Global Change and Human Impact Challenges in Managing Iconic National Parks

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Biodiversity is under increasing pressure worldwide from increasing human population, global economic and social changes, and climate change. These pressures result from the interaction between the expanding influence of humanity and ecological processes that alter the delivery of ecosystem goods and services (Dudley and Stolton 2012). Most of the world's national parks conserve places of high biodiversity value, maintain genetic diversity, protect cultural identities, and attract visitors from around the world seeking to experience iconic species and landscapes. Concomitantly, they help safeguard against the more recently identified pressures to biodiversity. In this paper, we address some of the effects that climate change has on the human and natural components of iconic national park systems, and the effects that human interactions have on the natural component of national parks, particularly at the local level.

Climate change, changes in land use, and corresponding changes in land cover have been proposed as the three greatest threats to biodiversity in the present century (Mooney et al. 2009). Climate change affects a wide spectrum of organisms, including their morphology, physiology, phenology, life history, abundance, and distribution. Land use and land cover changes have been identified as important feedback mechanisms affecting global change and corresponding shifts in social and ecological behavior of people, communities, and systems (Sommer et al. 2010). The related processes also affect the sustainability of national parks, which are compounded by socioeconomic, environmental, and political drivers to produce landscape fragmentation, over-harvesting of resources, and related pressures. Negative human impacts are two-fold: (1) local communities, reliant on natural areas for food, medicine, employment and cultural reasons, are consuming and often degrading ecosystems as the human imprint expands and intensifies within and along the edges of parks; and (2) tourism is increasingly consumptive in its demands for enhanced access to protected areas and increasing services as part of "experiencing" iconic species and landscapes.

We regard iconic national parks as local examples of human–artifactual–natural systems that are influenced by external abiotic, biotic, and globalization processes (see Miller et al., this issue; Walsh et al., this issue). The challenge for management of iconic national parks is to address threats while still meeting the protection and visitor objectives inherent in the

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national park concept; that is, providing for recreation use and values appreciation while at the same time protecting and preserving valued resources. Our focus on threats ignores opportunities inherent in any change process, but it allows us to highlight that park management can no longer stop at park boundaries, and must appreciate and take into account the dynamics and implications of exogenous and endogenous change. Without this, achievement of preferred outcomes will remain, most likely, unrealized.

Iconic national parks as early indicators

Usually, "iconic status" is attributed to a national park when it is associated with international recognition and concern for its protection and the sustainable utilization of its valued resources (see also Miller et al., this issue). As a human construct, the concept of iconic park is culturally determined and subject to challenge depending on perspectives, along with any deductive (or inductive) rationale for approaches to protection and use. Iconicity is some function of the acknowledged values of the park, the significance attributed to these values, and their perceived or real vulnerability to change or loss (Figure 1). In addition, utilization and marketing contribute to iconic status to the extent that parks and/or their valued constituent parts become symbolic of a place or concept (Table 1). Any international listing process (e.g., World Heritage listing) tends to acknowledge values and resource significance, but iconicity includes the additional criteria of status of the resource and community opinion.

Four important implications flow from a national park having iconic status: (1) while acting largely within the geographical confines of the park, managers need to give greater attention to external (exogenous) forces for change in both ecological and social system components; (2) management comes under closer scrutiny by national and international stakeholders; (3) increased numbers of national and international tourists are attracted; and (4) some members of the regional and national community are attracted also by the potential for economic benefits. The consequences are compounding, interdependent, and currently difficult to manage due to the uncertainty of relationships.

While all parks are subject to pressures, because of the number of interested observers, iconic national parks represent cases where the effects of changes in pressures are first observed and concern emerges. Therefore, iconic national parks are probably useful early indicators of changes that all protected areas will experience as a result of global change. Improved understanding of relationships between external drivers of change in the park system

Figure 1. The vulnerable red-tailed tropic bird (*Phaethon rubricaudia*) first returned to nest on Lady Elliot Island in 1982–1983 to add to its iconic status as the island with the highest seabird diversity within the Great Barrier Reef Marine Park. Photo by William (Bill) Carter.

Table 1. Explanation of terms related to what makes a park iconic.
Values are intrinsic, objectively measurable, and explicitly related to conservation status. Metrics include rarity or uniqueness and species richness or biodiversity.
Significance is extrinsic, subjectively measurable, and socioeconomically and culturally determined, and linked to perceived local, regional, national, and international importance.
Vulnerability is related to perceived imminence of loss, degradation, and reduction of integrity, often through a loss of site resilience imposed by threats to conservation and social–ecological sustainability.
Utilization relates to economic importance and community dependence on a national park for local and regional livelihoods and economic sustainability.
Promotion or marketing influences the levels of awareness of communities, from local to international, of the valued feature(s).

and the effectiveness of adaptive management strategies should help to inform park management of actions that will address problems of external drivers.

Climate change and iconic national parks (global driver dynamics)

Natural component response. Using a variety of approaches, the possible (and observed) impacts of climate change have been estimated and reported in the scientific literature. For example, at a meta level, it is possible to predict major shifts in biome types by combining biogeographic models, such as the Holdridge's Life Zone Classification Model with General Circulation Models (GCMs) that project changes under a doubled $C0_2$ scenario (e.g., Velarde et al. 2005). Biogeochemistry models, such as Forest–BGC (Bio-Geochemical Cycle), simulate the cycling of nutrients between biotic and abiotic components of the ecosystem and are useful for assessing the impacts of change in temperature, precipitation, soil moisture, primary production, and other climatic factors that give clues to ecosystem productivity. Dynamic local/global vegetation models, such as BIOME4 (see Kaplan et al. 2003) or AVIM3 (Atmosphere–Vegetation Interaction Model), integrate biogeochemical processes with dynamic changes in vegetation composition and distribution. Comparing present trends in species and communities with paleological data also provides indications of how species will accommodate future climate change, and migration dynamics (e.g., Tiffney and Manchester 2001).

As a base for assessing the impacts of climate change, the Intergovernmental Panel on Climate Change (IPCC) special report on emissions scenarios (SRES) (IPCC 2000) contains projections of future greenhouse gas emissions that supersede the IS92 family of projections made by the IPCC in 1992. The starting point for each projection is a "storyline" describing the way world populations, economics, political structures, and lifestyles may evolve over the next few decades (Wu et al. 2007). The storylines are grouped into four scenario families that have led to the construction of six SRES marker scenarios (Arnell 2004). An assortment of climate models (see Arnell 2004) from different research groups using different methods and data are often used to characterize changes in 30-year mean climate relative to 1961–1990 with comparisons with the 2020s (2010–2039), 2050s (2040–2069), and 2080s (2070–2099). Model runs are compared with gridded baseline climatology, describing climate over the period 1961–1990 at a spatial resolution of 0.5x0.5 degrees.

Global warming has the potential to cause species extinctions in many of the world's ecosystems and hence the loss of biodiversity in iconic national parks and elsewhere (Schaefer et al. 2007). Although some plants and animals will be able to achieve the required migration, or possibly even thrive, many will not have the capacity to adapt, especially those with low dispersal capabilities (Nelson et al. 2009). Global warming is likely to have a "winnowing" effect on ecosystems, filtering out species that are not highly mobile and favoring less diverse ecosystems that are dominated by pioneer and invasive species. The effects will be influenced significantly by species geographic distributions and climatic tolerances. Species with relatively larger distributions and greater climatic tolerances are at less risk. Island ecoregions may be especially at risk because of small populations, limited opportunities for migration, and sea-level rise. Barriers to migration and habitat loss will exacerbate climate-induced species loss (Adger et al. 2003), as the variety within a species becomes limited through isolation. Human population growth, land use change, habitat distribution, and pollution stress will exacerbate climate impacts. Maximizing habitat diversity and increasing connectivity may assist maintenance of existing biodiversity; however, this is likely to require consideration of lands beyond park boundaries to prevent the loss of some species from a locale. Budgets directed to enhance connectivity may, however detract from species-specific conservation efforts if overall funding is limited (Kirkpatrick 2011). Apart from the implications for ecological processes, if the species being lost are iconic, then implications cascade through the human (e.g., tourism) part of the system as well.

Human component response. While some opportunities may emerge with global climate change, societal vulnerability may exacerbate ongoing social and economic challenges, particularly for social groups dependent on resources that are sensitive to changes in climate (Leemans and Eickhout 2004). Risks are apparent in agriculture, fisheries, and many other system components that support the livelihoods of rural populations near protected areas. Vulnerability is another socially constructed feature influenced by institutional and economic dynamics, and determined by exposure, physical setting, and sensitivity and by ability and opportunity of system elements to adapt to change. Determinants of social resilience include the social, human, organizational, financial, and infrastructural aspects of societies; the flexibility and innovation in the institutions of government and the private sector to grasp opportunities associated with climate change; and the underlying health status and well-being of individuals and groups faced with the impacts of climate change. Population migration may be a limited option in many parts of the world; hence, other means of supporting adaptive capacity and enhancing resilience are required. Where migration occurs without careful planning, impacts on natural areas are foreseeable (Muriuki et al. 2011) The management challenge is to ensure that the delivery of ecosystem services is maintained (or enhanced) or the real (or perceived) benefits from the parks' existence eclipse those that come from unsustainable exploitive use. Herein lies the rationale for a strong ecotourism emphasis in iconic park management.

The threat of local human influences on iconic national parks (human–natural dynamics)

Human demographics and edge effects. Edge effects associated with increased population

growth around the margins of parks are ongoing issues for park managers, especially where park size is insufficient to protect species with wide home ranges. A study of 306 protected areas in Africa and Latin America used spatially explicit data from 1960 to 2000 to calculate the average annual rates of population growth within a 10-km buffer of the protected areas. The study found that buffer areas experienced more rapid population growth compared with randomly selected rural areas (Wittemyer et al. 2008). Increased human population growth is linked to habitat loss and disturbance that further isolates protected areas from surrounding habitats (Luck 2007). Higher rates of deforestation have been found in buffers as people move closer to national parks seeking economic and resource extraction opportunities (Messina et al. 2006; Muriuki et al. 2011).

Protected areas are often perceived to be cornerstones of conservation. Brashares et al. (2001) examined extinction rates for large mammals in West African nature reserves experiencing human influence. Actual extinction rates were compared with those predicted by reserve size alone. They found a strong positive relationship between human population outside the parks and extinction rates, where the real extinction rates for carnivores were higher than those predicted by models that only factored in reserve size (and not human population). Reserve edges showed higher extinction rates than reserve interiors. This study demonstrates that the perception of protected areas as a cornerstone of modern conservation planning and strongholds of biodiversity may be misguided. To address threats to reserve margins such as those identified above, more planning and investment should be put into the expansion and management of reserves, particularly where deleterious human influences are known to severely affect wildlife populations around protected area edges.

Human demographics and internal effects. Seeking evidence on whether parks could meet the needs of biological preservation in the context of population growth and development, Bruner et al. (2001) administered a questionnaire on land use pressure, local conditions, and management activities in 93 recently established parks larger than 5,000 ha in 22 countries. Seventy per cent of parks surveyed had human populations within their boundaries. Among the problems identified, over 50% had residents contesting park ownership in some way, had funding levels lower than the amount recommended for effective management, and had park staff lacking sufficient training. Factors such as number of people living within the protected area, local support, management budget, and local involvement of communities in management were not found to be significant correlates of park management effectiveness. The level of deterrents to illegal activities, such as hunting or logging, however, were significantly correlated, implying that increased guard presence and regulation enforcement could contribute to the success of long-term biodiversity conservation.

The challenge of effective management. In a meta-analysis of management effectiveness evaluations, Leverington et al. (2010) analysed over 4,000 assessments from around the world to find that 40% of protected areas had serious deficiencies. They found correlations between overall average management effectiveness in achieving target goals and the endogenous factors of adequacy of infrastructure, equipment and facilities, natural and cultural resource management processes, effectiveness of governance, and communication programs. Positive outcomes for values of conservation were correlated with staff skills, achievement of

outputs, and adequacy of law enforcement. Community-related indicators (e.g., community and stakeholder involvement, communication and community benefit programs) were correlated with impacts on communities. The exogenous factor of the external civil and political environment (support or otherwise) also affected outcomes. While these relationships do not establish causation (Leverington et al. 2010), they indicate multiple and interdependent factors affecting park conservation performance.

Responding to the challenge of human populations. The evidence presented supports the view that biodiversity protection and resident populations within and around parks may be incompatible. Yet many parks, perceived to be pristine, are often the result of a long history of human occupation. For numerous parks in the "old world," an ongoing human presence is often encouraged to maintain the preferred cultural landscape. In contrast, many parks in the "new world" are managed on the false assumption that they have never been occupied by humans, and human occupation is discouraged. While national park managers may deter people from living within park boundaries, displaced communities often face increased poverty, through land use restrictions, wildlife conflict, cultural degradation, increased cost of living, and isolation from urban centers. However, national parks, and their boundary areas, also afford benefits for rural inhabitants through access to road networks, employment, foreign aid, ecosystem services, and areas of safety during strife (Scherl et al. 2004).

These are ideological and ethical issues that are rightly debated. Here, we are simply making the point that the trajectory of human population growth means park management will increasingly have to respond to the pressure in innovative ways. Fostering a stewardship ethic (see Myers et al. 2011) and co-management (see Ross et al. 2009) may represent useful strategies, but they will need to be supported by demonstrable evidence that protection brings tangible benefits to affected communities and biodiversity protection. The very reasons that make protected areas ecologically interesting also make them attractive to tourists, to migrants looking for work, and for population settlement at the edges. Wittemyer et al. (2008) argue that to really understand the processes involved, one needs local data and local models. We propose a network of iconic protected areas facing social and ecological threats to their sustainability that can provide comparative case studies of system change and the effectiveness of management action.

The preserve–use debate

Central to the issue of sustainable development in and near national parks is the debate about trade-offs between environmental and social–economic benefits. Despite a park not being a "park" without people, by definition, some preservationists, especially when referring to North America, Africa, and Australia, argue that to successfully protect parks, people should not be allowed to live and work within their borders (Terborgh 1999). This is a philosophical position, in part supported by the evidence of the direct effects of human population pressure on the character of protected areas (Parks and Harcourt 2002; Cardillo et al. 2004). Conversely, others see people as an integral part of park ecosystems and their maintenance (Peres and Zimmerman 2001), again driven by a philosophical position and the rationale

that many or indeed all protected areas, especially those in Europe, Asia, and South America, are the result of human occupation. In a world increasingly shifting to governance systems that adopt democratic and egalitarian ideals, pragmatism demands that park management must work with communities, both internal and external to the park. This requires greater understanding of the capacity of the human (including management), artifactual, and natural components of iconic park systems for adaptation and the overlap and interactions between these components of the overall park system.

For populations living and working in or around national parks, we suggest that the range of benefits and negative impacts depends on the internal dynamics of the population and their responses to exogenous shocks. These are mediated by access to land and other natural resources, accessibility to labor and agricultural markets, the nature of the enforcement of protected area requirements on adjacent land uses, and the resilience of social and ecological systems to human and natural threats to the integrity and vulnerability of protected areas. The connectivity of protected areas to internal and external communities, farms, roads, and amenity resource areas are vital elements of the complex interplay between people, environment, and protected places (Brandon 2002).

The challenge of poverty alleviation and economic development. Confounding the preserve–use debate is the dialogue between conservationists and social advocates regarding the role that national parks play in the welfare of local peoples who live in and near them. In the past several decades, the dual goal of conserving natural resources, while at the same time improving human well-being, has gained greater attention (West et al. 2006; Pretty et al. 2009). However, a survey of 37 projects that attempt the joint achievement of biodiversity conservation and poverty alleviation found little systematic evidence in favor of synergies between these goals (Agrawal and Redford 2009).

Conservationists argue that environmental regulations and protected areas are essential for ensuring both the sustainability of the planet's biological systems and the health and welfare of people (Angermeier 2000). In contrast, social advocates contest the establishment and management of protected areas because: (1) only initiatives related to poverty alleviation can lead to successful biodiversity conservation, since these address the root causes of environmental destruction (Duraiappah 1998); (2) protected areas take away the property and rights of local people (e.g., Ghimire and Pimbert 1997); and (3) the distribution of economic benefits from protected areas tends to be so highly inequitable that it neither compensates for lost property and rights nor contributes to poverty alleviation (McShane 2003). As such, there is a growing literature on the impact of parks on the displacement of local people and the role of protected areas in reducing poverty (e.g., Geisler 2003; Agrawal and Redford 2009; Brockington et al. 2006). Displacement includes more than the physical dispossession of people from their lands; it also includes loss of access or restrictions on livelihood opportunities or future income related to environmental resources (Agrawal and Redford 2009), and can exacerbate poverty and human rights issues (Ghimire and Pimbert 1997; Geisler and deSousa 2001; Pilgrim and Pretty 2010). Geisler (2003) estimated that 85–136 million people have been displaced because of conservation projects, which also partly explains why many such projects have not achieved their objectives.

Part of the problem is that there are still many protected areas yet to resolve the issue of human residents (Brockington et al. 2006). Between 50% and 100% of stricter protected areas in South America and Asia are used or occupied by people (Bruner et al. 2001; Kothari 2004) and much of this occupancy and use of resources is illegal, which means that as legislation and enforcement tightens, millions of environmental refugees could be created (Geisler and de Sousa 2001). Reports from India suggest that nearly 4 million people face eviction following amendments to protected area policy (Kothari 2004).

A study of 12 cases in the Congo Basin identified the impact of protected areas on poverty reduction and displacement of local people. The study concluded that local government eviction strategies have further impoverished and displaced 120,000–150,000 people (Cernea and Schmidt-Soltau 2006). They recommended that the government desist with evictions and adopt a "pro-poor strategy" based on the "dual sustainability concept" of protecting people's livelihoods and well-being, while at the same time conserving the local biodiversity (see Roe et al. 2003). Pro-poor strategies also embrace issues of empowerment, especially for women and youth, through increasing work and education opportunities.

While many studies on the impact of protected areas have analyzed the distribution of benefits to people, comparatively few have demonstrated the benefits of protected areas for nature and biodiversity (Magome and Fabricius 2004). Nevertheless, how differences in gender, class, ethnicity, and identity structure the distribution of costs and benefits remains to be clarified (Brockington et al. 2006). In addition, studies are needed that directly analyze the effect of protected areas on human welfare through longitudinal cross-sectoral analyses at both the household and village levels before and after the establishment of parks (Wilkie et al. 2005).

Tourism and iconic national parks

Although tourism and recreation can bring significant social, economic and political benefits to an area, and draw attention to ethical issues, the presence of visitors may adversely impact biodiversity, particularly if use is made of sensitive environments (Richardson and Loomis 2004) and result in diminished attractiveness of a place for tourism (Sieck et al. 2011). Climate change alone may increase the vulnerability of numerous environments, but this may be magnified if, for example, warmer and drier weather encourages more visitors, or makes them more likely to participate in ecologically damaging and consumptive activities (Nyaupane and Chhetri 2009). Climate change is unlikely to be a homogeneous force, and its consequences are likely to vary between locations depending on the magnitude and speed of change and the characteristics of existing biological and human systems. In some cases, the change may provide an advantage to tourism with benefits also accruing to visitors and communities. As the climate changes, we can expect considerable change in the Earth's ecosystems and their functioning, and hence their capacity, positively and negatively, to deliver ecosystem services to inhabitants (both human and non-human). These changes, expressed as drought and intense rainfall events, will also affect the experiences of tourists (Hannah 2008).

Perhaps balancing the costs of tourism through over-use of vulnerable and iconic resources is the benefit tourism brings in funding conservation and management action and

supporting local communities. The paradox of iconic national parks is that the special nature of these areas is what attracts tourists to experience and interact with such places, yet in doing so, tourism can further threaten iconic settings, shaping visitation patterns and resultant satisfaction levels. Lack of understanding of the dynamics of tourism's interaction with place, especially the ability to predict ecological, cultural, and social change with changing tourism type and intensity (Carter and Beeton 2008), limits management capacity to balance the dual goals of national parks.

Conclusion

Iconic national parks epitomize society's concern for natural heritage conservation globally and the concerns of management locally. They therefore provide an ideal focus for assessing the human and natural drivers of change, connectivity between local and global forces, and capacity-building for the management of natural and cultural heritage in the face of escalating global change. National parks are often seen as islands of naturalness in a sea of human activity: the foundation stones of conservation. Nevertheless, human activity is increasingly threatening the resilience of parks, especially in the context of global environmental change. Thus, national parks are not islands. They are interconnected, reciprocal, and reinforcing components within broader ecological systems influenced by socioeconomic and political systems. Despite legislative constraints, national park managers can no longer treat parks as property where management influence must stop at the boundaries, because management influences are transgressing the boundaries. It also seems unwise to ignore the opportunities that change brings. To realize the opportunities in positive ways requires greater understanding of the human–artifactual–natural system within and around national parks.

The problem for managers is that high levels of uncertainty remain about how the national park system interacts with broader socioecological systems, how global change will affect the dynamics of these systems, and how the effect of on- and off-park action will influence the products and outcomes of system interactions. Sustainable national park management is rapidly moving from predominantly ecological considerations to becoming strongly entrenched in sociopolitical and economic considerations. We posit that iconic park systems are sensitive to changes in these domains and under scrutiny by international audiences. They therefore can act as early warning systems of responses to global and local change, and foci for exploring the dynamics of human–artifactual–natural systems where biodiversity and heritage conservation and recreational /tourism use are dual objectives.

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