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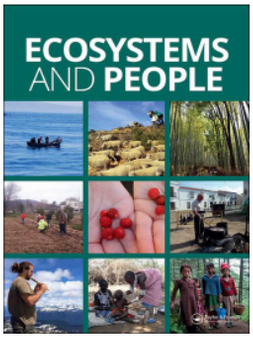

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REVIEW

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Engaging with the future: framings of adaptation to climate change in conservation

Claudia Munera-Roldan [a], Matthew J. Colloff [a], Bruno Locatelli [b,c] and Carina Wyborn [a]

[a]Fenner School of Environment and Society, Australian National University, Canberra, Australia; [b]Forests and Societies, Cirad, University of Montpellier, Montpellier, France; [c]Climate Change Team, Cifor, Lima, Peru

ABSTRACT
The term 'adaptation' is commonplace in conservation research and practice, but often without a reflection on the assumptions, expectations, or frames of reference used to define goals and actions. Communities of practice (e.g. conservation researchers, protected areas managers) have different interpretations of climate change impacts on biodiversity and different ways of defining, operationalizing and implementing adaptation. Their cognitive and motivational expectations for the future are associated with different paths to reach such desired futures. To understand how adaptation is framed in conservation, we undertook a systematic review with a thematic synthesis of the definitions of the term as used in the academic conservation literature. From a sample of 150 articles, only 36 provided a definition of adaptation. We critically appraised the explicit definitions to identify emergent themes that represent particular adaptation approaches. Themes were then grouped, and each group was assigned to a scholarly tradition, onto-epistemological approach and theoretical perspective. Based on theoretical perspectives on social change, we propose a framework (including individual cognitive basis, social interactions, and openness to alternatives) to analyse how change is framed in the definitions and how the framings influence adaptation options. The grouped themes represent passive, active, or indirect adaptation approaches. We used these themes to generate a conceptual model to guide conservation researchers and practitioners engaged in climate adaptation research, policy and management to aid reflection and understanding of the options available to design adaptation agendas and allow negotiation of diverse interests, views and expectations about the future.

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1. Introduction

Global biodiversity agendas are calling for novel conservation approaches and increased actions to address climate change effects on biodiversity and society while supporting 'habitable climate, self-sustaining biodiversity and a good quality of life for all' Pörtner et al. (2021). Adapting to climate change is and will continue to be an imperative for social-ecological systems (SES) through strong and innovative efforts. By SES we refer to the interconnected systems of people and nature, 'characterised by strong connections and feedbacks within and between social and ecological components that determine their overall dynamics' (Biggs et al. 2021, p. 5). Actions to prepare for and respond to actual or expected global environmental change are influenced by individual and collective framings of reality (Castree et al. 2021), previous knowledge, experiences, and expectations for the future. For example, adaptation in biodiversity conservation contexts usually concerns technical responses to known biophysical risks (e.g. floods, bushfires) or environmental changes (e.g. phenological shifts) through the evaluation of impacts and vulnerability, identification of options and implementation of responses (Noble et al. 2014). These responses represent visions or aspirations for the future, defining what elements are to be conserved and influencing social and political agendas.

As researchers and practitioners in climate adaptation integrate knowledge and practice among disciplines and across sectors (Nalau and Verrall 2021), different adaptation interpretations have emerged in the literature (Bassett and Fogelman 2013). Conceptualization and implementation of the adaptation concept involve contestation among adaptation stakeholders with diverse world views, knowledge, values, rules and preferences (Wise et al. 2014) and different ways of addressing uncertainty and social-ecological change (Wyborn et al. 2016). Accordingly, there are multiple interpretations of what adaptation is and what adaptation success looks like (Singh et al. 2021). Understanding adaptation concepts requires revising existing assumptions and expectations, and recognizing the diversity in framings of risk, time,

CONTACT Claudia Munera-Roldan Claudia.Munera@anu.edu.au
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and space to identify adaptation opportunities and diversify available options to address current change and prepare for the future (Morchain 2018).

The effects of climate change on biodiversity are well documented, as are the options to respond to it. Several articles detail adaptation options for protected areas (e.g. Hannah 2010; Gross et al. 2016), at species level (e.g. Foden et al. 2018) and SES (e.g. Colloff et al. 2020; Fedele et al. 2020). Working with nature and ecosystems to support adaptation to climate change is central to Ecosystem-based Adaptation (EbA; CDB 2009), Ecosystem-based Disaster Risk Reduction (Klein et al. 2019) and Nature-based Solutions (Seddon et al. 2019; Palomo et al. 2021). Other approaches in conservation practice include Climate-smart Conservation (Stein et al. 2013) and Pro-poor Conservation (Adams et al. 2004). All these approaches reflect a plurality of paradigms and frameworks, but rarely with a reflection on what or whose frames of reference are informing choices, what is deemed desirable, and how to deal with change (Osaka et al. 2021).

The lack of clarity in conceptual framings of adaptation and transformation can impede action (Feola 2015). Exploring the plurality of narratives, concepts and frameworks in use can stimulate discussions about the problem and approaches to find common ground in research and practice. Uncovering how climate adaptation is used in biodiversity conservation helps identify how epistemic communities (Haas 1992) frame and translate adaptation to communities of practice. In this paper, we explore future-orientation characteristics of the definitions and concepts of adaptation used in the academic literature to examine the ontological and epistemological origins that frame perceptions of change and concepts of adaptation. To foster reflexivity about these concepts and framings, we propose a model to guide biodiversity conservation practitioners and researchers dealing with climate change to critically think about future adaptation outcomes.

As far as we are aware, there is no published analysis exploring characteristics of future-orientation in relation to adaptation concepts, as used in conservation research. We explored: 1) how adaptation is defined; 2) emergent themes and concepts and 3) similarities and differences between adaptation concepts. We used a systematic review with a thematic synthesis of the literature by analysing themes and concepts to evaluate how the definitions are enabling an understanding of climate change impacts and preparation for the future. From this review, we developed a conceptual framework for conservation researchers and practitioners engaged in the interface between adaptation research, policy, and practice. We do not advocate a specific definition or approach but provide a critical perspective to think *about what adaptation is* and prepare strategies to deal with changing futures.

2. Methods

A thematic review is a qualitative method to identify concepts or themes and elicit how terms are applied in different situations (Thomas and Harden 2008). By analysing patterns of meaning within concepts used in particular contexts, boundary objects can be identified as well as common approaches used by communities of practice. We adapted the thematic synthesis procedure of Haddaway et al. (2018) to the following sequence: 1) select relevant literature on adaptation in conservation; 2) screen articles; 3) map and extract themes; 4) identify concepts, and 5) analyse concepts.

2.1. Literature selection, screening, and theme mapping

The literature was selected by running a broad query in the database Scopus using the search string:

> 'conservation' AND ('climat* chang*' OR 'eco* transform*')

Using the term (adapt*) returned too many results, in different disciplines, so we abandoned it. We selected articles in English (2010–2019), in peer-reviewed journals. The search was restricted to title, keywords, and abstract. The search generated 7,252 papers. We used revtools, an R Package to screen articles for similar topics or themes to identify relevant papers for synthesis (Westgate 2019). After several iterations we obtained a sub-sample of 441 articles. Manual screening of texts gave a final sample of 150 articles (Figure 1 and Appendix A). We excluded articles that: 1) described climate change impacts on ecosystems and/or biodiversity but did not address adaptation; 2) were about adaptive management but did not address climate change; 3) did not contain an explanation of, or approach to, climate adaptation; 4) reported sectoral vulnerability (e.g. forestry, fisheries or water resources) but which did not address biodiversity conservation (i.e. actions directed to preserve biodiversity or some elements thereof).

Each article conveying an adaptation concept was appraised as providing an explicit definition of adaptation. Those articles with a definition were critically assessed for key narratives and themes, which were then tabulated in MS Excel. Duplicate or overlapping themes were combined or clarified to obtain a list of grouped themes (clusters) by manual screening of articles that contained a definition of adaptation. The final number of themes and clusters emerged using an inductive coding approach while screening the 150 articles. Themes were coded using a cluster

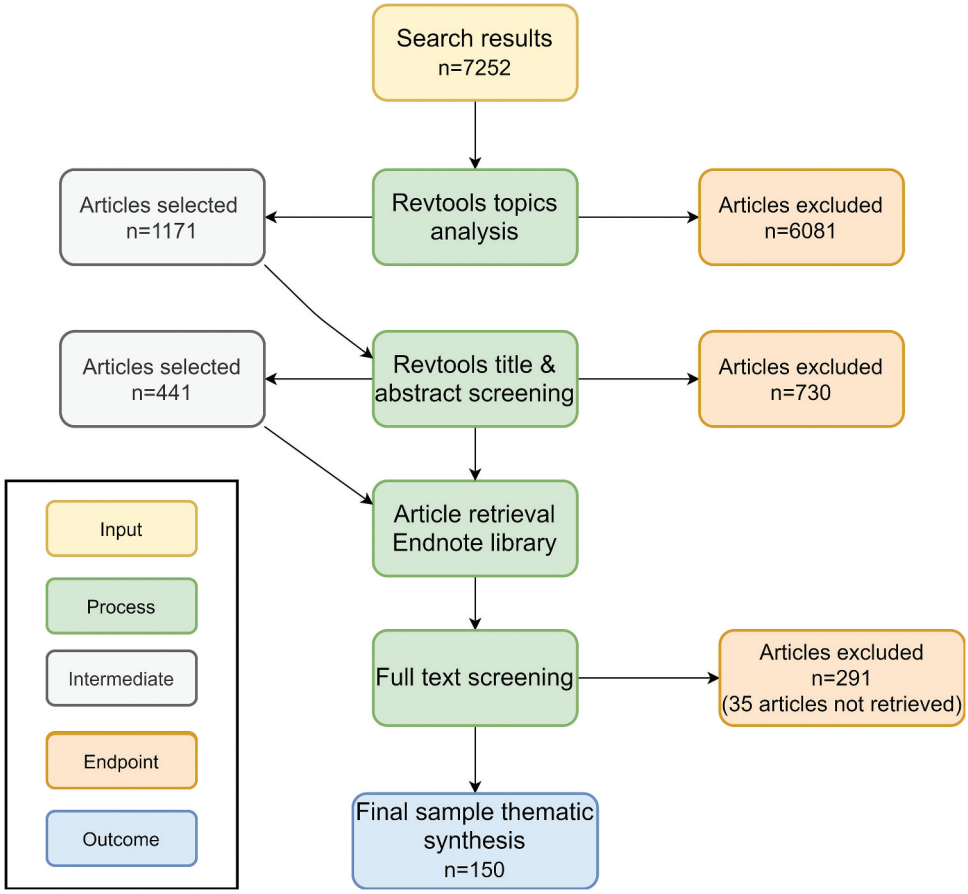

Figure 1. Flow diagram showing the stages of the systematic review process.

analysis of word similarity using qualitative data analysis software NVivo 12 (QSR International 2020).

2.2. An analytical framework for adaptation concepts

Understanding the epistemological and ontological diversity of adaptation concepts can help identify contestation between stakeholders engaged in adaptation activities (Bennett et al. 2017). Ontology concerns 'what is' the nature of reality to be explained, while epistemology is the knowledge choices used to understand the world (Moon and Blackman 2014). Different disciplinary traditions are grounded in different ontologies and epistemologies influencing what aspects of reality are studied, and which types of research methods are deployed to understand that reality.

Using an interdisciplinary basis to construct an analytical framework for adaptation concepts, we use elements from the Five Dimensions of Futures Consciousness (Ahvenharju et al. 2018) and components from the review of transformation by Feola (2015). Both frameworks are based on theoretical perspectives on social change. That of Feola (2015) is based on social theory and uses the criteria of Sztompka (1993) to classify social change processes: system model, awareness of time scales, understanding of causality, awareness of change and its outcomes. The framework of Ahvenharju et al. (2018) is based on social psychology and how people understand, prepare for and embrace the future. A primary assumption in our analysis is that nature and social orders (social institutions, structures, relationships) interact and are produced together (Jasanoff 2004). A simplified summary of these frameworks is explained in Figure 2 covering three broad domains to analyze the definitions.

The first domain is the cognitive basis on which individuals contemplate future consequences (Ahvenharju et al. 2018). This cognition includes 'time perspective'; an imagined logic between temporal elements in a system, such as patterns of decline or stability: 'the form and time span the change process takes' (Feola 2015, p. 379). Time perspective is linked with causality, assignment of function and intentionality: how an understanding of sequences of events and their consequences influences the capacity of actors to respond to change. Agency beliefs in this domain address how individuals and collectives have confidence in their capacity to influence future events.

The second domain involves systems-based and social-collective features of adaptation, involving system perception and the relatedness of system elements, including concern for nature and other people. SES are multi-dimensional, non-linear and involve interactions among their components

(resources, ecosystems, actors, communities) under a range of environmental, social, economic, and institutional conditions. Concern for others implies an understanding of how systems responses to drivers of change affect human and non-human agents (Dunlop and Brown 2008).

The third domain is openness to alternatives, involving critical thinking and questioning commonly accepted views of systems changes. Openness to alternatives implies exploring, using and applying new knowledge and options instead of looking for and sticking to predictions and plans (Ahvenharju et al. 2018). This domain brings together the previous ones.

After coding the themes extracted from the definitions, we aggregated similar themes in groups. We then used the three domains explained above (Figure 2) to explore how change is framed in the definitions and how the framings influence adaptation options. Table 1 describes the concepts used to assign ontological, epistemological, and theoretical perspectives to the grouped themes, following Moon and Blackman (2014).

3. Results

3.1. Thematic synthesis

Some 36 of the 150 articles screened provided an explicit definition of adaptation. Adaptation definitions were diverse, with a total of 83 themes across the 36 definitions, from maintaining conditions to accommodating change. These themes were aggregated into nine clusters based on overlap in scope (see examples in Table 2). Some themes appeared in more than one definition of adaptation and were therefore shared among clusters. (See Appendix A for details of which articles, themes and clusters were collated.) The thematic analysis reflected the conceptual diversity informing adaptation and how issues of visibility, authority and legitimacy influence the conceptualization of adaptation. For example, at least 12 definitions followed the IPCC definition of adaptation (IPCC 2007, 2014).

Each cluster represented a set of ideas, approaches, and expectations of adaptation. The nine clusters were: 1) Nature by Itself (evolutionary and autonomous adaptation); 2) Resilience (ability of systems and its elements to absorb change and recover from disturbance), 3) Managing Nature (active manipulation to prevent, or control perceived environmental crises); 4) Caring for Nature (non-manipulative management actions based on care and empathy); 5) Ecosystems (approaches promoting conservation and sustainable use of ecosystems, with ecosystem properties providing a basis for adaptation); 6) Opportunities (existing options to facilitate and implement adaptation); 7) Learning and Understanding (active processes involving collective production of knowledge on climate change, impacts and adaptation); 8) Institutional Processes

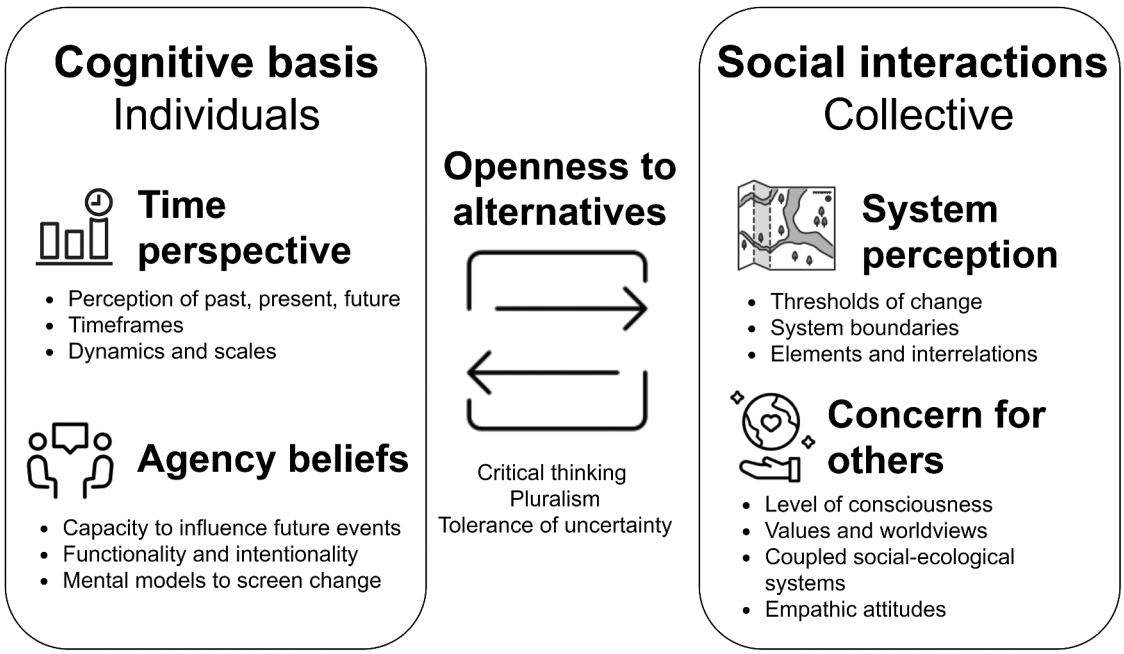

Figure 2. Analytical framework for adaptation concepts. The first domain (left) represents individuals' cognitive capacity to understand temporal characteristics of social-ecological processes and ability to respond to change and influence future events. This domain shapes the social, collective ways of understanding the system (right), its elements, boundaries, and the level of concern towards others. Openness to alternatives (center) or the individual and collective capacity to critically think about current options to deal with change helps to connect these domains. Based on Ahvenharju et al. (2018) and Feola (2015)

Table 1. Summary of concepts used in the analyses, explaining the ontological basis, epistemological approach, and theoretical perspective assigned to grouped themes from the adaptation concepts. Adapted from Moon and Blackman (2014, p. 1169).

	Elements	Definition
Ontology ('what is' the nature of reality to be explained)	Realism	One reality exist. Reality can be explained through appropriate methods (naïve realism). Defining reality remains uncertain because the structures affecting reality can change (structural realism). Understanding nature requires critical examination (critical realism).
	Relativism	Multiple realities exist. Reality has a unique construction in people's mind (relativism), or is constructed and shared by a group, but multiple realities are constructed across groups (bounded relativism).
Epistemology (Knowledge choices used to understand the world)	Objectivism	Knowledge is created by observing and documenting reality
	Subjectivism	Knowledge is influenced by people's interpretations of reality
	Constructivism	Knowledge is created through people's interactions with reality
Theoretical perspective (Systems of values guiding action)	Positivism	Knowledge from natural science methods can be applied to predict the social world
	Structuralism	Knowledge comes from understanding formal structures, ideas, and concepts in use, and can be applied to predict all aspects of human culture
	Critical theory	Question and challenge existing truths
	Feminism	Understanding power relations and behaviours to enable change
	Post-structuralism	Deconstruct language and discourses in use to understand a problem and its causes
	Pragmatism	Any method should be used to understand a problem

(governance options to facilitate adaptation) and 9) Anticipating (envisioning actions and responses).

We identified three emergent adaptation approaches from the clusters: 1) Passive (letting nature work); 2) Active (intervening); and 3) Indirect (creating the right conditions) (Figure 3). Proximity between clusters indicates the multiple concepts informing adaptation in conservation (representing a scholarly tradition) and the related onto-epistemological and theoretical perspective from which they are derived (Table 3).

3.2. Analysis of concepts

Below, we explore similarities and differences among the adaptation themes, following the three domains in the analytical framework for adaptation concepts (subsection 2.2.).

3.2.1. Time perspective and agency

Adaptation approaches connecting past, present and future through anticipation are embedded in the clusters Anticipating, Learning and Understanding, Opportunities and Managing Nature. Although the definitions of adaptation generally do not address time (32 of 36), we identified three temporal perspectives in the clusters. First, adaptation processes related to continuous, unidirectional perceptions of time attempt to prevent or minimise change (e.g. maintenance of ecosystems processes and functions), as in Nature by Itself, Caring for Nature and Managing Nature. In clusters such Institutional Processes and Anticipating, linear events (e.g. adaptive management, adaptation pathways) can have different directions, acknowledging options for alternatives to accommodate change. In the second perspective, cyclical natural processes allow adjustments under some degree of human intervention, as in Ecosystems, Resilience, Anticipation, Learning and Understanding and, in part, Caring for Nature. The third perspective lies between the former two and reveals the dual temporality of resilience thinking. The capacity of a system to self-organise following disturbance and maintain itself within critical thresholds denotes a cycle (Holling and Gunderson 2002, p. 34), but transformational change at small scales, which enables resilience at large scales (Folke et al. 2010) denotes non-linear, continuous change. Resilience as used in the definitions of adaptation means either maintenance of current conditions, facilitation of change, or support for system recovery.

Climate change is an exogenous force in all clusters. Exogenous drivers involve external pressures (e.g. effects of climate change and globalization) and the adaptation responses to those pressures, while endogenous drivers are properties of the system and its elements (e.g. phenology, consumption of natural resources). However, endogenous forces are evident in Nature by Itself and Resilience clusters, whereby ecosystems have inherent capacity to persist, adapt, or transform. In the clusters Caring for Nature and Managing Nature, adaptation responses to exogenous drivers are related to ideas of 'efficiency', thus justifying interventions. The cluster Ecosystems incorporates both endogenous and exogenous forces playing out over time.

The Caring for Nature and Ecosystems clusters entail maintenance of ecosystem functions as part of adaptation (e.g. Groves et al. 2012), while the functional role of rules and social processes is embedded in Managing Nature, Institutional Processes, Anticipating, Opportunities and Learning and Understanding.

Deliberation, planning and action for conservation adaptation are underpinned by our ability to explain facts in relation to perceptions of cause and effect. Concepts of causality and change may be objective or subjective, depending on the mental models used by different individuals and collectives (Moon et al. 2019). The nine clusters outlined above show contrasting approaches to time perspectives and agency

Table 2. Examples of definitions extracted from the articles containing definitions of adaptation and the emergent themes and clusters extracted from the definition. Clusters follow Full set in Appendix A.

Citation	Definition	Emergent themes	Clusters
Groves et al. (2012)	'Climate change adaptation refers to the adjustment of natural or anthropogenic systems to a changing climate for the purpose of moderating impacts or capitalizing on novel opportunities (IPCC 2007). We argue that integrating adaptation into systematic conservation planning is imperative … '.; 'we describe five explicit adaptation approaches that can be incorporated into regional scale conservation plans, trade-offs involved in their application, assumptions implicit in their use and additional data that may be required for their implementation: (1) conserving the geophysical stage, (2) protecting climatic refugia, (3) enhancing regional connectivity, (4) sustaining ecosystem process and function and (5) capitalizing on conservation opportunities emerging in response to climate change (e.g. Reducing Emissions from Deforestation and Forest Degradation [REDD])'.	Adjustments in natural systems Adjustments in human systems Identify and exploit opportunities Conserve geophysical stage Protect climate refugia Corridors and connectivity Maintain ecosystems processes and functions Mitigation *n* = 8	Anticipating Learning and understanding Opportunities Ecosystems Caring for nature Nature by itself *n* = 6
Lukasiewicz et al. (2016)	'Climate change adaptation refers to the actions that people take in response to projected or actual climate change' (Parry et al. 2007; p.27). A related but as yet lesser known concept is that of 'maladaptation', which refers to actions that seek to avoid or reduce vulnerability to climate change, but end up increasing it in other systems, sectors or social groups (Barnett and O'Neill 2010); 'Our research drew on an ecosystem-based approach to climate change adaptation which advocates strategies that improve environmental health as a way of ameliorating climate change impacts' (The World Bank 2009). Such strategies include the use of protected areas (Dudley et al. 2010), protection, maintenance and restoration of resilient, connected ecosystems (Cottingham et al. 2005) and conservation of biodiversity 'hotspots' (Catford et al. 2012)."	Human actions in response to climate change Avoid maladaptation Ecosystem-based adaptation Improve environmental health to reduce impacts Protected areas Resilient, connected ecosystems Protect biodiversity hotspots *n* = 7	Anticipating Managing nature Ecosystems Caring for nature Resilience *n* = 5

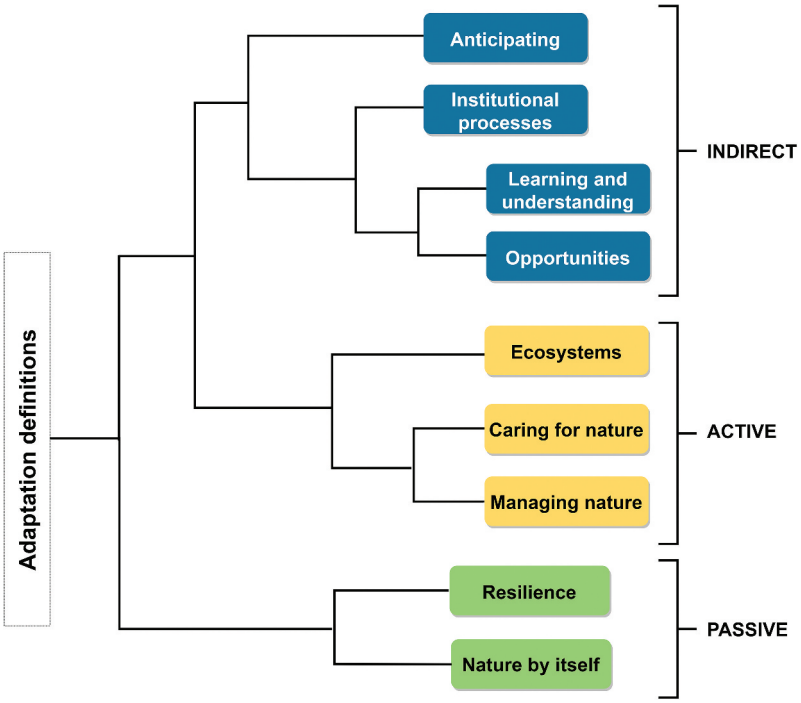

Figure 3. Cluster analysis by word similarity of the themes within the clusters and definitions. Clusters in blue represent *Indirect* mechanisms to create the right conditions; clusters in yellow are *Active* interventions and in green *Passive* interventions.

in relation to how, when, where and why human intervention may be required in conservation adaptation.

3.2.2. System perception and concern for others

The adaptation definitions and themes acknowledge the complex interactions between nature and people within SES but differ in concepts of what constitutes the system. Nature by Itself, Caring for Nature and Managing Nature mostly focus on natural systems and components, such as vulnerable species or biotic communities. Some definitions address 'complex social-ecological systems' (e.g. Jacobs et al. 2019) and take a systems approach to 'managing for ecosystem processes and function rather than for particular species' (Jantarasami et al. 2010). Ecosystems

Table 3. Emerging clusters (grouped themes) of adaptation in biodiversity conservation. Each concept was analysed to establish the scholarly tradition, concepts, and theories informing adaptation (ST), ontological basis (OB), epistemological approach (EA), and theoretical perspective (TP); OB, EA, and TP follows Moon and Blackman (2014).

Grouped theme	Description	References	Scholarly tradition, onto-epistemological & theoretical basis
Nature by Itself	Adaptation linked with evolutionary & autonomous adaptation, indicating natural processes that lack conscious or directed actions & responses: species & ecosystems have intrinsic capacity to adapt to change. Conservation thinking before the 1960s was broadly of the 'nature for itself' type, which prioritizes wilderness and intact natural habitats, generally without people and has scientific underpinnings from wildlife ecology, natural history and theoretical ecology	Metzger et al. (2006); Mace (2014)	ST: Biological/evolutionary sciences OB: Naïve realism EA: Objectivism TP: Positivist
Caring for Nature	'Caring is not only an attitude of concern for the well-being of another, but also … a practice that seeks to tend to another's needs'. Empathy as a driver for conserving nature (feelings of connectedness, grieving loss of ecosystems/species) and 'the constituting role of (re)productive activities and "sustaining services"'. Nature conservation is mobilized by human agency, where humans are care-givers' & 'care-receivers '. The practice of care can occur on a 'non-interference' vs. 'manipulating interventions' gradient.	Jax et al. (2018)	ST: Feminist philosophy OB: Structural realism EA: Subjectivism TP: Feminism & post-structuralism
Ecosystems	'Ecosystem-based adaptation uses biodiversity and ecosystem services in an overall adaptation strategy. It includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change'. EbA 'may require managing ecosystems to provide particular services at the expense of others'.	CDB (2009)	ST: various, mainly ecology OB: Critical realism EA: Constructionism TP: Structuralism
Resilience	' … resilience … is a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables'. 'Resilient forests are those that not only accommodate gradual changes related to climate but tend to return toward a prior condition after disturbance either naturally or with management assistance'.	Holling (1973); Millar et al. (2007)	ST: Ecological resilience OB: Structural realism EA: Objectivism TP: Positivism
Managing Nature	Conservation biology as a response to environmental crisis 'shaped the relations between ecological science, natural resource management and environmental politics'. Conservation management actions are interventions undertaken by individuals to reach predetermined conservation goals (e.g. prevent, ameliorate, or accommodate change), for example restoration aims to repair or improve some conditions assumed to be malfunctioning.	Robin (2011); Prober et al. (2019)	ST: various, mainly ecology OB: Critical realism EA: Constructionism TP: Structuralism
Opportunities	'Factors that make it easier to plan and implement adaptation actions, that expand adaptation options, or that provide ancillary co-benefits'.	Klein et al. (2014)	ST: multiple traditions OB: Relativism EA: Subjectivism TP: Structuralism
Learning and Understanding	'The processes that are in place to enable learning and how to strengthen them'. 'Enabling adaptive processes of improving management goals, policies and practices through learning are adopted to help bridge the science-policy gap'. 'A systematic understanding of climate change adaptation by local natural resource managers is needed, not only to characterize the current status of adaptation, but also to enhance future efforts to track adaptation at scales relevant to state agencies or regional organizations'	Wyborn et al. (2016); Wise et al. (2014); Adger et al. (2009)	ST: multiple traditions OB: Bounded relativism EA: Constructionism TP: Constructivism
Anticipating	'Adaptation needs arise when the anticipated risks or experienced impacts of climate change require action to ensure the safety of populations and the security of assets, including ecosystems and their services'.; 'All efforts to "know the future" in the sense of thinking about and using the future are forms of anticipation. Equally the future is incorporated into all phenomena, conscious or unconscious, physical or ideational, as anticipation'.	Noble et al. (2014); Miller et al. (2013)	ST: multiple traditions OB: Relativism EA: Subjectivism/Objectivism TP: Constructivism/Positivism
Institutional Processes	Options to facilitate transitions or transformation of governance arrangements to accommodate change while acknowledging scientific uncertainty, considering social values and the cross-scale and systemic nature of climate impacts (vertical and horizontal integration).	Wyborn et al. (2016); Wise et al. (2014)	ST: multiple traditions OB: Bounded relativism EA: Constructionism TP: Critical theory/pragmatism

and Resilience clusters regard systems as dynamic human-nature interactions; Resilience approaches address the complexity of biodiversity as a systems property that contributes to resilience (Peterson et al. 1998).

Adaptation occurs at different scales within a system and depends on how system boundaries are defined. Caring for Nature, Ecosystems and Managing Nature contain an explicit focus on the physical boundaries of protected areas, whereas Institutional Processes address the fuzzier boundaries of protected area governance. In Ecosystems, Caring for Nature, Resilience, and Institutional Processes clusters, human-nature interactions are central to adaptation. However, Resilience has broad framings in the definitions, sharing with Nature by Itself the theoretical perspective that nature has an intrinsic capacity to adapt to change. Thus, the scale at which autonomous adaptation is expected to occur defines system boundaries and the limits of acceptable change. Some articles address the spatial scale of adaptation in terms of ecological connectivity: interactions of system components (genes, individuals, populations, and species) across scales drives ecosystem processes such as dispersal, colonisation and recruitment, as in the Ecosystems and Resilience clusters.

Managing Nature and Caring for Nature are both action-oriented but differ in process and systemic perception. Managing Nature involves active management intervention to resist change in some biophysical elements (e.g. species translocation), while Caring for Nature involves actions to ameliorate impacts and can include landscape approaches (e.g. restoration, facilitating autonomous adaptation). Opportunities, Anticipating, Learning and Understanding, and Institutional Processes involve actions by individuals and collectives to prepare for, and respond to, exogenous drivers of change.

The diversity of system perceptions highlights differences between approaches of preventing versus accommodating change. The capacity to reframe responses to change is examined below.

3.2.3. Openness to alternatives

This domain connects the individual domain (time perspective and agency beliefs), with the collective (system perception and concern for others), where perceptions of change affect adaptation actions (sub-subsection 2.2).

The adaptation concepts differ in whether change is to be avoided or embraced. Themes range between maintaining the status quo (Nature by Itself), or accepting change, as in Resilience. Both clusters have a theoretical basis in biological sciences whereby species and ecosystems have an intrinsic capacity to adapt to change. However, Resilience addresses change via systems absorbing shocks and maintaining integrity. Thus Resilience-related themes acknowledge the dynamic nature of systems (Bernazzani et al. 2012), but the goal of maintaining integrity may prevent adaptation and change.

Themes in Managing Nature include options to use non-native species to maintain or restore ecosystem services, contrary to traditional conservation approaches that focus on protecting native species through eradicating alien species. Maintaining ecosystem functions is more important than the origin of the organisms that deliver them, enabling alternative adaptation approaches and constructs of novel and modified ecosystems (Hobbs et al. 2014).

Openness to alternatives implies that agents understand and examine the temporal contexts of the strategies available to them (MacKenzie 2021). Visioning helps agents anticipate change and its consequences, thus guiding action (e.g. Bernazzani et al. 2012; Brazier et al. 2012; Watson et al. 2012). Adaptiveness, including adaptive management, adaptation pathways and building adaptive capacity (e.g. Fuentes et al. 2011; Weisshuhn et al. 2018), enables reframing decision contexts in response to anticipated or unexpected changes (Gorddard et al. 2016). These processes, involving human agency in adaptation, occur in Institutional Processes, Learning and Understanding, Opportunities, and Anticipating.

Adaptation may be driven by emotions (e.g. solastalgia – grieving for degradation and loss of ecosystems; Albrecht et al. 2007), symbolism (terms and metaphors to communicate meaning), or rely on scientific explanations (based on biological, social and economic theories). In studies of social change, the role of trauma has been explored in the willingness to accept change and new approaches. Trauma is linked to negative memories of loss and pessimistic imaginaries of the future (Alexander et al. 2004). Caring for Nature and Managing Nature reflect this perceived sense of loss, while Ecosystems, Anticipating, Learning and Understanding, and Institutional Processes help identify actions to minimise damage, reduce threats and accommodate change.

Opportunities, Anticipating, Institutional Processes, Learning and Understanding use reflexivity to understand and rationalise cause-and-effect events into actions. The concepts address issues of trauma and loss grounded in ontological positions, belief systems, held values that frame people's expectations for the future (Alexander et al. 2004), influencing their capacity to deal with uncertainty.

4. Discussion

The term adaptation functions as a boundary object in conservation research and practice, with different meanings linked to a range of expectations and

adaptation approaches. Experts and communities of practice use adaptation-related terms indistinctly, enabling 'acceptance across groups despite different meanings attached to them' (Goldman et al. 2018). However, repeated use of concepts without careful consideration of meaning, interpretation and application, can constrain options to address complex ecological dynamics under uncertain change (Johnson and Lidström 2018), including adaptation governance and socio-economic aspects (Rubio Scarano 2017).

The themes and clusters differ in terms of how a system is described (natural vs. societal), temporal perspectives (linear vs. cyclical) and openness to change, representing specific characteristics to anticipate and prepare for the future. These differences are explained by the diverse scholarly traditions, ontologies and epistemologies from whence the clusters emerge. The definitions represent a spectrum of approaches from realism to relativism that reflect variation in the acceptance of uncertainty and openness to change. The epistemological and theoretical space in which scientists and managers operate can enable or constrain participation of stakeholders and adaptation options. Below, we explain these findings in relation to what future consciousness means (Ahvenharju et al. 2018).

The negative impacts on biodiversity caused by climate change can engender urgency to explore options for adaptation (Loorbach et al. 2017). This sense of urgency is related to rates of biophysical change and how time is conceptualized (linear vs. cyclical, fast vs. slow) which, in turn, influences the nature and pace of responses (e.g. reactive or anticipatory; Múnera-Roldán et al. 2020). The rate and magnitude of biophysical change influences how social change and adaptation occurs under conditions of stability, incremental, or transformative change (Colloff et al. 2020, Figure 2 therein), conditioning the nature of changes to institutional structures and processes, including cultural identity (Sablonnière 2017). Addressing long-term thinking starts acknowledging that urgent issues requiring immediate action (e.g. epidemics, bushfires) will always occur in parallel to and compete with, considerations of how to address long-term consequences of present actions in decision making and management (MacKenzie 2021).

A long-term perspective helps identify adaptation options, connecting everyday knowledge with expectations for the future. Conservation using climate change refugia is one example of adaptation considering long temporal perspectives (Morelli et al. 2020). However, only one of the articles providing a definition recommended protecting climate refugia and, among the 150 screened articles, only four mentioned it. Spatial planning and climate refugia are promoted globally as an adaptation option, but these efforts have not been successful (Carrasco et al. 2021). This might suggest that, in defining adaptation options, decision makers might not be addressing spatial and temporal perspectives of conservation actions in relation with pace and rate of transformation, and social-ecological systems responses to change.

Time perspective is linked with characteristics of agency as causality, assignment of function and intentionality. People assign function to system elements based on their mental models of what that element is, does and how it changes, affecting how drivers of change are classed as endogenous or exogenous (Sztompka 1993). Awareness of change and its consequences prompts a sense of agency, by connecting knowledge and understanding to the intent to act and then to current or future adaptation actions.

Agency beliefs are instituted through 'mainstreaming adaptation'; the translation of awareness of the need to respond to climate change into policies and frameworks for adaptation (Burch et al. 2014). Agency involves the capacity for transformation, reorganizing and developing structures and processes to learn about and respond to systems changes (Alexander and Sztompka 1990), and is central to identify options towards transformative change as suggested by Palomo et al. (2021). Questioning current approaches and rules and being open to alternatives can enable learning to respond to ecological change. Critical thinking and learning processes can help to address power imbalances by including other voices and forms of knowledge, thus creating options to identify unconventional solutions.

A utilitarian, instrumental approach to ecosystem functions and services in some conservation approaches (e.g. EbA, environmental peacebuilding) privileges scientific positivist approaches, marginalising other world views and knowledge (Woroniecki et al. 2020). The recommendations in the articles often focus on strengthening scientific and technical knowledge for adaptation. Accordingly, adapting conservation to climate change may be missing opportunities for knowledge co-production and addressing power imbalances. Part of what is missing is the importance of empathy to nature; humans and nature are not decoupled (Kiik 2018). Acknowledging the inseparability of human-nature interactions helps address power imbalances and re-draws the boundaries of social and natural systems.

Scientific and technical knowledge is usually preferred to inform decisions in adaptation. Although this desire for predictive certainty via empirical testing of reality (e.g. species models, vulnerability analyses) is valid, it is important to recognise that approaches advocating only scientific knowledge to anticipate change, reduce uncertainty and exercise control can exclude other perspectives and ways of doing (Borie et al. 2019). This can create an

assumption that adaptation to climate change is a problem to be solved only by science and technology, rather than an issue to be addressed through pluralism and changes in societal values and rules.

Applying pluralistic adaptation approaches involves developing a holistic, systems perspective to planning and action to address the complex dynamics of SES and understanding how climate change and other drivers create cascade effects through the system, its elements (Dunlop and Brown 2008) and also how humans respond to climate change (Watson 2014). Identification of tipping points, thresholds of potential concern and limits of acceptable change then provides a basis to translate understanding of system cascades into adaptation actions (Biggs et al. 2011; Freitag et al. 2014). Addressing tipping points and thresholds to avoid maladaptation is a fundamental principle of the adaptation pathways approach (Wise et al. 2014; Fedele et al. 2019).

5. A conceptual model for adaptation in conservation

We consider there are three basic types of adaptation, whereby perceptions of change and the conservation goals guide adaptation options and mechanisms (Figure 4): 1) incremental adaptation; 2) a continuum of resistance, resilience and transformation, and 3) adaptation as transformation.

Adaptation as an incremental process, separate from transformation. For conservation goals aiming at preserving system structure and functions, as in Caring for Nature, adaptation options are framed as responses to maintain current prevailing societal objectives through reducing climate-related risks (Dow et al. 2013). Adaptation is mainly through coping actions and incremental short-term responses (Adger et al. 2009) through active (e.g. preventing change by controlling invasive species; Peterson St-Laurent et al. (2021), or passive approaches (e.g. climate refugia; Morelli et al. 2020). If ecological change is not prevented, then 'limits to adaptation' have been reached (Dow et al. 2013; Barnett et al. 2015) and transformation is necessary.

Adaptation as a continuum of resistance, resilience and transformation. This form of adaptation aligns most closely with Managing Nature. Conservation goals aiming to build resilience would need to explore epistemologies and frames of reference under which resilience is defined and decisions are made (Peterson St-Laurent et al. 2021). These include defining the current regime, system boundaries, tipping points, effects of driver variables across spatial-temporal scales (Smit et al. 2020) and exploring alternative states under scenarios of change. Resilience is not about systems 'bouncing back' to an original state, but 'the ability to adapt and change, to reorganize, while coping with disturbance' (Walker 2020, p. 1). If the system is likely to transform to an alternative stable state, then new structures and functions arise, creating new options and priorities for conservation adaptation. Resilience can also include the capacity for incremental change.

Transformation as an integral and necessary part of adaptation. For conservation goals accepting systems are dynamic and unpredictable, adaptation involves accepting, anticipating and accommodating change to achieve transformation (Rickards 2013). This approach, which aligns with Ecosystems cluster, enables dynamic adaptive management, constant updating of rules and practices and consideration of novel ecosystems. Adaptation occurs via a mix of incremental and transformative actions, whereby 'windows of opportunity' created by changes in decision contexts for adaptation enable successful implementation (Lavorel et al. 2019). Anticipatory responses can also lead to transformative adaptation (Freitag et al. 2014) while exploring options to update current conservation decision contexts and adaptation processes (Colloff et al. 2017).

All three adaptation types require careful attention to governance issues (i.e. responsibilities, rules, resources). Some adaptation actions might not have leverage under current regulations (McCormack 2018), or resources may be insufficient to implement management and deal with unfolding changes, restricting individual and institutional capabilities to shape future events (agency).

Adaptation actions are likely to benefit from critically examining current values, norms, and frames of reference guiding conservation actions while identifying transitions towards practices that support flexible and proactive implementation in response to global environmental changes (Colloff et al. 2021). Similar models to understand adaptation options have been proposed recently, as the Resist-Adapt-Direct framework (Lynch et al. 2021), or Peterson St-Laurent et al. (2021) resistance-resilience-transformation typology. Our proposed model complements such frameworks and can help researchers and practitioners unpack what and whose frames of reference are used to address socio-ecological change, and thus shape the development and implementation of conservation and adaptation agendas. But more importantly, the model can help foster dialogue and reflexivity over whether decisions made today are adequate for the future in a rapidly changing world.

6. Conclusions

The themes in the definitions of adaptation reflect diverse narratives of what adaptation is, how to implement it, perceptions of change, and expectations for the future. This lack of clarity is persistent and has

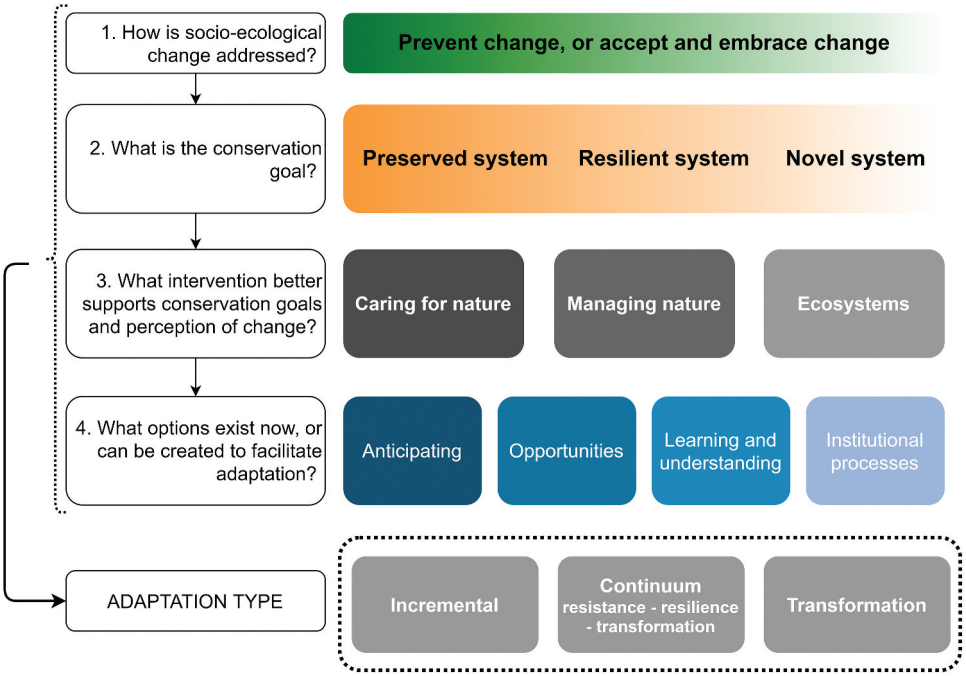

Figure 4. A conceptual model for adaptation in conservation. Depending on the perception of change (1) and the desired goals (2), the interventions (3) can differ. The options (4) for adaptation represent indirect underlying basis for all adaptation types, which can be an *incremental* process and separate from transformation, a *continuum* of resistance, resilience and transformation, or occur via *transformation* as an integral and necessary part of adaptation.

made it difficult to operationalise adaptation frameworks (Peterson St-Laurent et al. 2021). Conservation biology is a subject in constant evolution, where different concepts have been applied over time (Mace 2014). Our findings reflect this plurality. To aid scholars and practitioners seeking to navigate this potentially confusing terrain, we offer a heuristic to enable critical reflection on current options, revise assumptions, question established truths and negotiate contested views of climate-related change.

We found different concepts and approaches to deal with change, including the capacity to recognize system conditions, elements, and their dynamic interactions at different spatial-temporal scales. Adaptation approaches shape current and future options to address change, including what needs to be done differently, what elements should be maintained, and acceptance of when a system transformation is inevitable. Defining conservation adaptation goals (either by preserving current conditions, building resilience, or accepting novel systems) is highly context-dependent, a result of how values, rules and knowledge frame adaptation decision-making for conservation (Gorddard et al. 2016), shaping how we prepare for the future.

Adaptation approaches are enabled by flexibility, diverse values and knowledge. Processes of reflexivity can help reconcile different expectations and forms of knowledge to facilitate managing change (Múnera-Roldán et al. 2020). Such facilitation then aids the understanding of responses by SES as they unfold in the present, enabling options for alternative management under rapid ecological change. Open dialogue and critical reflection about expected conservation goals, options, concepts, and onto-epistemological foundations of adaptation and conservation science and practice (Moon and Blackman 2014) can help clarify what adaptation means in a specific context. In this way, those involved in adaptation can learn and build from this conceptual diversity to create a common, pluralistic ground to better understand current options and implement adaptation while opening up future options and choices.

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ORCID

Claudia Munera-Roldan http://orcid.org/0000-0003-0601-2312
Matthew J. Colloff http://orcid.org/0000-0002-3765-0627
Bruno Locatelli http://orcid.org/0000-0003-2983-1644
Carina Wyborn http://orcid.org/0000-0002-4314-347X

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