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Cross-scale feedbacks and scale mismatches as influences on cultural services and the resilience of protected areas

Kristine Maciejewski,[1,3] Alta De Vos,[1] Graeme S. Cumming,[1] Christine Moore,[1] and Duan Biggs[2]

[1]*Percy FitzPatrick Institute, DST/NRF Centre of Excellence, University of Cape Town, Rondebosch, Cape Town 7701 South Africa*
[2]*Australian Research Council Centre of Excellence for Environmental Decisions, Centre for Biodiversity and Conservation Science, University of Queensland, Brisbane, Queensland 4072 Australia*

Abstract. Protected areas are a central strategy for achieving global conservation goals, but their continued existence depends heavily on maintaining sufficient social and political support to outweigh economic interests or other motives for land conversion. Thus, the resilience of protected areas can be considered a function of their perceived benefits to society. Nature-based tourism (NBT), a cultural ecosystem service, provides a key source of income to protected areas, facilitating a sustainable solution to conservation. The ability of tourism to generate income depends, however, on both the scales at which this cultural service is provided and the scales at which tourists respond to services on offer. This observation raises a set of location-, context-, and scale-related questions that need to be confronted before we can understand and value cultural service provision appropriately. We combine elements of resilience analysis with a systems ecology framework and apply this to NBT in protected areas to investigate cross-scale interactions and scale mismatches. We postulate that cross-scale effects can either have a positive effect on protected area resilience or lead to scale mismatches, depending on their interactions with cross-scale feedbacks. To demonstrate this, we compare spatial scales and nested levels of institutions to develop a typology of scale mismatches for common scenarios in NBT. In our new typology, the severity of a scale mismatch is expressed as the ratio of spatial scale to institutional level, producing 25 possible outcomes with differing consequences for system resilience. We predict that greater differences between interacting scales and levels, and greater magnitudes of cross-scale interactions, will lead to greater magnitudes of scale mismatch. Achieving a better understanding of feedbacks and mismatches, and finding ways of aligning spatial and institutional scales, will be critical for strengthening the resilience of protected areas that depend on NBT.

Key words: cultural ecosystem services; ecological scale; institutional level; nature-based tourism; park; protected areas as socioecological systems; reserve; scale mismatch; socioecological system; spatial resilience.

Introduction

Protected areas are central to conservation, with many conservation strategies relying on maintaining and expanding protected areas and networks of protected areas to counter increasing pressure on biodiversity. Although the importance of protected areas is widely acknowledged by conservation biologists (Margules and Pressey 2000, Chape et al. 2005), setting aside or maintaining areas for conservation may be controversial. Certain cases of protected area establishment have occurred without due process or sufficient consideration of the rights and existing claims of local communities (Orlove and Brush 1996, Agrawal and Gibson 1999, Berkes 2004). Additionally, maintaining protected areas that include land containing desirable natural resources or that are located in desirable areas for urban development is increasingly difficult (Cohn 2011). The creation and maintenance of protected areas in the postcolonial era thus depends heavily on negotiation and compromise. Furthermore, once areas have been formally listed as protected, they must be managed and maintained. Enforcing regulations and maintaining access to protected areas requires not only political will and active engagement by stakeholders, but also income, making them a potential burden on society. Protected area management and enforcement is thus subject to the demands and requirements of the stakeholder community.

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[3]E-mail: krismacski@gmail.com

When most people think about protected areas they envisage long-standing, iconic places, such as Yellowstone National Park in the USA. These parks appear in the public imagination as fixed, immovable, and constant. Not all protected areas, however, enjoy the same prestige or institutional protection. Many protected areas are considerably more vulnerable to the winds of political, social, and economic change (Biggs 2011, Mascia and Pailler 2011, Biggs et al. 2014; Cumming et al., *in press*). Therefore, a resilience-based approach to understanding and managing protected areas is useful as it draws attention to the ability of the system to maintain its identity in the face of disturbances and unpredictable change (Adger 2000, Gunderson and Holling 2002).

If we accept that the resilience of protected areas is dependent in part on their perceived benefits to society, understanding and quantifying those benefits becomes important. The existence of some protected areas can be fully justified in economic terms, as demonstrated through cost–benefit analyses of direct returns (Naidoo and Rickets 2006, O'Farrell et al. 2011). Further, recent focus has been primarily on regulating and provisioning services, i.e., carbon storage, pollinator populations, or the contributions made by headwater parks to downstream water quality and quantity (Turner et al. 2012). By quantifying the services that protected areas provide, benefits to society can be justified in economic terms (Hughes et al. 2005). However these regulating and provisioning services may not be enough to justify land conversion, and thus, many protected areas depend heavily on maintaining social and political support to outweigh economic or other motives for land conversion. For example, protected areas that sit on precious mineral resources or fertile farmland may be forced to periodically justify their existence and continued opportunity costs.

While it is acknowledged that protected areas provide cultural services, such as aesthetic and recreational value, and spiritual experiences (Millennium Ecosystem Assessment 2005), these cultural benefits are not often formally included in cost-benefit analyses (De Groot et al. 2002). One reason for this is the difficulty of quantifying attitudes that may vary widely and subjectively across the human population (van Jaarsveld et al. 2005, Daniel et al. 2012).

Cultural ecosystem services are the nonmaterial benefits that people obtain from ecosystems. They include recreational value, spiritual and religious values, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, and ecotourism (Millennium Ecosystem Assessment 2005). In protected areas, most of these services are experienced when people undertake nature-based tourism (hereafter, NBT). NBT offers an important connection between protected area management, protected area resilience, and cultural services because it provides a key source of revenue (Chase et al. 1998, Dharmaratne et al. 2000, Daniel 2012) and a strong financial incentive to manage biodiversity sustainably and make cultural services accessible (Krüger 2005, Weaver and Lawton 2007).

The income derived from NBT can be used to assess cultural services and quantify their economic value in protected areas (Lee 1997, Naidoo et al. 2011, O'Farrell et al. 2011, Egoh et al. 2012). Each park entry can be viewed as a willingness to pay for the services that the park offers (Chase et al. 1998), and thus, management may be heavily influenced by tourist needs and demands. As a result, tourism data provide a potentially insightful means for exploring NBT-related cultural service provisions, the socioecological interactions that drive NBT-related cultural services, and the potential role of NBT-related cultural services in protected area resilience.

There is considerable interest from the conservation community in the idea that NBT may provide sufficient income to justify the costs of setting land aside for protection (Dharmaratne et al. 2000, Kiss 2004). The assumption that NBT will provide an economic solution for a particular protected area is, however, heavily dependent on the level of NBT-related cultural service that the area provides (Gelcich et al. 2013). In considering NBT-related cultural service provision, it is important to recognize that cultural services are coproduced by the ecosystem and the socioeconomic system, a service requires demand for it to be considered a service (Biggs et al. 2014).

The coproduction of cultural services means that mapping out a service production chain from ecosystem element to socioeconomic benefit is a problem. The potential socioeconomic benefits of tourism are only realized if cultural services are taken advantage of, much as a shoe shop only makes money by selling shoes, regardless of the quality of its product. The same waterfall in two different protected areas, for example, might generate a lot of income in an area that is situated near a highway and little income in another area, which is difficult to access. Similarly, the ability of tourism to generate income depends on both the scales at which cultural services are provided and the scales at which tourists respond to services on offer.

NBT-related cultural service provision by protected areas therefore raises a set of location-, context-, and scale-related questions. These questions must be considered before we can understand and value cultural service provision appropriately. When assessing the long-term resilience of protected areas and the contributions that NBT-related cultural service provision makes to their sustainability, variations in the relative magnitudes of supply and demand across different scales are important considerations. Aligning patterns and processes that occur at different scales goes beyond the demands of tourists and the ability of protected area managers to meet those demands; it also incorporates elements of pricing structures, broader questions of governance and security, and international relationships and marketing (Biggs et al. 2014).

Cumming et al. (*in press*) have proposed that protected areas can be analyzed as socioecological systems using Ostrom's (2009) framework, with some additions: notably, a greater awareness of scale and cross-scale interactions and a more explicit definition of the relationships between the scales of ecosystem processes and the levels of institutional arrangements. We apply this framework to NBT-related cultural service delivery via NBT in protected areas and extend it to further investigate cross-scale interactions and scale mismatches. We assert that long-term success in conservation depends on strengthening the alignment between elements and processes at the different scales. This includes enhancing interactions across scales between protected area managers, local stakeholders, the tourist community (local, national, regional, and global), and the local, national, and global media.

Socioecological Scales and Scale Mismatches in Nature-Based Tourism

Ecological scale refers to the spatial and temporal dimensions of a pattern or process occurring within the ecological sphere (Cumming et al. 2006). Landscape ecologists define scale using extent (the magnitude of a dimension) and resolution, or grain, which refers to the precision of the measurement (Gibson et al. 2000). The ecological elements and processes that produce cultural services utilized by nature-based tourists exist over a range of different scales. The spatial scales of protected areas range from patches within an individual protected area to functional landscapes and networks.

Social scale has been used to refer to the different dimensions of institutional size, representation, and power (Gibson et al. 2000). These dimensions range from individuals to networks of organizations, and include the rules, laws, policies, and norms that govern the extent of resource-related rights and management responsibilities (Cumming et al. 2006). The management approaches of protected areas therefore differ across scales that influence (and are influenced by) governance, affecting outputs and outcomes of the socioecological systems (Ostrom 2009). Governance in formal protected areas, such as national parks, is often characterized by a top-down, command-and-control approach to management (Goss and Cumming 2013). Private protected areas, on the other hand, are usually owned and managed by the same individual and therefore are more conducive to a bottom-up management approach at a finer scale. In NBT, social-scale increases from individual tourists at a patch scale, or sub-tenure unit, to various tourist communities at a protected-area scale and national governments and politics on an international scale. The use of spatial terminology to define social scale can be confusing, because equivalent institutions may operate at quite different spatial scales (e.g., the governments of nation states have effective scales that cover several different orders of magnitude). We therefore follow Cumming et al. (*in press*) in referring to institutional levels when discussing rules, laws, and governance structures. In this framework, protected areas exist as both institutions and biophysical entities that consist of different spatial scales and institutional levels. Institutional levels may define corresponding spatial, ecological, and social scales, ranging from patch to global or international scale (Cumming et al., *in press*; Fig. 1). Rules and management practices therefore vary across scales, ranging from a single management policy at the patch scale to national or international context at the global scale. Fig. 1 provides a conceptualized framework which compares the different spatial scales and institutional levels (from 1 to 5) at which social and ecological systems are organized. The institutional levels are dynamic, as informal networks of power of influence can play an important role in generating or prohibiting cross-scale feedbacks (Calgaro et al. 2013). However, the levels depicted in Fig. 1 are a requisite simplification (sense Stirzaker et al. 2010) of these dynamic relational interactions; they are simplified in order to understand the impact of cross-scale mismatches and feedbacks. Temporal dynamics also differ across scales ranging from short term processes and initiatives to long term processes and long-standing national assets (Fig. 1).

Ecological and social processes act synergistically to produce outcomes, and thus, neither can be considered in isolation (Hughes et al. 2005). In 2000, Poiani et al. developed a hierarchical classification of habitats (ranging from small patches to entire regions) and associated species (ranging from small patch species to long distance migratory species). The utility of the functional landscape approach (Fig. 1) lies in its representation of the relationship between the scales and levels at which different system elements exist and the frequency and/or magnitude of their interactions. For example, fewer resources and a finer scale of action are required when conserving a local-scale species, such as an endemic butterfly, as opposed to a broader conservation approach involving international agreements and global corporations when conserving an intercontinental migratory species, such as migratory songbirds (Cumming et al., *in press*; Fig. 1). Although the strongest interactions between elements are likely to occur at the same scales and levels, protected areas are complex systems (Cumming et al., *in press*) and interactions often occur across scales or levels (Peters et al. 2004). For example, in a given protected area, the ecological community may be influenced by invasive species that enter from the surrounding landscape; local management actions may be driven by international agreements, such as the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) or the Convention on Biological Diversity; and the revenue generated by tourism may be affected by global

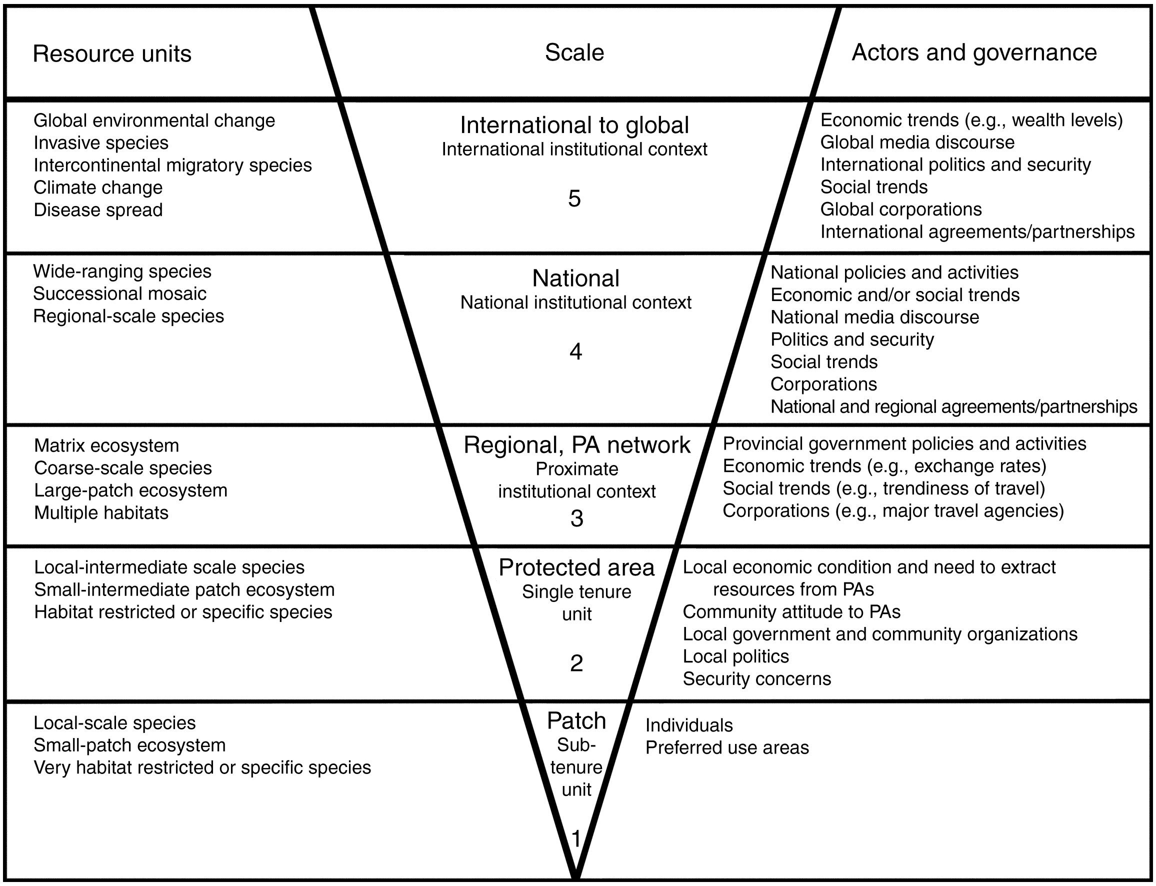

FIG. 1. Summary of socioecological patterns and processes dynamically nested across different scales and adapted for nature-based tourism from Cumming et al.'s (*in press*) protected area framework. Each unit represents both a spatial scale (akin to traditional ecological scales) and an institutional level across which pattern and process interactions need to be reconciled through cross-scale feedbacks to avoid scale mismatches. This figure extends the depiction of Poiani et al. (2000) of the ecological components of a functional landscape. PA indicates protected area.

events such as conflict, terrorism, or fluctuations in the international stock market (Biggs 2011, Biggs et al. 2014).

Scale mismatches occur when the alignment of different system elements at different scales and/or levels results in dysfunctionality. More formally, they imply that one or more functions of the socioecological system are disrupted, inefficiencies occur, and/or important components of the system are lost (Cumming et al. 2006). They can be defined as spatial, temporal, or functional in nature (Cumming et al. 2006). Spatial-scale mismatches arise in conservation when differences appear between the geographic extent of the problem and the solution (Guerrero et al. 2013) or when jurisdictional boundaries are too small for effective management (Crowder et al. 2006). Temporal-scale mismatches relate to processes that occur over different timescales (Cash et al. 2006). For example, the implementation of a conservation strategy is a lengthy process, and long-term participation of stakeholders is critical to reflect changes in ecological and social system (Pierce et al. 2005, Pressey and Bottrill 2009). When the same stakeholders are not involved throughout the entire planning and implementation process, a temporal-scale mismatch may thereby occur. Marine ecosystems have been destroyed as a consequence of temporal mismatches occurring between biological systems and human institutions, where marine systems occur at different timescales to the implementation of policies (Crowder et al. 2006). Functional-scale mismatches occur when the scope of processes considered for solving the conservation problem differs greatly from the scope of processes actually used (Kates et al. 2001, Guerrero et al. 2013). Functional mismatches can also be driven by a misalignment between supply and demand.

A New Typology For Assessing Scale Mismatches

Cumming et al.'s (*in press*) framework organizes the social and ecological elements of protected areas into five discrete, hierarchical institutional levels (ranging from 1, meaning a sub-tenure unit, to 5, meaning an international context) and spatial scales (ranging from 1, meaning patch, to 5, meaning international). We

PLATE 1. Global tourist demands influence overstocking of charismatic species such as elephants in small private protected areas. Photo credit: K. Maciejewski.

propose that the severity of a scale mismatch correlates with its magnitude, so we used these hierarchical scales to generate a ratio of institutional level to spatial scale, using the following simple equation

$$\frac{\log(\text{institution level value} + 1)}{\log(\text{spatial scale value} + 1)}$$

where log brings all scales and levels of investigation into a comparable form and the addition of 1 prevents the possibility of logging a value of 0 or <1. Interactions that take place within the same institutional and spatial scale do not result in a scale mismatch. If we consider a simple scale mismatch value as a log of the institutional level in question (from 1 to 5) divided by a log of the spatial scale in question (from 1 to 5), interactions at equivalent scales and levels will produce a mismatch value of 1. Conversely, a scale mismatch may result when an action or event at one institutional level affects a socioecological element at a different spatial scale (scale mismatch index <1) or vice versa (scale mismatch ratio >1).

If we consider each of the 25 possible combinations of spatial scale and institutional level, a range of likely outcomes can be predicted (Table 1). Conceptually, each outcome is accompanied by the likelihood of a loss in system resilience, which we predict will relate to the severity of the mismatch (Fig. 2). In this context, we follow Cumming et al. (2006) in defining a loss of system resilience as a scenario where the system experiences a loss of its critical components or a disruption in socioecological functioning, or when inefficiencies occur. For our analysis, we scored the magnitude of resilience reduction as follows: 0, if resilience was unaffected or positively affected; 1, if mild inefficiencies occurred; 2, if critical component were lost or functioning of SES were disrupted; 3, if critical components were lost, functioning of SES were disrupted, and efficiencies occurred; 4, if multiple components were lost, inefficiencies occurred, and functioning of SES were disrupted; and 5, if system changes were catastrophic and resulted in a regime shift. The Appendix offers a more comprehensive treatment of our method.

Typically, scale mismatch ratios with indices greater than 1 manifest as social, economic, or ecological problems that can't be fixed by local management, while those with scale mismatch indices smaller than 1 imply a lack of attention to local detail or a lack of local management capacity (Table 1). A loss in resilience occurs when one or more of the functions of the socioecological system are disrupted, inefficiencies occur, or an important component of the system is lost. The greater the institutional level to spatial scale ratio, the greater the loss in resilience, with 0 being lest severe and -5 being most severe.

TABLE 1. Scale mismatches between institutional level and spatial scale, expressed as a mismatch ratio and related to the loss in resilience in the socioecological system.

Scenario	Institutional level	Spatial scale	Example outcome	Reference
A	1	1	no mismatch	N/A
B	2	1	too many leaders for a small spatial scale	Ankney (1996)
C	3	1	local management inadequate	Lindsey et al. (2013)
D	4	1	inadequate attention to detail	Maciejewski and Kerley (2014)
E	5	1	inadequate attention to detail	TFCAs; Duffy (2006), Anderson et al. (2013)
F	1	2	crop-raiding elephants	Nyhus and Suimianto (2000)
G	2	2	no mismatch	N/A
H	3	2	no real problem, missing infrastructure	Wade et al. (2001)
I	4	2	inadequate attention to detail	N. Ban, L. Evans, M. Nenadovic, and M. Schoon (*unpublished manuscript*)
J	5	2	inadequate attention to detail	TFCAs; Duffy (2006), Anderson et al. (2013)
K	1	3	introduction of invasive species	González et al. (2008)
L	2	3	inadequate ability to manage ecosystem processes	Ellenberg et al. (2007)
M	3	3	no mismatch	N/A
N	4	3	regional areas overwhelmed by national management problems	Namibia conservancies
O	5	3	inadequate attention to detail	TFCAs; Duffy (2006), Anderson et al. (2013)
P	1	4	regional politics, human conflicts affects ecotourism	Beyers et al. (2011)
Q	2	4	boundary issues, encroachment by people into ecotourism PAs	Weladji and Tchamba (2003)
R	3	4	lack of mandate to take broader action	N. Ban, L. Evans, M. Nenadovic, and M. Schoon (*unpublished manuscript*)
S	4	4	no mismatch	N/A
T	5	4	international policies might not be implemented at the national scale if governance is weak	TFCAs; Duffy (2006), Anderson et al. (2013)
U	1	5	global climate change influences can't be managed locally	Halpin (1997)
V	2	5	various problems of poor governance	Meduna et al. (2009)
W	3	5	management overwhelmed by regional problems	N. Ban, L. Evans, M. Nenadovic, and M. Schoon (*unpublished manuscript*)
X	4	5	management overwhelmed by regional problems	TFCAs; Duffy (2006), Anderson et al. (2013)
Y	5	5	no mismatches	N/A

Notes: Key to abbreviations: N/A, not applicable; PA, protected area; GBR, Great Barrier Reef; KAZA, Kavango Zambezi Transfrontier Conservation Area; and TFCA, Transfrontier Conservation Area.

To illustrate how the institutional-level to spatial-scale ratio can be applied, we expand on the examples listed in Table 1. These examples demonstrate how spatial, temporal, and functional mismatches negatively affect system resilience. As illustrated by the crop-raiding elephants example (scenario F in Table 1), human–wildlife conflict (Nyhus and Suimianto 2000) may result from a cross-scale interaction where the spatial scale of the ecological process exceeds the institutional level; the outcome is a lack of institutional support and neglect of local details (e.g., local community needs) in favor of strategies that might generate more revenue from tourism. On the other hand, reduced resilience will also result from a cross-scale interaction where the institutional level exceeds the spatial scale. For example, decisions made at a national institutional level without sufficiently accounting for local variability in the rezoning of the Great Barrier Reef Marine Park (GBRMP) in 2004 (scenario I in Table 1) substantially altered the types and distribution of property rights and

Table 1. Extended.

Case-study example	Institutional level to spatial scale ratio	Loss of resilience
N/A	1	0
A conflict in management approaches with waterfowl abundance leads to population explosion in Canadian Geese.	1.59	−1
Government priorities favor livestock production and override ecotourism management decisions.	2	−2
Global tourist demands influence overstocking of charismatic species, such as elephants, in small private PAs, leading to land degradation in PAs.	2.32	−3
Local communities are unable to forego their immediate natural resource needs and wait out time to see benefits from ecotourism in TFCAs. Local communities are not stratified by age and gender, but one part of the community often favor one implementation over another. International borders that open for tourism also facilitate the spread of more localized problems, such as poaching. Also, international policies often can't address these problems.	2.58	−4
Elephants move out of PA to raid crops in surrounding farms, resulting in park–people conflict.	0.63	−1
N/A	1	0
Tanzanian tourism fails to realize potential as tourist destination due to lack of infrastructure and trained staff.	1.26	−1
Local communities are unable to forego their immediate natural resource needs and wait to see benefits from ecotourism.	1.46	−2
Bad experiences with previous top-down, market-oriented environmental interventions by international bureaucracies.	1.63	−3
Loss of critical components, disruption of PA functioning.	0.5	−2
High numbers of international tourists at Penguin breeding colony leads to overcrowding, thereby reducing Penguin breeding success.	0.79	−1
N/A	1	0
National policy to implement disease fences and prioritize agricultural affects ecotourism opportunities.	1.16	−1
PAs not prepared to manage translocated elephants from KNP; hasty translocation due to international funding pressure.	1.29	−2
Guerilla warfare in the DRC results in loss of wildlife and disruption in PA functioning.	0.43	−3
Illegal movement of people into PAs due to lack of management.	0.68	−2
Using a single policy instrument to manage a large scale system (GBR) results in many trade-offs between ecosystem services.	0.86	−1
N/A	1	0
Difficult to negotiate international agreements in Angola due to national policies, red tape, and inefficiencies; concern about state of Zimbabwe in the creation of the LTCA.	1.11	−1
Rapidly changing climate conditions occurs on a global scale and causes changes in ecotourism PAs that cannot be prevented.	0.39	−4
Poor payment of ecotourism management and staff in PA leads to mismanagement, poaching, and poor maintenance of facilities, thereby reducing cultural service delivery to tourists.	0.61	−3
In the GBR, flows and land use from surrounding areas affect the integrity of the system, yet management can only affect what is inside.	0.77	−2
Migration of elephants and people in the KAZA and Limpopo TFCA regions impeded by fences prior to establishment of TFCAs. Landmines on the Angolan side of the KAZA are a potential problem for opening the area to elephants.	0.90	−1
N/A	1	0

associated returns from ecosystem goods and services (e.g., reduced profits from fishing) to local communities (N. Ban, L. Evans, M. Nenadovic, and M. Schoon, *unpublished manuscript*).

The greater the difference between interacting scales and levels and the greater the magnitude of the cross-scale interaction, the greater the degree of mismatch. For example, global climate change at a broad spatial scale well exceeds the level of management that occurs in NBT (scenario U in Table 1) and therefore results in a high mismatch value. A large scale mismatch value also results from a top-down management approach where high institutional levels are used to manage small-scale NBT (scenarios E and J in Table 1; Fig. 2). These observations suggest that the institutional level to spatial ratio is proportional to a loss in resilience. In other words, the greater the scale mismatch in the cross-scale interaction, the more vulnerable the protected area becomes.

Although we have focused here on spatial scale, the same principles apply to temporal scales and functional connections. Long-lasting institutions may be inflexible or unable to cope with rapid change, and newer institutions may lack the history or the credibility to cope with slow change.

Situations may also arise in which spatial, temporal, and functional mismatches occur in combination. For example, in the Eastern Cape Province of South Africa (hereafter referred to as the Eastern Cape), management decisions in private nature reserves are heavily influenced by the annual number of visitors (Maciejewski and Kerley 2014). At a single-tenure and protected-area level, managers (social elements at the patch scale) perceive demand from international tourists (social elements at the international scale) to stock charismatic species, such as elephants (ecological elements at the patch and protected-area scale; see Plate 1). Managers may perceive more charismatic animals to produce more revenue in the short term and may overstock megaherbivores or carnivores, leading to serious longer-term ecosystem degradation at the patch level (scenario D in Table 1; see also Kerley and Landman [2006]).

Another, more complex example comes from the GBRMP in Queensland, Australia, where the state gross domestic product generated by NBT to the GBRMP exceeds that of all other industries (McCook et al. 2010). At the patch and protected-area scales, this marine protected-area network is composed of many oceanic ecosystem types from coral reefs to deep oceans. It also encompasses a number of different zoning types, ranging from general use (where withdrawal of resources and activities, such as trawling, are allowed) to preservation where all access and activity is prohibited (N. Ban, L. Evans, M. Nenadovic, and M. Schoon, *unpublished manuscript*). This zoning has changed a great deal in the last 20 years, and while the current dynamic management approach is commended by world conservation bodies, there remain scale mismatches that could threaten the region and resources into the future, as indicated in scenario R in Table 1. N. Ban, L. Evans, M. Nenadovic, and M. Schoon (*unpublished manuscript*) outline a number of scale mismatches under the current governance strategy. First, the conservation benefits of the strategy will take decades to become fully realized, while the impacts of the fishing restrictions necessary for these benefits are already being felt at a finer temporal scale by resources users (Russ and Alcala 2011). Second, the benefits of this management plan (at the single-tenure and proximate institutional context) are of global importance and impact, although the majority of the cost burden is felt locally.

Cross-Scale Feedbacks and Resilience in Nature-Based Tourism

As Cumming et al. (*in press*) highlight, the resilience of NBT is not only contingent on the interaction between socioecological elements at different scales. Rather, the functioning of protected areas and the health of the tourism sector are influenced by the way in which these, and other elements of protected area tourism, are connected by local to global flows of matter, organisms, information, rules, money and perceptions and the ways that these flows are mediated and managed (Hall 2010, Mathevet et al. 2010, Biggs 2011, Thompson et al. 2011, Calgaro et al. 2013).

In the Eastern Cape example (scenario D in Table 1; Fig. 2), managers' decisions are affected by the fact that they are often made at a single-tenure unit level without regulating rules flowing from proximate and national contexts. The degradation of ecosystems may affect their attractiveness to international tourists, but this feedback is slow and may take even longer to be recognized by managers.

Similarly, in the GBRMP example, social and ecological mismatches are compounded by the fact that flows into the park from all surrounding catchments that incorporate such activities as grazing, cropping, and mining have a large impact on the park's ecosystem health and resilience. This, in turn, affects water quality, as well and the quality of Australia's tourism products and their international tourism brand. The magnitude and nature of these feedbacks are therefore important to the resilience of NBT. Changes in critical system interactions can lead to a change in the function and structure and ultimately push the system past a threshold forcing a regime shift (Walker et al. 2006). It is therefore important to identify the important feedbacks in a system and understand which feedbacks cause a loss of resilience and which can strengthen resilience (Folke 2006). This can be a challenging task, given that these feedbacks are often the critical regulatory feedbacks in a system. The fact that their effects are decoupled from the scale of their production means they may often go undetected, and their effects are often ascribed to other, more easily perceived phenomena (Cumming et al. 2006).

The ways in which scale mismatches affect the resilience of protected areas depends heavily on how they relate to and affect cross-scale feedbacks. Formally, a cross-scale feedback occurs when (1) A influences B and B influences A, and (2) A and B are system elements (actors or resources, rather than interactions) that exist at different scales (Cumming et al. 2006; Cumming et al., *in press*). Cross-scale feedbacks can also occur as closed feedback loops (A influences B influences C influences A) that can produce surprising dynamics, such as dampening or exacerbation of local variability (Cumming et al., *in press*).

Cross-scale feedbacks are not necessarily problematic for protected areas; indeed, they may be of prime importance for their long-term sustainability. They may, however, be closely related to scale mismatches, particularly since many cross-scale influences result in feedback effects. It also seems likely that many scale mismatches arise from an inability of governance systems to cope with biophysical variation at broader or finer scales. The rhino poaching crisis in South

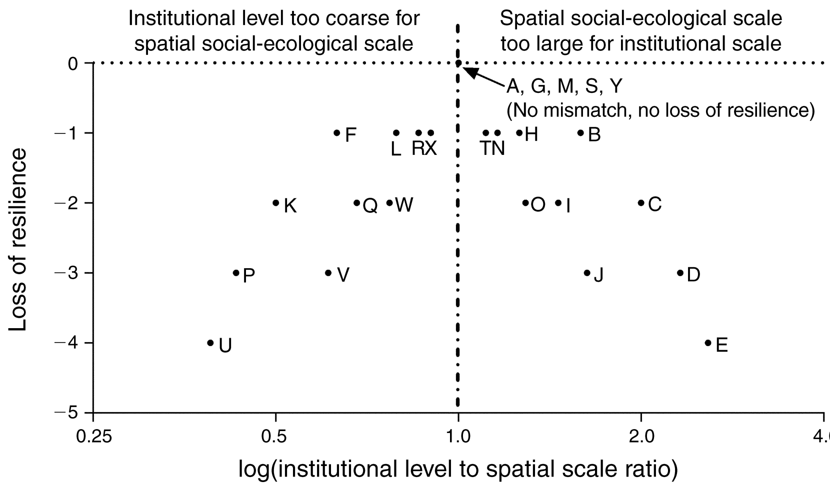

FIG. 2. This typological depiction plots the scale-mismatch value (as defined in *A New Typology for Assessing Scale Mismatches*) of scenarios A–Y in nature-based-tourism case studies, as described in Table 1, against a notional loss of resilience. In this context, a loss of resilience occurs when one or more functions of the socioecological system are disrupted, inefficiencies occur, and/or important components of the system are lost.

Africa (Biggs et al. 2013) shows how cross-scale dynamics must be managed in order to build resilience. Cross-scale interactions (i.e., between global demand for rhino horn and local production) have resulted in a scale mismatch that has resulted in a rapid escalation of poaching to meet an unsustainable illegal trade (Biggs et al. 2013). It is possible that reversing the international ban on the rhino horn trade and releasing existing stockpiles of horn would increase the local supply of rhino horn, thereby affecting the global price and creating a cross-scale feedback loop that could enhance resilience (Biggs et al. 2013, Challender and Macmillan 2014).

In Fig. 3, we present four different scenarios where processes in NBT interact across different spatial scales and institutional levels to produce benefits or cause problems due to cross-scale effects and feedbacks. As shown in the Eastern Cape case study in Fig. 3, regulatory feedbacks from rules imposed by a regulatory body at a proximate institutional context might serve to prevent managers from overstocking small, fenced areas with too much game. If a private farm is declared a

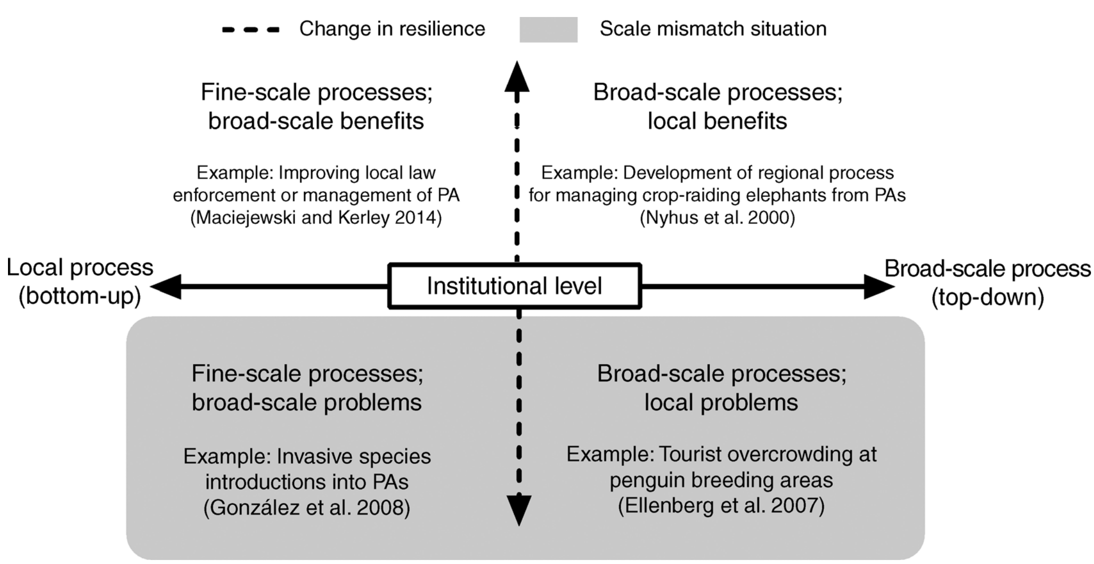

FIG. 3. A typological summary, with examples from the literature, of scenarios where processes in nature-based tourism interact across different institutional and spatial scales to produce benefits or cause problems due to cross-scale effects. Enhanced or reduced system resilience, which can result in scale-mismatch situations, thus occur as a function of the interaction between cross-scale effects and feedbacks. PA indicates protected area.

private nature reserve, it accepts benefits and rules imposed on it by a governing body that exist at a proximate institutional level. If it remained a private farm, land conversion would be relatively simple and at the owner's management discretion. However, once declared a private nature reserve, the owner's management practices may be monitored by a regulating body, which may prevent overstocking, and ultimately land-conversion.

This bottom-up management approach of using fine-scale processes to benefit broad-scale effects may resolve the scale mismatch between tourist demands and the supply of NBT-related cultural services and build resilience in this complex system (Fig. 3; fine-scale processes, broad-scale benefits). A top-down feedback may be effective when the institutional levels are exceeded by the spatial scale as illustrated in the crop-raiding elephant case study (scenario F in Table 1). In this example, regional processes, such as erecting electric fences around the protected area or the use of deterrents may solve the local park–people conflict (Fig. 3; broad-scale processes, local benefits). In the GBRMP example (scenario R in Table 1), cross-scale feedbacks can be used to highlight the mismatches between social and ecological components. By considering the cross-scale flow of goods, inferences can be made about how costs and benefits are allocated, which can help elucidate the source and nature of the challenges facing large-scale systems like the GBRMP.

Cross-scale feedbacks do not always have a positive effect on NBT and may reduce the resilience of a system. For example, in the case of invasive species (scenario K in Table 1), a scale mismatch between institutional level and spatial scale on the Galápagos Islands resulted in a cross-scale feedback that disrupted the functioning of the whole socioecological system. Despite rigorous conservation policies, invasive species proliferated (González et al. 2008; Fig. 3; fine-scale processes, broad-scale problems). Even though this took place at a fine-scale level, these invasive species introductions resulted in broad-scale problems by threatening the ecological integrity of the archipelago, thereby reducing resilience of the Galápagos system.

Similarly, the improper management of tourists surrounding the yellow-eyed penguin (*Megadyptes antipodes*) also illustrates how a cross-scale feedback may reduce the resilience in a socioecological system (scenario L in Table 1; Fig. 3). Tourists are attracted to this species of penguin, which is one of New Zealand's flagship species (Ellenberg et al. 2007). The tourist numbers at penguin breeding areas are unregulated, however, which has led to tourist overcrowding. A top-down effect therefore occurs where high levels of human disturbance (broad-scale processes) have reduced the breeding success and lowered fledging weights (fine-scale problems), placing pressure on the resilience of the system (Ellenberg et al. 2007; Fig. 3; broad-scale processes, local problems), while potentially making the penguin rarer and, hence, even more desirable to see.

Discussion

We have shown that using a socioecological framework to contextualize NBT in protected areas can offer useful insights into factors that might affect their sustainability and resilience as a function of NBT-related cultural service delivery. Cross-scale interactions are inherent in the system and often lead to scale mismatches that may affect the functioning of NBT. We have argued that the degree of scale mismatch relies on the magnitude of the cross-scale interaction; the greater the difference between interacting scales and levels, the greater the mismatch. Managing NBT for resilience depends in part on identifying these scale mismatches and either developing appropriate institutions, such as boundary organizations (Cash and Moser 2000) or creating cross-scale feedbacks to mitigate the negative impacts.

Pelosi et al. (2010) reviewed literature on scale mismatches and found that only 15% of studies adopted a systematic approach to assessing them. They argued that the lack of a systematic approach, and the incorrect or inadequate use of scale mismatch terminology, has hindered efforts to resolve mismatches. Our new typology (Table 1; Fig. 2) contributes to addressing this failing and has considerable potential for expansion to provide a way of more rigorously (and more quantitatively) connecting ideas about scale mismatches to the analysis of system resilience. In addition to its value for protected areas, which have been the focus of this article, our approach is thus relevant for socioecological management problems more generally, including (for example) those in urban (Borgström et al. 2006), fishery (Andrew et al. 2007), and agricultural (Pelosi et al. 2010) contexts.

The proposition that socioecological resilience is most strongly reduced by the largest scale mismatches (as measured using the institutional level to spatial scale ratio; Fig. 2) requires further exploration and testing. There are clearly many details in this relationship that will need to be resolved. For example, resilience is not normative, and it is possible that a scale mismatch may create a resilient trap that keeps a socioecological system locked in a collapsed state (e.g., if scales of propagule dispersal are too small to support vegetation recolonization in a heavily human-modified landscape). Our work should thus be read as proposing the general hypothesis that socioecological resilience relates predictably to the magnitude of a relevant scale mismatch, leaving the finer details of the relationship for future, more in-depth empirical analysis.

In the practical realm, there is a clear case for the incorporation of scale and cross-scale interactions brought about by NBT-related cultural service delivery into the analysis of protected area resilience if we are to advance our understanding of the tenability of ecotourism as a strategy to sustain protected areas into the future. NBT-related cultural service delivery may affect the resilience of a system that highlights the importance of time in understanding cross-scale dynamics. In an ecotourism context, it is very likely that a temporal mismatch will exist between ecological processes and the scale at which disturbances and changes to these processes can be detected and managed. For example, natural hazards such as the 2004 Indian Ocean tsunami have the propensity to disrupt future tourist flows (Calgaro et al. 2013). In many systems, cross-scale interactions that may not be significant at first may escalate unpredictably over time. For example, in the Eastern Cape case study, ecological degradation caused by overstocking may not result in reduced visitation rates at first. However, should visitation rates be sufficiently reduced, a private owner might decide to convert his land back to a more economically viable use, such as crop or livestock farming, which would constitute a regime shift. We anticipate that future research will identify a strong set of connections between cross-scale feedbacks, scale mismatches, and regime shifts (Kinzig et al. 2006). While our analysis shows that socioecological elements inevitably interact across multiple scales to produce positive and negative outcomes, we do not investigate the mechanisms that produce cross-scale feedbacks and scale-mismatch. We postulate that understanding how the structure of systems at different scales interacts with agency to produce desired and undesired effects may prove key to understanding these connections and conditions that facilitate regime shifts. The structure and agency may work together to create favorable and unfavorable outcomes across space and time, however this falls outside the scope of this study. We focused explicitly on interactions between socio-ecological components that exist at different scales and the scale-crossing mismatches that may result from this. We did not focus on the mechanisms that produce cross-scale feedbacks, such as the interplay between structure and agency.

The ability of NBT-focused protected area systems to generate income depends on both the scale at which cultural services are provided and the scale at which tourists respond to services on offer. Depending on a protected area's context, a misalignment in temporal, spatial, or functional scales could compromise the current or future identity or functioning of a protected area, thereby affecting the resilience of the whole socioecological system. The resilience of ecotourism is therefore closely linked to the management of cross-scale feedbacks and scale mismatches.

The location of a protected area, as well as its ecology, affordability, and infrastructure plays an important role in attracting tourists and generating income (A. De Vos, G. Cumming, C. Moore, and K. Maciejewski, *unpublished manuscript*). At a single-tenure and protected-area level, it might be difficult to perceive and implement rules and strategies that factor in these landscape- and national-level processes. However, feedbacks that occur as a result of rules made at the national institutional level might enhance resilience by ensuring that broad-scale processes are taken into consideration when developing the business model of a park.

While we have made a strong case for including the analysis of cross-scale feedbacks and scale mismatches to better understand and manage protected areas that rely on NBT, more research is needed to investigate the connection between cross-scale feedbacks, scale mismatches, and regime shifts. There is also scope for future research to focus on the mechanisms that produce cross-scale feedbacks, such as the interplay between structure and agency. Socioecological systems are complex dynamic systems containing a myriad of factors and cross-scale processes that may influence the social sphere within natural resource management. As our analysis shows, a greater understanding of cross-scale feedbacks and scale mismatches (and finding ways to strengthen the alignment of scales) can contribute to enhancing the resilience of socioecological systems.

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Supplemental Material

Ecological Archives

The Appendix is available online: http://dx.doi.org/10.1890/13-2240.1.sm