timeframe that it takes for people to shift thinking.

Similarly, an adaptation conservation expert noted that:

(18) I don't like to believe that people won't come around. Since I started doing this ... there has been a lot more openness. Granted a lot of it is window dressing. But I don't fault the conservation biologists, they are the product of the educational system, and the model that they came out of. So while I want to shake people and say 'it's not working' ... the work they are doing is important. Protected areas are a key part of adaptation. But they need to be done within a broader context.

Lastly, others highlighted the critical link between changing perspectives over time and institutions.

(6) [Conservation in an era of climate change means conserving] the capacity for change. The capacity to change our functional or utilitarian view of what biodiversity does for humans, but also a capacity for people to change their perspectives over time, because they have, and they will. So it is a dynamic set of expectations, values and goals that people express. And how you set up the institutions that allow those objectives and approaches to evolve over time is as much a part of it as trying to keep certain species in certain places.

4.3.2. Livelihoods

Topics relating to livelihoods in the context of adaptive conservation strategies considering the impacts of climate change were substantively discussed in only two interviews. We report them here because although the intersection between livelihoods, rights and conservation activities has been extensively examined in the literature on social dimensions of conservation (e.g. Wilshusen et al., 2003; Brockington et al., 2006; West et al., 2006), thus far, with few recent exceptions (e.g. Heller and Zavaleta), insights from this literature have not been addressed and or systematically and substantially integrated in the climate change conservation literature.

When asked if livelihoods were considered alongside species projections in conservation adaptation projects, a climate adaptation specialist responded:

(10) These conversations [livelihoods and conservation adaptation] aren't meeting. There needs to be more bringing together ... otherwise we run into a situation where it is much worse ... and we've seen how community and conservation needs have clashed in the past. This is an opportunity ... to bring the people who think dominantly about conservation and the people who think dominantly about livelihoods, and the scientists who are thinking about these climate scenarios to start working together because we are going to have to respond to this in a connected fashion, to meet this challenge.

When asked what was required the same expert responded:

(10) We need to be developing a way of feeding into [the bioclimate envelope projections] and scenario planning, the information that is coming from the ground – from conservation practitioners, and communities. [The on-the-ground reality would] make the recommendations that experts make on these projections more realistic in terms of what can be achieved ... otherwise people are going to say: 'what the hell are you suggesting?'

The integration of livelihoods with ecological projections reflects a crucial research gap in addressing the challenge of

how to adapt conservation policy to the impacts of climate change. Further, this comment tempers suggestions by some that the core adaptation response for conservation objectives ought to be to 'save more and save aggressively'. As encapsulated in the views above, the design of adaptive conservation policy requires consideration not only of projections of future ecological patterns and processes, but also the implications of various strategies for those whose livelihoods will be impacted.

4.3.3. Jurisdictions

Others underscored the need for organizations and agencies to work across jurisdictional divides in a cross-sectoral and multi-stakeholder context in order to integrate conservation efforts within the broader landscape context.

(4) There is a great need to work across jurisdictions ... land management units are like little fiefdoms. People sometimes work across them, but people don't really collaborate across long distances. Unless we think about how we are managing change across much larger areas, across jurisdictions, and across management unit lines, then we could be working in opposition. If one protected area is managing to promote change of a particular species and another is promoting retention where it is, you will wind up with management efforts that are working against each other.

(13) There is a need for cross-sector engagement. So if one [seeks] to build an ecological network within a fragmented landscape ... [you need] partnerships between conservation organizations and ... government agencies, those involved in water management for flood protection, river management, agricultural policy, farmers, foresters, landowners and land managers. It requires a huge stakeholder engagement to effectively implement a landscape scale program.

At the same time, others highlighted the complexity of multi-stakeholder decision-making under assumptions of a relatively static model of ecosystem dynamics – let alone doing so incorporating the impacts of climate change. As one senior negotiator involved in ecosystem-based management for the central and north coast planning process commented during a conversation about academic proposals for conservation adaptation and incorporating climate change into management frameworks: "these folks are just trying to get a handle on adaptive management in a static context – asking them to consider climate change will blow their minds. They can't agree on a static model". S/he went on to note that in this case, where the negotiations have had a lengthy (decade long) history of personal effort for many of the individuals involved, that: "the heads of the people involved recognize the [need to integrate the impacts of climate change], but their bodies won't let them – there is a visceral resistance to change" given all that has occurred and given all the effort that has already gone into the plan as it currently exists.

On the topic of consensus-based processes for adaptive management in another region, one expert noted:

(6) This is one of the reasons why the [regional planning process] is stuck ... because of the complexities of the social interactions. Folks can't come to consensus ... they can't even get to "maybe" in terms of ... the vision of the immediate future. Everyone is saying ... this is mine and this is mine ... there is no institution that allows for those sorts of discussions to occur – to get through those things. So what happens are ephemeral, emergent, planning processes that ... some NGO, or government puts together, but then disappears. It is a missing institution problem [that is required] so that you can collaborate enough so that some actions can be taken.

5. Implications for understanding adaptation in conservation policy

The findings of our interviews with climate change and conservation experts serve both to identify an emerging set of key policy-relevant ideas, and point to a set of future research needs and questions.

5.1. Interviews reveal active consideration of topics beyond what is represented in the literature

The experts in this study engaged extensively with a number of outlier topics not widely or systematically represented in the conservation adaptation literature at the time of these interviews (2007–2008). These topics include the need to consider disturbance regimes in understanding and ultimately enabling species and population transitions; the need to systematically integrate property rights, livelihoods, and governance with proposed adaptation options such as new protected areas; and the need to discuss decision-making/prioritization criteria including explicit conservation triage. In some cases the greater extra-literature set of views expressed in this study may simply represent the front of knowledge as it develops in this relatively new field. This is arguably the case for the first two examples (disturbance regimes and human concerns), where expertise from different fields is only just being integrated for the purpose of better understanding the specific challenge of conservation adaptation.

Conversations surrounding the concept of conservation triage are less straightforward to interpret. On the one hand, and as indicated above, we were not entirely surprised by the degree of engagement that respondents displayed on this topic given our informal observations prior to conducting these interviews. On the other hand, the openness and complexity of views of many experts on this topic contrasts with the primary conservation literature (Fig. 3) in which triage has so far been presented primarily as being "morally corrosive" (e.g. Noss, 1996).[10] While we intended to engage in a discussion about the concept of triage, in many cases, participants volunteered triage principles as a necessary component of adapting conservation policy to the impacts of climate change. In other interviews, when asked, it led to extensive and often impassioned discussion. Of those who discussed triage, three respondents rejected the concept of outright, but 10 others agreed that while undesirable and problematic, some form of triage would occur, and they regarded transparent discussion of the concept as important, especially as it might come to be applied in practice.

Combined, these observations may indicate still nascent and developing ideas as suggested for other emerging topics such as integration of livelihoods. On the other hand, the data assembled in Section 4 suggest alternative interpretations for why principles for conservation triage considering climate change impacts have not been systematically examined. Specifically, some experts may be reluctant to examine the potential scientific basis of a triage framework as part of their career foci given that other prominent conservationists have spoken disparagingly of the concept (e.g. Noss, 1996; Pimm, 2000). Related to this explanation is that they may be tacitly recognizing that explicit triage-thinking falls outside current conservation norms, which are designed to maintain – not let go of -extant species or systems. Additionally, many conservation scientists engage in the work that they do

[10] Since this study (and literature search) was completed, a recent paper by Bottrill et al. (2008) has addressed the concept of triage in the context of conservation prioritization. Further, the concept of triage is referenced in the following agency reports (Dunlop and Brown, 2008; Baron et al., 2008) and in Daedalus (Parmesan, 2008).

precisely because they care deeply about the processes and patterns of life on Earth. In many cases, they have dedicated a lifetime of work to raising awareness and advancing research with the goal of maintaining biodiversity across scales. Adopting a triage-type framework of explicit loss and active intervention challenges this core effort.

An alternative/additional explanation for the greater engagement with the concept of triage detected here relative to the literature relates to precautionary concern and ambivalence towards more interventionist alternatives and the "messaging" that results in public settings. By messaging we mean the deliberate decision not to discuss triage in public. For instance, a number of experts acknowledged the technical necessity for triage ("we need to figure out the criteria") yet stated that they were not discussing it publicly in order to maintain a focus on other preferred alternatives (such as increasing resources for conservation and new protected areas). Such topical avoidance reflects understandable precautionary behavior in defense of 'slippery slope' fears that discussing interventions, ecosystem engineering and triage might bring their possibility more fully into being; a self-fulfilling prophecy of sorts.

The relatively rich discussions of triage in our interviews combined with ambivalence towards the concept, indicates two key points that can help us understand conservation adaptation from both theoretical and practical perspectives. First, our results underscore the complex relationship between individually held knowledge and the mobilization (or not) of that knowledge in more public spheres of the scientific literature. This observation fits with the interpretation of Kingdon (1995) and other scholars interested in theorizing policy change over time that the values of specialists play a key role in evaluating new policy alternatives – in this case, by the mechanism of selective discussion in the literature. Similarly, our results fit with the propositions of resilience scholars who suggest that the perspectives (or mental models) of key stakeholders (including experts) play a critical role in determining the dynamics and nature of change (Walker et al., 2006). In sum, our evidence supports theoretical perspectives that new proposals are unlikely to gain support if they are in contrast with the held values of existing specialists. We discuss the value commitments of specialists further in the section below.

Second, and more practically, our findings suggest that it may be time to move beyond outright rejections of triage-like proposals (that consider the impacts of climate change) and to instead systematically and openly discuss its development (or not). Scholars from the policy sciences, resilience research and environmental history all highlight that the evaluation of alternatives change over time. Recalling Kingdon (1995) these nascent discussions on interventions, revised objectives and triage, may eventually be interpreted as having gone through a gestation period (the point at which we are at now), after which some proposals may "suddenly" become acceptable (even if only for discussion).

5.2. New policy alternatives are shaped by technical knowledge and value-based commitments of specialists

As indicated above, publicly accepting the implications of climate change impacts on biodiversity (including the possibility of interventions like assisted migration and triage-type prioritization) arguably incurs substantial social costs – both personally and for the current valued goals of conservation (e.g. maintain *a priori* species and ecosystem in place). In particular, the anticipated consequences that arise from a technical understanding of biodiversity change dynamics in response to climate change impacts are placed in tension with value-based commitments that underpin the discipline of conservation with its goal to save everything, and a dedication to protected areas as natural spaces best left free of human intervention because "nature can handle things better than we can" (Section 4.1.1). Here, we argue that the way in which proposed adaptation strategies have evolved so far reflects these value-based commitments including a reluctance to publicly engage with more transformative alternatives in which current values would be untenable. From a policy perspective, this observation is important because it underscores the material consequences of values in designing adaptive policies. This interpretation may partially explain why some of the proposed conservation adaptation alternatives have been described as "window dressing" (alternatives that contain modifications that look adaptive but that do not pose a substantive challenge to conventional means, objectives and expectations of success).

From the perspective of psychologists, this observation can be understood as a problem of "protected values", where people strongly prefer not to trade one value or objective of importance for another equally important value because doing so would challenge held beliefs, values or norms (Baron and Spranca, 1997). Combined, these observations indicate the blurred boundary between objective science and advocacy in the "science-based" approaches of many regional, national and international conservation organizations. Although this study was not designed to examine the relationship between conservation advocacy and science, the topic was volunteered on a number of occasions.

(2) I hate to see myself as an advocate . . . but almost unavoidably I am. I work with [large conservation organization], I've come from that background. I can't split myself in half. It is very tricky. But I've got to maintain credibility, and it is very difficult if you are seen as a big greeny.

(17) I have to be very careful. But people like E.O. Wilson, or Tom Lovejoy, who have plenty of respectability, can be strong advocates at this point [in their careers], so I don't know where the breaking point is. . .

5.3. The presence of uncertainties does not hinder development of new alternatives

Related to the acceptance of new policy alternatives is the relationship between scientific uncertainty and decision-making. In our study, the majority of experts expressed the view that uncertainties relating to climate change impacts are often irreducible and therefore that decision-making must proceed in a learning by doing approach (only one expert expressed the view that adaptation cannot proceed in the face of uncertainty) (Table 2). In short, the presence of uncertainties is not viewed as a barrier to change. Rather, the evidence assembled in Section 4 indicates that some of the more influential barriers to adapting conservation means and objectives to the impacts of climate change include a combination of a precautionary ambivalence to more extensive interventions, institutional barriers, and value-based resistance to anticipated difficult species for species trade-offs.

Finally, while many conservationists view the impacts of climate change as a potential opportunity (or window) to motivate policy change, the most commonly advocated proposals for change in public spheres of publication and advocacy are characterized by the same sets of means (expand protected areas and migration corridors), and goals (save *a priori* identified targets) as conventional approaches. In other words, the impacts of climate change are used as an opportunity to expand (not necessarily change) existing mandates. This despite the evidence for active considera-

tion of potentially transformative proposals for conservation policy as presented here. One can cautiously speculate that a future expression of crisis, failure of the current response, or scheduled review may in time, allow for more public and systematic dialogue on emerging more transformative adaptation options for biodiversity. Clearly, substantive change in means and objectives can take time. It may also require the critical mass of a new generation of conservation scholars trained less in preservationist ideals and perhaps more in conservation interventions and the management of ecological processes.[11] With the passage of time, evidence of success or failure of current approaches, and (potentially) changing values, it is possible that previously rejected debates (but now with a history of debate) may eventually come under consideration.[12]

6. Concluding remarks

The empirical findings presented in this study serve both to underscore the ecological and social complexities of adapting conservation policy to the impacts of climate change, and to identify an agenda for future interdisciplinary research. For the former, our results indicate that policy adaptation in response to the impacts of climate change in the domain of conservation is unfolding under the influence of both of scientific information and value-based commitments. On the latter, our results highlight the need to build on the existing ecology and biogeography-focused scholarship from the field of conservation adaptation, to further engage with insights from disciplines across the natural and social sciences. This integration will aid in addressing as yet unresolved problem dimensions that include: the role of disturbance and interventions in species transitions, revised objectives including conservation triage, and human dimensions including the integration of livelihoods, property rights and governance.[13] This list of topics is partial, but arguably represents an important research agenda for future empirical work.

Lastly, viewed from the perspective of change dynamics in linked SESs we know that conservation policy in particular, and resource management policies more generally (Gunderson et al., 1995), have changed in the past, as they will continue to evolve in the future. Further, as has been proposed (Walker et al., 2006), and demonstrated in this paper, the perspectives of key stakeholders including specialists will play a key role in determining the nature of change over time.

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[11] On this latter point, insights from restoration ecology will have much to offer the developing field of conservation adaptation as it comes to be implemented in practice.

[12] History shows us that this has been the case both in the field of conservation (e.g. on topics such as whaling, pesticide use, controlled burns, invasive species) and other sectors more broadly (drinking and driving, seatbelt use, reproductive and other medical technologies, civil rights).

[13] We are currently in the process of developing a research programme in effort to make progress on integrating human dimensions into adaptive proposals for conservation considering the impacts of climate change. We are approaching this in the tradition of other multi-disciplinary efforts applied to environmental management broadly defined (e.g. Dahlem Conference Format).

Appendix A. Sample interview questions

Introduction and background

- Can you tell me a about your work as it relates to climate change and conservation?
- How did you come to be involved in this work?
- What are your interests at this meeting/conference?

Means and objectives

- What adaptive strategies are required given climate change?
- What objectives would this achieve?
- What guidance would you give biodiversity managers as to what they should be trying to achieve?
- In the context of protected areas, how would you describe your views on acceptable levels of human activities?
- What are your views on interventionist proposals such as assisted migration?
- How should we think about invasive species in an era of dynamic species ranges?

Success

- In 50 years, if we have successfully responded to this challenge – what will we have achieved? What would success look like?
- In what ways do you think we may have to adjust our expectations of conservation initiatives?
- How (or have) your views on conservation adaptation changed over time?

Uncertainties and decision-making

- What are your thoughts on the relationship between uncertainties in outcomes of new strategies and the possibility of trying them nonetheless?
- A topic that is coming up in relation to conservation and climate change is the concept of "**conservation triage**". Have you heard this? What does it mean to you? What do you think about it?

Implementation and governance

- What do you foresee in the way of social challenges where implementation of adaptive strategies are concerned?
- What do you see as the barriers to trying new things and becoming "ecosystem engineers"?

Other

- What do you see as the key unresolved issues for conservation adaptation?
- Is there anything else that you would like to add/discuss?
- Is there anyone else who we should speak with?

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