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PARKS: THE INTERNATIONAL JOURNAL OF PROTECTED AREAS AND CONSERVATION

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IUCN PROTECTED AREA DEFINITION, MANAGEMENT CATEGORIES AND GOVERNANCE TYPES

IUCN DEFINES A PROTECTED AREA AS:

A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

The definition is expanded by six management categories (one with a sub-division), summarized below.

Ia Strict nature reserve: Strictly protected for biodiversity and also possibly geological/ geomorphological features, where human visitation, use and impacts are controlled and limited to ensure protection of the conservation values.

Ib Wilderness area: Usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, protected and managed to preserve their natural condition.

II National park: Large natural or near-natural areas protecting large-scale ecological processes with characteristic species and ecosystems, which also have environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.

III Natural monument or feature: Areas set aside to protect a specific natural monument, which can be a landform, sea mount, marine cavern, geological feature such as a cave, or a living feature such as an ancient grove.

IV Habitat/species management area: Areas to protect particular species or habitats, where management reflects this priority. Many will need regular, active interventions to meet the needs of particular species or habitats, but this is not a requirement of the category.

V Protected landscape or seascape: Where the interaction of people and nature over time has produced a distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

VI Protected areas with sustainable use of natural resources: Areas which conserve ecosystems, together with associated cultural values and traditional natural resource management systems. Generally large, mainly in a natural condition, with a proportion under sustainable natural resource management and where low-level non-industrial natural resource use compatible with nature conservation is seen as one of the main aims.

The category should be based around the primary management objective(s), which should apply to at least three-quarters of the protected area – the 75 per cent rule.

The management categories are applied with a typology of governance types – a description of who holds authority and responsibility for the protected area.

IUCN defines four governance types.

Governance by government: Federal or national ministry/ agency in charge; sub-national ministry/agency in charge; government-delegated management (e.g. to NGO)

Shared governance: Collaborative management (various degrees of influence); joint management (pluralist management board; transboundary management (various levels across international borders)

Private governance: By individual owner; by non-profit organisations (NGOs, universities, cooperatives); by for-profit organsations (individuals or corporate)

Governance by indigenous peoples and local communities: Indigenous peoples' conserved areas and territories; community conserved areas – declared and run by local communities

For more information on the IUCN definition, categories and governance type see the 2008 *Guidelines for applying protected area management categories* which can be downloaded at: www.iucn.org/pa_categories

IUCN WCPA'S BEST PRACTICE PROTECTED AREA GUIDELINES SERIES

IUCN-WCPA's Best Practice Protected Area Guidelines are the world's authoritative resource for protected area managers. Involving collaboration among specialist practitioners dedicated to supporting better implementation in the field, they distil learning and advice drawn from across IUCN. Applied in the field, they are building institutional and individual capacity to manage protected area systems effectively, equitably and sustainably, and to cope with the myriad of challenges faced in practice. They also assist national governments, protected area agencies, nongovernmental organisations, communities and private sector partners to meet their commitments and goals, and especially the Convention on Biological Diversity's Programme of Work on Protected Areas.

A full set of guidelines is available at: www.iucn.org/pa_guidelines
Complementary resources are available at: www.cbd.int/protected/tools/

A NOTE FROM THE EDITORS: THE WORLD PARKS CONGRESS IN *PARKS*

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The World Parks Congress is a once-a-decade event; the largest meeting of protected area professionals on the planet. During the course of the Congress in Sydney last October, there were literally hundreds of presentations from all over the world, covering everything from hard ecological science to case studies of conservation in practice. *PARKS* has been closely connected with the Congress, through the members of the editorial board, the fact that most of our reviewers were present in Sydney and by carrying editorials and papers outlining the aims of the Congress in the run up to the meeting. In this issue, we already have several papers drawing directly from material prepared for and presented at the Congress. The editorial also presents the text of *The Promise of Sydney*, the major statement arising from the gathering, which forms the core of WCPA's work for the coming decade.

We hope to include more papers in the next several issues of *PARKS* that are inspired by or based on material prepared for the Congress, once people get time to write up their results. We encourage potential authors to get in touch. The usual conditions apply; all papers are peer reviewed by two reviewers and must relate directly to protected area management. Although we publish in English, we particularly welcome submissions from people outside the English-speaking world and we are happy to work with authors to improve readability. Author's instructions can be downloaded from our website. Please help keep the legacy of the Congress alive by preserving key presentations in a permanent form.

Top left and above: The World Parks Congress © IISD/ENB (www.iisd.ca/iucn/wpc/2014/)

PARKS is published electronically twice a year by IUCN's World Commission on Protected Areas. For more information see: parksjournal.com and www.iucn.org/parks

PARKS is published to strengthen international collaboration in protected area development and management by:

- exchanging information on practical management issues, especially learning from case studies of applied ideas;
- serving as a global forum for discussing new and emerging issues that relate to protected areas;
- promoting understanding of the values and benefits derived from protected areas to communities, visitors, business etc;
- ensuring that protected areas fulfill their primary role in nature conservation while addressing critical issues such as ecologically sustainable development, social justice and climate change adaptation and mitigation;
- changing and improving protected area support and behaviour through use of information provided in the journal; and
- promoting IUCN's work on protected areas.

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THE WORLD PARKS CONGRESS 2014: INSPIRING SOLUTIONS FOR PARKS, PEOPLE AND PLANET

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ABSTRACT

The largest-ever gathering of those involved with protected and conserved areas worldwide took place in Sydney, Australia in November 2014. The programme encompassed a broad scope of discussions under the headline of *Inspiring Solutions for Parks, People and Planet*. The event aimed to: (i) find better and fairer ways to conserve natural and cultural diversity, involving governments, businesses and citizens in establishing and managing parks; (ii) inspire people around the world and across generations to reconnect with nature; and (iii) demonstrate nature's solutions to our planet's challenges such as climate change, health, food and water security. More than 6,000 participants took part in a full spectrum of workshops, events, pavilions, world leaders' dialogues, e-posters and field visits and helped craft a new vision for the role of protected areas in the decade and generations to come. This challenge, the *Promise of Sydney*, was handed over to the IUCN President, Mr Zhang Xinsheng and adopted by acclamation at the Closing Plenary on 19 November 2014.

Key words: Protected areas, World Parks Congress, Promise of Sydney

INSPIRING SOLUTIONS: THE PROMISE OF SYDNEY

The world's largest-ever gathering of those involved with protected and conserved areas worldwide took place in Sydney, Australia from 12 to 19 November 2014. As outlined in *PARKS* (Sandwith et al., 2014), the programme for the meeting encompassed a broad scope of discussions under the headline of Inspiring Solutions for Parks, People and Planet. The event aimed to: (i) find better and fairer ways to conserve natural and cultural diversity, involving governments, businesses and citizens in establishing and managing parks; (ii) inspire people around the world and across generations to reconnect with nature; and (iii) demonstrate nature's solutions to our planet's challenges such as climate change, health, food and water security. More than 6,000 participants took part in a full spectrum of workshops, events, pavilions, world leaders' dialogues, e-posters and field visits to take stock of progress since the last Congress in Durban, South Africa and to craft a new vision for the role of protected areas in the decade and generations to come.

In particular, the Sydney Congress spelled renewal by revising the world's perception of protected areas; they are not only a critical and successful means to secure biodiversity on Earth, but also their unique diversity of governance and management across all components of society are instrumental in helping the world to achieve sustainability and societal aspirations. As in the past, the Congress provided evidence of the vitality of the global movement of those involved in protected areas and signalled both warnings and promising directions for the years ahead. Achim Steiner, UN Under Secretary-General and UNEP Executive Director, remarked in the Opening Plenary (Steiner, 2014), that the protected area community had come a long way since Durban and had adapted significantly in response to the challenges presented there. Regarding the Promise of Sydney, he made a call for us to 'commit to bold, transformative actions and effective implementation at site, national and international levels. Let us learn from the past, but also recognize that it is today's youth that will inherit our protected area legacy, and the responsibility for managing the protected areas of the future. They will also bear the cost of our decisions today. Such decisions must ensure that the protected areas of the future will not be fenced off last frontiers that ward off humans to keep in what is left of our natural heritage. But rather that the

The World Parks Congress, Plenary session, Friday, 14 November 2014 © IISD/ENB (www.iisd.ca/iucn/wpc/2014/)

Parks of the future will be a place where multiple values interact: ecological, biological, cultural, societal, economic and aesthetic – brought together by sound management and sustainable financing, as a basis for biodiversity conservation and sustainable development. Now this is a promise worth keeping.'

The Congress was designed to launch a step-change in protected and conserved areas implementation by highlighting the most innovative approaches to addressing challenges and opportunities, and to forge new directions that would give lasting impetus to the work ahead. A few highlights of the Congress and its outcomes are:

- The welcome to country and the commitments of the host country Australia to address challenging conservation objectives in tropical rainforests, the Great Barrier Reef and the Coral Triangle;
- Participation from five Heads of State and 20 ministers who made significant commitments to improve the conservation status of protected areas in their countries;
- The ceremonial arrival in Sydney of the Mua Voyagers from Fiji, the Cook Islands, Samoa and New Zealand, who travelled more than 6,000 km in ocean-going canoes (vaka) to deliver both a challenge and a promise from the many small island states affected by sea level rise and a rapidly changing climate;
- A call for much greater marine and ocean protection supported by commitments from several governments to expand marine protection to secure the ecosystem services on which livelihoods and food security depend, including in the high seas;
- The launch of the IUCN Green List of Protected Areas that recognizes those areas that are successful in meeting international standards for conserving biodiversity and ensuring equitable governance, accompanied by pledges from many countries to enhance the effectiveness of their protected areas and prevent the impacts of the illegal wildlife trade and exploitation;
- A renewed focus on the needs and aspirations of the new generation of people who will live in the world's rapidly expanding cities and other human settlements, and whose attitudes towards nature can be shaped through early experiences of nature, and whose health and well-being can be enhanced by nature;
- The recognition that the diversity, quality and vitality of governance of the world's protected and conserved areas is the foundation of sustainability, and pivotal to the role of protected areas in helping humanity address the demanding challenges of climate change, disaster-risk reduction and more generally the achievement of the sustainable development goals.

It is too soon to know precisely what the impact of Sydney will be. Even a 10 year horizon is very hard to predict in rapidly changing times, especially when world leaders have announced the need for huge investments in infrastructure that will place increasing pressure on wildlands, protected areas and biodiversity conservation in the next decades (Laurance et al., 2015). But the sheer scope and depth of the discussions over such an intense period will remain an inspiration for a new generation of conservation leaders. The challenge will be to fulfil the aspirations embodied in the Promise of Sydney, included

in full below, which was handed over to the IUCN President, Mr Zhang Xinsheng and adopted by acclamation at the Closing Plenary on 19 November 2014. It is now our joint opportunity and responsibility to maintain this momentum.

As the convenors of the IUCN World Parks Congress 2014, we would like to draw your attention to these significant outcomes embodied in the various components of The Promise of Sydney (See Box for the full text). We invite your further commitment and implementation of these innovative approaches to achieve a step-change in conservation by ensuring that protected areas continue to make their vital contribution to global sustainability in the decades ahead.

ABOUT THE AUTHORS

Inger Andersen, a Danish national, is the Director General of IUCN, International Union for Conservation of Nature. She has been passionate about environmental sustainability and conservation since the beginning of her career. Prior to assuming this role in January 2015, she was the Vice President of the Middle East and North Africa at the World Bank, where she spent 15 years in various management positions related to environmental management and sustainability. She also worked for 15 years at the United Nations where she was UNDP's Coordinator for the Arab Region.

Ernesto Enkerlin Hoeflich is Chair of IUCN's World Commission on Protected Areas. He is a prominent Mexican conservationist, environmentalist, opinion leader and researcher specialized in protected areas, ecosystem services, sustainability, biodiversity stewardship and rural development. From 2001 to 2010, he was National Commissioner for Protected Areas of Mexico (CONANP).

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Stream session © IISD/ENB (www.iisd.ca/iucn/wpc/2014/)

THE PROMISE OF SYDNEY

Over 6,000 participants from 160 countries met at the IUCN World Parks Congress 2014 in Sydney, Australia. Acknowledging the traditional owners of the land where we met, we celebrated an enormous variety of inspiring ways of addressing the challenges facing the planet, through protected area approaches that respect and conserve nature, while benefitting human health and prosperity. We recognized that rebalancing the relationship between human society and nature is essential, and that ecosystems and their variety of life fully support our existence, cultural and spiritual identity, economies and well-being.

We celebrate the expansion and improved governance and management of protected and conserved areas around the world, and the leadership and initiatives of many regions, including the first ever Asia Parks Congress, since we met in Durban in 2003. In particular, we laud the establishment of new marine protected areas, as healthy oceans are critical to life on Earth and must be protected at much greater scale. We acknowledge the increasing role of Indigenous Peoples', community, and privately-conserved areas and territories in reaching biodiversity conservation and societal goals, and the opportunities presented by new communication and other technologies to better understand and engage new constituencies, including young people in the world's rapidly expanding cities. We commend numerous improvements of corporate practice, and the many success stories and varied partnerships across sectors for nature conservation and sustainability.

Despite these advances, we recognize that threats to nature, its biological diversity and protected areas are now at the highest level in human history, due to a convergence at immense scale of the impacts of human consumption patterns, population growth, and industrial activity. Many protected and conserved areas are at risk or are poorly managed, and many rangers on the frontline have sacrificed everything for this cause. This reality must be faced directly, truthfully, and collaboratively. Bold vision and concerted action are required if we are to meet both conservation goals and human aspirations for current and future generations. There is no time to lose.

We, therefore:

Promise to INVIGORATE … our efforts to ensure that protected areas do not regress but rather progress. We will scale up protection in landscapes, wetlands and seascapes to represent all sites essential for the

conservation of nature, especially in the oceans. We will enhance diversity, quality and vitality in governance and management, including the appropriate recognition and support of areas conserved by Indigenous Peoples, local communities, and private entities. We will strive to promote sustainable land-uses and eliminate activities and policies that degrade, threaten or result in extinction or the loss of ecosystems and their biodiversity, including the rampant illegal wildlife trade and the impact of invasive alien species. We will recognize, respect, resource and support our frontline staff to do their often dangerous but always critical work.

Promise to INSPIRE ... all people, across generations, geography and cultures to experience the wonder of nature through protected areas, to engage their hearts and minds and engender a life-long association for physical, psychological, ecological, and spiritual well-being. We will motivate and engage a new generation of urban and rural communities, as an essential investment in the future of sustainability on the planet, and in the quality of life of people everywhere. Further, by working in partnership with and recognizing the long traditions and knowledge, collective rights and responsibilities of Indigenous Peoples and local communities to land, water, natural resource and culture, we will seek to redress and remedy past and continuing injustices in accord with international agreements.

Promise to INVEST... in nature's solutions, supported by public policy, incentives, tools and safeguards that help to halt biodiversity loss, mitigate and respond to climate change, reduce the risk and impact of disasters, improve food and water security, and promote human health and dignity. We will work to enable protected and conserved areas and their stewards to design and monitor effective, evidence-based and culturally appropriate responses to these challenges and to provide a compelling case for increased recognition, incentives, capacity and direct funding. We will encourage regional learning networks and initiatives that support these aims. We will collaborate with new partners to promote sustainable and equitable economies that respect planetary boundaries and social justice.

OUR PROMISES

Commitments to fulfil the Promise of Sydney Vision were announced by many governments, organizations and individuals throughout the proceedings of the Congress.

Those made by governments, international organizations and civil society organizations during the Congress are listed in a register of promises: worldparkscongress.org/about/promise_of_sydney_commitments.html

All patrons, champions, partners, participants and organizations commit to this Vision and to fulfilling our promises, commitments and undertakings. We commend our promises to IUCN, and the forums to be established that will continue the dialogues that will lead to the fulfilment of our Promises and this Vision. The IUCN President, in accepting the Promise of Sydney from the IUCN World Parks Congress 2014 invited further promises and commitments to be made.

These can be notified to promiseofsydney@iucn.org and will be added to the online register of promises.

INNOVATIVE APPROACHES FOR PARKS, PEOPLE AND PLANET

A wealth of new and compelling solutions is at our fingertips, supported by inspired and committed women, men, and determined young people. We draw attention to the diverse contributions made in Sydney that provide **inspiring solutions** to achieve our vision across a vast array of issues, and that now provide a body of evidence and knowledge to overcome barriers to implementation. We will communicate and disseminate these innovative approaches, seek to work across sectors to recombine and apply promising approaches to addressing existing and new challenges. We offer a suite of **recommendations** designed to put these ideas into action, through new and innovative programmes, partnerships and funding, and will strive to take these into a strategic review of our respective organizations and initiatives.

The full suite of innovative approaches emanating from the Streams and Themes of the Congress can be found here: worldparkscongress.org/about/promise_of_sydney_innovative_approaches.html

A PANORAMA OF INSPIRING SOLUTIONS

With support from the Global Environment Facility through UNDP, and several partners, a platform for sharing and exchanging inspiring solutions has been established and will continue to be populated with examples from the IUCN World Parks Congress 2014 and the many organizations and individuals involved.

It can be found here: worldparkscongress.org/about/promise_of_sydney_inspiring_solutions.html

RESUMEN

El encuentro más importante de quienes intervienen en el quehacer de las áreas protegidas y conservadas en todo el mundo tuvo lugar en Sídney, Australia, en noviembre de 2014. El programa abarcó un amplio abanico de debates bajo el título *Los parques, la gente y el planeta: inspirando soluciones*. El evento tuvo como objetivo: (i) encontrar formas mejores y más justas para conservar la diversidad natural y cultural, haciendo partícipes a gobiernos, empresas y ciudadanos en el establecimiento y la gestión de los parques; (ii) inspirar a millones de personas en el mundo entero y a través de generaciones a relacionarse con la naturaleza; y (iii) demostrar que existen soluciones basadas en la naturaleza para enfrentar los desafíos de nuestro planeta como el cambio climático, la salud, y la seguridad alimentaria e hídrica. Más de 6000 personas participaron en una amplia gama de talleres, eventos, pabellones, diálogos de líderes mundiales, carteles electrónicos y visitas de campo, y ayudaron a elaborar una nueva visión del papel de las áreas protegidas en la década y las generaciones venideras. Este desafío, la Promesa de Sídney, fue entregado al Presidente de la UICN, el Sr. Zhang Xinsheng, y aprobado por aclamación en la sesión plenaria de clausura, el 19 de noviembre de 2014.

RÉSUMÉ

Le rassemblement le plus important au monde de personnes impliquées dans les aires protégées et conservées a eu lieu à Sydney en Australie en novembre 2014. Le programme englobait un vaste champ de discussions autour du thème « les parcs, la planète et nous : des solutions sources d'inspiration ». L'événement visait à: (i) trouver des moyens meilleurs et plus justes de conserver la diversité naturelle et culturelle, en impliquant gouvernements, entreprises et citoyens dans l'établissement et la gestion des parcs ; (ii) inciter les gens partout dans le monde et à travers les générations de se rapprocher de la nature ; et (iii) attester des solutions naturelles aux défis de la planète tels que le changement climatique, la santé, la nourriture et l'eau. Plus de 6000 participants ont pris part à un nombre varié d'ateliers, d'événements, de conférences et de dialogues avec les leaders mondiaux. Ils ont contribué élaborer pour les décennies à venir et les générations futures une nouvelle vision pour les aires protégées. Cet engagement, la Promesse de Sydney, a été transmis au Président de l'UICN, M. Zhang Xinsheng et adopté par acclamation à la séance plénière de clôture, le 19 novembre 2014.

OBLIQUE AERIAL PHOTOGRAPHY: A NOVEL TOOL FOR THE MONITORING AND PARTICIPATORY MANAGEMENT OF PROTECTED AREAS

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ABSTRACT

Protected areas are our principal conservation strategy, but require surveillance and monitoring for effective management. Many are threatened by shifting cultivation, a practice that is difficult to detect accurately with satellite imagery and is generally carried out clandestinely in isolated areas. Since 2010, oblique aerial photography has been used to detect, understand and rapidly respond to shifting cultivation in national parks and new protected areas in Madagascar. Protected areas are flown over annually at a height of 500 m above the ground along fixed transects spaced 3 km or 6 km apart: comparison of images between years reveals new clearings, which are accurately located and measured using Google Earth and GIS software. Aerial images are used by foot patrols to locate clearings on the ground and enforce rules (in national parks) or improve dialogue between protected area managers and shifting cultivators (in new protected areas). Oblique images are intuitively easy to understand and thus provide a powerful tool for discussions with resource users and other stakeholders to facilitate participatory management. The method used is significantly cheaper than the use of satellite images and requires minimal training, and thus has potential for use by protected area management agencies worldwide.

Key words: Biodiversity, conservation, deforestation, Madagascar, shifting cultivation, surveillance

INTRODUCTION

Our principal tool to stem biodiversity loss resulting from anthropogenic processes is the establishment and management of protected areas, which now cover over 15 per cent of the world's land surface (Juffe-Bignoli et al., 2014). Signatories to the Convention on Biological Diversity are required to extend the coverage of terrestrial protected areas to 17 per cent of their national territory by 2020 and ensure that they are 'effectively managed' (CBD, 2010), however their effectiveness depends on their ability to buffer their constituent ecosystems and species from the processes that threaten their viability (Gaston et al., 2008), and, globally, we know little about the success of protected areas in maintaining their condition over time (Cabeza, 2013; Geldmann et al., 2013). Key aspects of protected area management required to ensure their effectiveness include surveillance, which allows the detection of threats and facilitates the enforcement of rules, and monitoring, which permits managers to quantify changes over time and subsequently evaluate the effectiveness of management actions as part of the adaptive management cycle (Lindenmayer et al., 2012). In addition, managers must have an understanding of local resource use dynamics and the factors affecting the livelihood decision-making of adjacent communities if they are to develop appropriate, evidence-based strategies and interventions (Geoghegan & Renard, 2002; St John et al., 2013).

Habitat loss, and particularly deforestation, is the primary threat to biodiversity in tropical developing countries (Laurance & Peres, 2006; Bradshaw et al., 2009). Globally, there has been a shift in the drivers of tropical deforestation over recent decades, with industrial agriculture replacing shifting cultivation (also known as swidden agriculture or slash-and-burn) as the

Although extensive areas remain, almost all of Madagascar's forests are threatened by shifting cultivation © Louise Jasper

principal cause of deforestation in Latin America and South-east Asia (Rudel et al., 2009; Ziegler et al., 2009; Ziegler et al., 2012). However, in many other tropical developing countries, small-scale farmers practising shifting cultivation techniques for either subsistence or export-oriented cash cropping remain the principal agents of deforestation (Carr, 2009; Mertz, 2009; Gorenflo et al., 2011). Although data are scarce, the practice may support hundreds of millions of people worldwide (Mertz et al., 2009), amongst them the poorest of the rural poor (Angelsen & Wunder, 2003; Hulme & Sheperd, 2003). The enforcement of protected area rules, if unaccompanied by other measures, offers only a partial solution to shifting cultivation as a conservation problem, since it may simply displace the activity elsewhere (a phenomenon known as leakage, Ewers & Rodrigues, 2008; Kindermann et al., 2008).

Shifting cultivation is particularly difficult for protected area managers to detect, monitor and manage because, being illegal in most countries, it largely takes place in remote areas (Mertz et al., 2009; Heiniman et al., 2013). Remote sensing using satellite imagery provides a range of powerful tools that are increasingly used to monitor deforestation worldwide (Jensen, 2007), however the detection and monitoring of shifting cultivation in this way is problematic due to the highly dynamic nature of the phenomenon and the complex, small-scale land use mosaics that it produces, composed of fields, fallows of various lengths and secondary forests, each with complex spectral signatures (Asner et al., 2009; Mertz, 2009; Hurni et al., 2013a). As a result, remotely sensed data on deforestation patterns associated with shifting cultivation are rarely available at the regional or local scale required by protected area managers (Hurni et al., 2013b). In addition, satellite images may be expensive at the necessary resolution and available only after significant time lags, and require highly specialized technical expertise that is beyond the capacity of most State protected area management authorities and NGOs working on the ground in tropical developing countries. Critically, satellite images also tell managers little about

the actors involved in shifting cultivation nor the factors affecting their livelihood decision-making, thus limiting their utility in developing tailor-made management responses. Further, the outputs of remote sensing analyses (essentially maps of various kinds) may be difficult to interpret by non-specialists, limiting their value as tools for communicating with and engaging other protected area stakeholders, including decision-makers, national and local authorities and shifting cultivators themselves. There thus remains a clear need for reliable, effective and efficient methods that can be used by protected area managers in tropical developing countries to rapidly detect and respond to shifting cultivation.

Here, we describe a new method for detecting and understanding shifting cultivation in protected areas in Madagascar, based on the use of oblique aerial photography in conjunction with the online tool Google Earth. We first describe the context and challenges of protected area management in Madagascar, and then outline the method used in aerial photography and image treatment, before describing how the outputs of the surveillance programme are used in protected area management. We then present some preliminary results on the effectiveness of the method in reducing deforestation in southwest Madagascar, and conclude by discussing the role of aerial photography in protected area management and the strengths and weaknesses of the approach with respect to the alternative method, remote sensing using satellite imagery.

MATERIALS AND METHODS

- **Study system**

Madagascar is a global conservation priority possessing an unparalleled combination of diversity and endemism (Brooks et al., 2006; Holt et al., 2013). The vast majority of the endemic biota is forest dependent (Goodman & Benstead, 2005), and is thus threatened by deforestation, which remains a major problem in all remaining forest areas – for example, 8.6 per cent of forest cover was lost in the decade from 1990-2000 (Harper et al., 2007), and deforestation continues to occur even within national parks (Allnutt et al., 2013). Most of this deforestation is associated with shifting cultivation (Casse et al., 2004; Gorenflo et al., 2011), which has been illegal throughout the country since pre-Colonial times (Raik, 2007) and takes two main forms – *tavy*, the cultivation of hill rice in the humid east, and *hatsake*, the cultivation of corn (and occasionally other crops such as tobacco, cassava and sorghum) in the dry west and south (Scales, 2014). In both regions the process involves farmers cutting the shrubs and smaller trees within a defined area of forest during the dry season (which lasts from about May to November), leaving the vegetation to dry for several months, and then burning it. The ash from burning fertilizes the soil which is sown and cultivated before the arrival of the rains in around November (north and east) or December-January (southwest), but the land is generally abandoned after 3-5 years due to declining fertility and the invasion of unmanageable weeds (Razanaka et al., 2001; Pollini, 2012).

The drivers of shifting cultivation are complex (Razanaka et al., 2001; Scales, 2014). Traditionally a subsistence activity, over recent decades the uptake of *hatsake*, in particular, has been heavily influenced by booms in the price of maize as an export crop (Blanc-Pamard, 2004; Minten & Méral, 2006; Scales, 2011). Since it takes place at the forest frontier, it is usually carried out by migrants: in southwest and western Madagascar these may be migrants from the far south fleeing drought or seeking cash with which to buy Zebu cattle (Réau, 2002; Casse et al., 2004), but also residents of the region who turn to the forest as a safety net when farming their permanent fields becomes insufficiently productive, for example following the loss of irrigation infrastructure, changing rainfall patterns or the destruction of their fields in extreme flooding events (Virah-Sawmy et al., 2014; Gardner, unpublished data). However, wealthy local residents may also be involved in the process, employing migrant labourers to carry out *hatsake* for them under a share-cropping arrangement (Minten & Méral, 2006; Scales, 2011).

As part of efforts to stem ongoing biodiversity loss, the Government of Madagascar committed, in 2003, to tripling the coverage of their protected area system (Kremen et al., 2008; Corson, 2014). Prior to 2003 the protected area network consisted of 47 strict nature reserves, national parks and special reserves (Randrianandianina et al., 2003) – 'strict' categories of protected area (IUCN categories Ia, II and IV respectively) managed by the State (through the para-statal Madagascar National Parks (MNP)) for conservation, research and recreation, and in which all extraction of natural resources was banned or highly regulated. The Durban Vision, as the expansion process became known, entailed major changes in the country's approach to protected area management.

Since the majority of sites prioritized for the creation of new protected areas as part of the Durban Vision (Kremen et al., 2008) are home to large populations of people that depend on natural resources to varying extents for their subsistence and household income, the existing model of strict protected areas was recognized as inappropriate. Most new sites are therefore proposed/

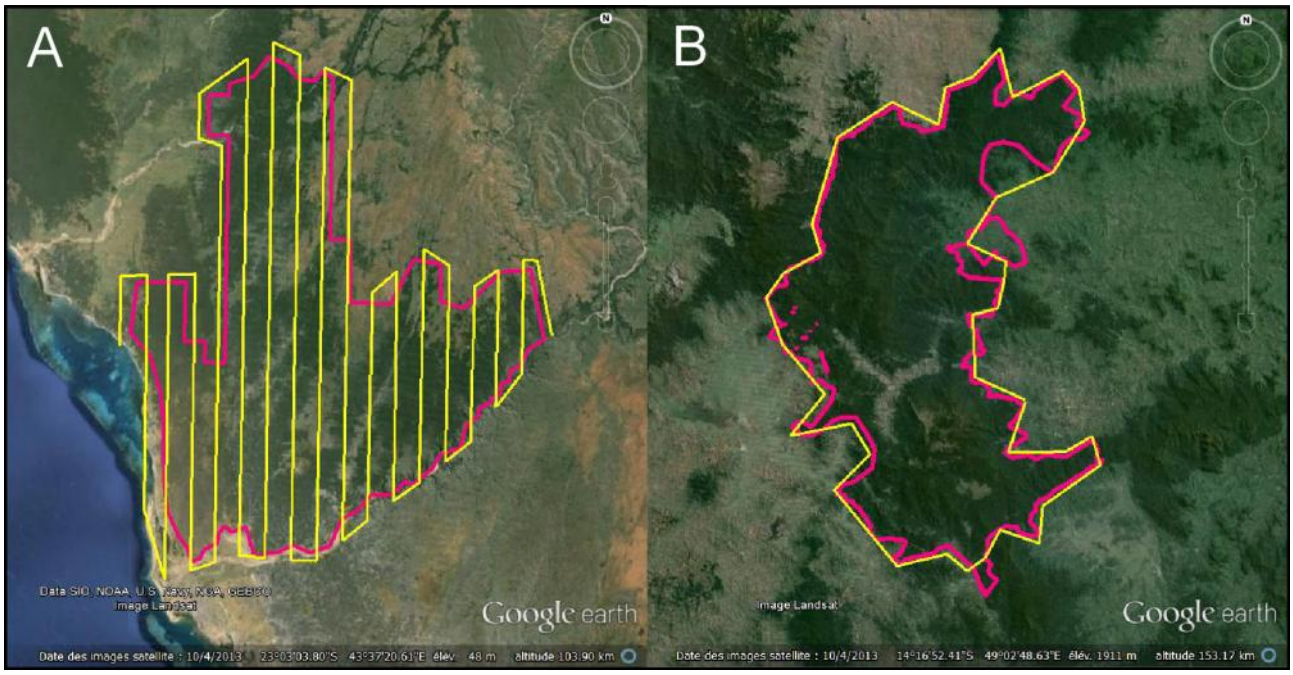

Figure 1: Satellite images of A) Ranobe PK32 new protected area in southwest Madagascar (sub-arid, low altitude) and B) Tsaratanana-Marojejy Corridor in northern Madagascar (humid, mountainous), showing different transects/flight routes used as a result of prevailing conditions. Protected area boundaries are marked in pink and flight routes shown in yellow. (Images produced on Google Earth)

designated as 'multiple-use' protected areas (IUCN categories III, V and VI) in which the sustainable use of natural resources is permitted according to a zoning plan (Gardner, 2011) (although shifting cultivation remains illegal throughout the country), and the majority are managed through shared governance arrangements by non-governmental organizations (NGOs), local community associations and regional authorities (Virah-Sawmy et al., 2014). The objectives of the new, expanded protected area system (SAPM), which includes the Durban Vision generation of new protected areas as well as the MNP-managed portfolio of strictly-protected sites, were expanded to include the conservation of Madagascar's cultural heritage and the sustainable use of natural resources for poverty alleviation and development alongside biodiversity conservation, but this creates a great challenge for managers since most traditional forms of resource use have negative impacts on endemic biodiversity (Gardner, 2009; Irwin et al., 2010). Thus approaches to protected area management have largely focused on improving the sustainability of existing land-use practices and developing alternative livelihoods to reduce dependence on natural resources (Gardner et al., 2013), as well as the contractual transfer of management rights to local communities through natural resource management transfers (Ferguson et al., 2014; Pollini et al., 2014). Neither MNP nor the NGO promoters of new protected areas have the authority to apply the law within protected areas, which remains the mandate of the State's Environment and Forests Service (MNP, 2014).

- **Oblique aerial photography**

Oblique aerial photographs are taken from a high point at an angle of approximately 45° from the observer, i.e. in between parallel and perpendicular to the ground, neither horizontal nor vertical. The method of oblique aerial photography described here has been developed by Aviation Sans Frontières-Belgique (ASF-B) since 2006, in collaboration with WWF Madagascar and Western Indian Ocean Programme Office (henceforth WWF), Madagascar National Parks (MNP) and the Madagascar Protected Area System (SAPM), and implemented since 2010. Initially focusing on national parks and new protected areas within the spiny forest ecoregion of southwest Madagascar, the programme was subsequently extended to include the Tsaratanana-Marojejy Corridor in northern Madagascar from 2011.

Each participating protected area is subject to an annual over-flight in a small, four-seat aircraft (Cessna 182). Permanent 'transects' are established over each site, and programmed into the GPS of the pilot to facilitate repeated transects. In the relatively flat and dry areas of southern Madagascar transects are laid in parallel and spaced 3 km apart, covering the whole protected area (Fig. 1a), however cloud cover associated with the mountainous rainforest of northern Madagascar can prevent flying across the centre of protected areas: in these sites, in addition to parallel transects, alternative transects are established around the forest edge at the base of the mountain to minimize the constraints of possible cloud cover (Fig. 1b). Since shifting cultivation

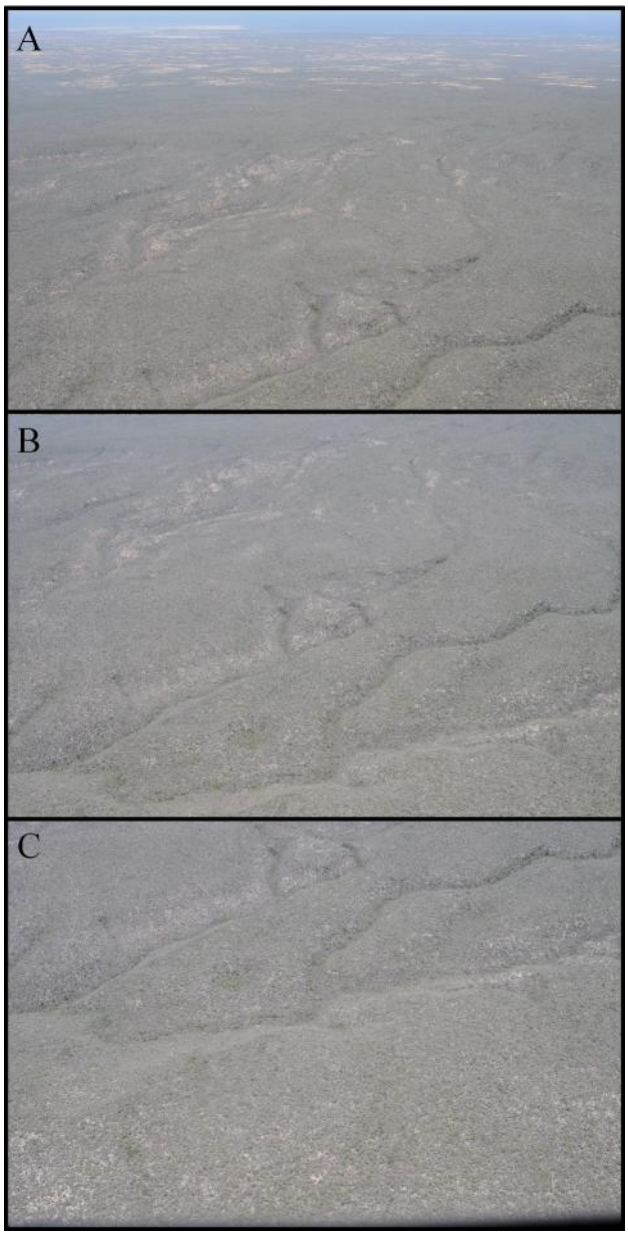

Figure 2: Representative sequence of photographs taken from a Cessna 182 aeroplane at an altitude of 500 m above Tsimanampesotse National Park at the end of the dry season. Photographs are taken perpendicular to the direction of travel, with three frames exposed every 3s (one with the horizon at the top of the screen (A), one covering the centre distance (B), and one covering the near distance with the plane window forming the lower border (C)) to ensure maximum coverage of the landscape. (Images: Xavier Vincke)

takes place primarily at lower elevations, this method nevertheless permits the observation of deforestation at the forest edge. In the spiny forest, parallel transects placed 3 km apart permit 100 per cent detection of new clearings > 0.5 ha in area; however, the distance between transects can be increased in order to reduce flight distance and therefore cost, with a resulting decrease in detection power. We estimate that transects spaced 6 km apart permit detection rates of approximately 80 per cent of new clearings > 0.5 ha in area.

All transects are flown at a height of 500 m above ground level with two observers taking photographs manually, perpendicular to the direction of travel (one facing left, and one facing right). Each observer takes three photographs every 3 s; one with the horizon at the top of the viewfinder, one a little lower, and the third with the bottom of the plane window at the bottom of the viewfinder. This allows the majority of the landscape to be covered (Fig. 2). All images are taken with a Nikon D300S with a fixed focal length of 28 mm, 400 ISO with automatic f-stop and shutter speed, and automatic white balance. The camera is connected to a global positioning system (GPS (Garmin, Pilot III)), therefore each photograph contains the geographical coordinates and height of the location from which it was taken amongst its properties. No stabilization apparatus is needed for the camera, which is simply hand held by the photographer.

Aerial transects in dry southwestern Madagascar are carried out in November-December, at the end of the burning season and before the start of the rains. Flights in humid eastern and northern sites are vulnerable to windy and cloudy weather, and therefore take place in July and August when conditions are most favourable.

- **Image analysis**

Photographs taken in successive years from the same transect and with the camera facing in the same direction can be directly compared to identify new sites of deforestation, following processing in Adobe Photoshop to increase clarity and contrast. On all substrate types, newly burned clearings can be easily distinguished from older clearings by their grey colour resulting from ash deposits; older clearings assume the colour of the substrate (white for limestone, red for sands and other soils).

The specific location of each identified clearing is determined using Google Earth and ARCview or ARCgis geographical information systems (GIS) software. KML files showing the flight route (transects) and protected area limits are loaded onto Google Earth, and the image of the clearing opened alongside (ideally on a second screen, although half-sized windows on the same screen are also possible). A landmark is created in Google Earth at the point from which the image was taken, using the geographical coordinates embedded in the image properties, and is given the same name as the image. Zooming in to the landmark until the height from which the image was taken (500 m) is reached, the view angle is then rotated until a view equivalent to that shown in the image is obtained. Comparing the aerial photograph and Google Earth image by eye, a polygon corresponding to

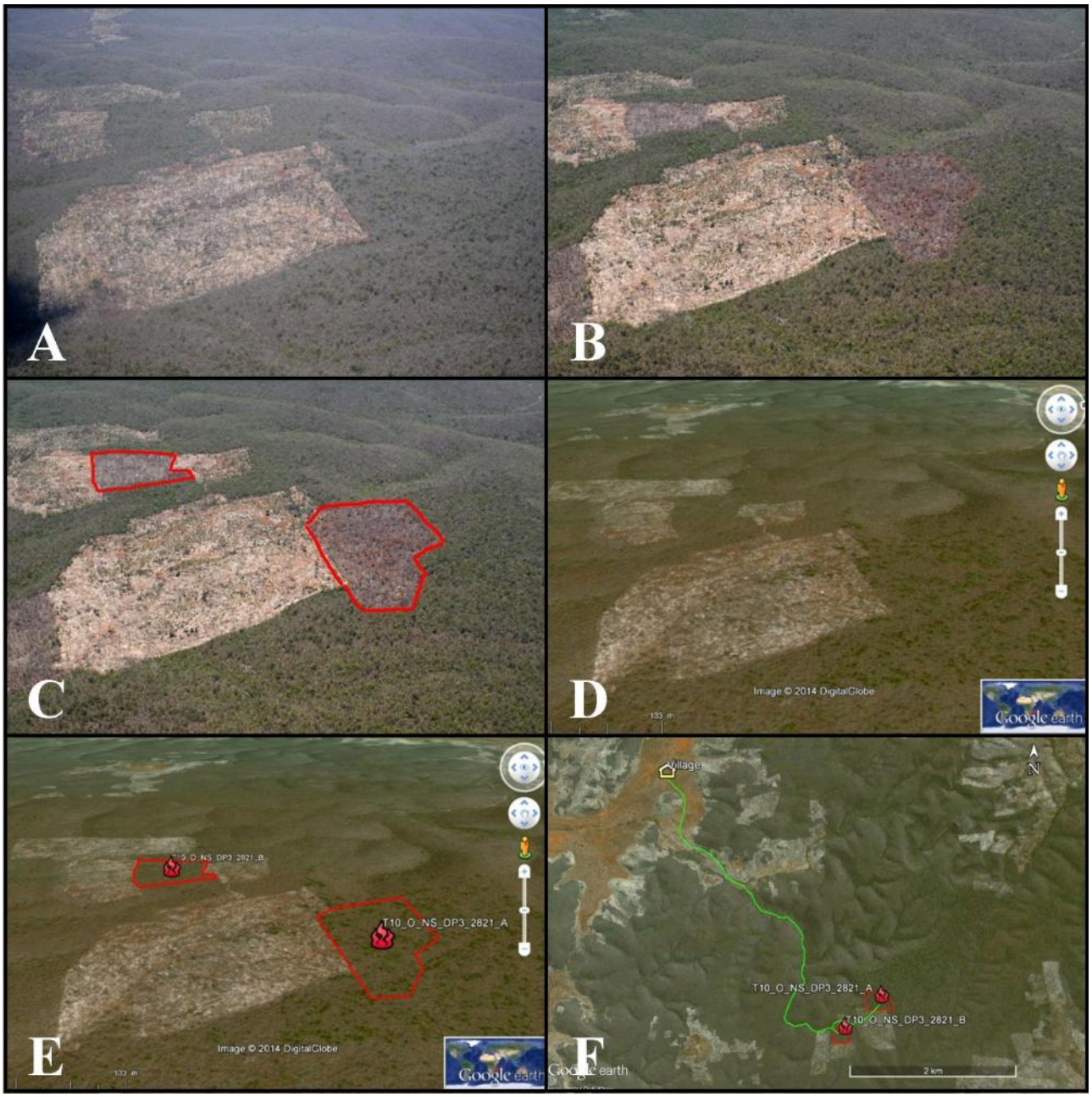

Figure 3: Sequence of images illustrating the analysis of oblique aerial photos taken as part of an aerial surveillance programme. The first two images show an area of Ranobe PK32 new protected area taken in November 2012 (A) and December 2013 (B). New clearings are clearly visible and marked in red (C). On Google Earth, an analyst zooms in to the point and height from which the image was taken, using coordinates embedded in the image properties, and rotates the view to find the view equivalent to the image (D). New clearings are manually drawn on Google Earth (E), and the data imported into GIS to calculate area and quantify deforestation rates. Maps are also produced on Google Earth to enable foot patrols to reach new areas of deforestation (F). (Images D-F produced on Google Earth, A-C by Xavier Vincke)

the clearing is then manually drawn on Google Earth and marked by a landmark at its centre (Fig. 3). The area of each polygon (clearing) is automatically calculated in Google Earth Pro but can also be calculated by importing the KML files of deforestation polygons drawn on Google Earth into GIS software. Plotting the cumulative area of new clearings allows managers to calculate and monitor the area and rate of deforestation on an annual basis.

Maps of new clearings produced on Google Earth are used by protected area managers to identify important areas of deforestation and prioritize sites for rapid intervention, which requires field staff to reach the locations on foot. For each clearing to be visited, aerial images and Google Earth are used to identify the nearest village and map accessible routes to the clearings using existing paths; once the most accessible route is identified, it is marked on the satellite image alongside hamlets and other features and landmarks. A vertical view of the image is printed and laminated, and serves as a map for foot patrols; the coordinates of landmarks along the route and other features are printed on the

reverse side, providing a tool that allows patrols to easily locate new clearings by following the route marked on the map and using the 'go to' function on hand-held GPS units to reach selected landmarks.

- **Use of aerial photographs in protected area management**

While the monitoring of deforestation rates over time generates data that can be used to evaluate the effectiveness of management interventions as part of the adaptive management cycle, the primary use of oblique aerial photography is to enable the rapid detection of, and response to, deforestation in and around protected areas. Following the identification of priority sites for intervention through the analysis of aerial images, foot patrols visit each target area to engage with farmers practising illegal shifting cultivation. Foot patrols generally comprise staff of the protected area managers or promoters (i.e. MNP or NGO promoters, as well as representatives of community-based governance structures) and representatives of local authorities (for example the mayor of the commune and village leaders (elected and traditional) from the area in which the deforestation occurred); they may also include agents of the Environment and Forest Service, which has legal authority and responsibility for all Madagascar's forests. Patrols typically travel initially to the nearest hamlet to the observed clearing, and then visit the clearing itself with villagers from that hamlet.

The form of management intervention carried out by patrols varies according to management category and governance mode of the protected area in question: in strict protected areas managed by MNP, patrols focus on law enforcement and may involve the arrest of the perpetrators of the deforestation, or delivery of a summons to appear in court. In new protected areas, however, patrols do not enforce the law but focus on sensitization and communication, for which oblique aerial photographs are a powerful tool. Patrols visiting hamlets and villages adjacent to deforestation areas use oblique aerial photographs (printed and laminated) to initiate and illuminate discussions with shifting cultivators about their livelihoods, the impacts of their activities on the surrounding landscapes and potential alternatives or management responses, as well as to discuss the illegality of their activities and the existence of the protected area. Aerial imagery plays an important role in these discussions; agents initially use a close-up image of the village or hamlet in question, which helps to initiate villagers into the analysis of photographs as they recognize individual buildings, trees and other landmarks. Images situating the village in the wider landscape, alongside those showing the increase in deforestation in successive years, provide villagers with powerful new insight into the changes occurring in the surrounding landscape and the rate at which forests are disappearing. In addition to any direct dissuasion effects resulting from these visits by the authorities, the use of aerial photographs in discussions with shifting cultivator communities has allowed protected area management staff to gain knowledge and understanding of the social dynamics of shifting cultivation and the factors shaping the livelihood decisions of farmers that has proved invaluable in the formulation of management strategies, while also providing communities with an avenue to express their concerns directly to managers.

The ease with which oblique aerial photographs can be intuitively interpreted, compared to vertical pictures, maps and satellite images, renders them a powerful communications tool. As well as facilitating dialogue with shifting cultivator communities themselves, the images generated during the course of the programme have proved valuable for communicating with diverse audiences and protected area stakeholders. For example, the images have been used by WWF to highlight the severity of the shifting cultivation crisis afflicting southwest Madagascar and persuade regional decision-makers, including the Environment and Forest Service, the judiciary and decentralized regional authorities, of the urgency of implementing appropriate policies and ensuring the application of national forest law. In addition, the photographs formed the basis of a travelling public exhibition focused on deforestation and associated environmental problems (including erosion and sedimentation of coastal fishing grounds); the exhibition reached an estimated 10,000 people in 20 towns and villages across Madagascar, and provided an important opportunity for public education in a country where contemporary environmental issues are only rarely discussed in school curricula or mass media. The exhibition is now on permanent display at an environmental education centre managed by the NGO, Bel Avenir, adjacent to the Ranobe PK32 protected area, and is visited by hundreds of school children each month.

PRELIMINARY RESULTS

Since the launch of the programme in 2010, 58 surveillance flights have been carried out over 20 national parks, existing or proposed new protected areas, and management transfers. Preliminary analysis of deforestation rates indicates that deforestation has been reduced in areas subject to repeated aerial surveillance and accompanying field patrols; for example, in the southern part of Tsimanampesotse National Park, the total area of new deforestation fell from 20 ha in 2010 to

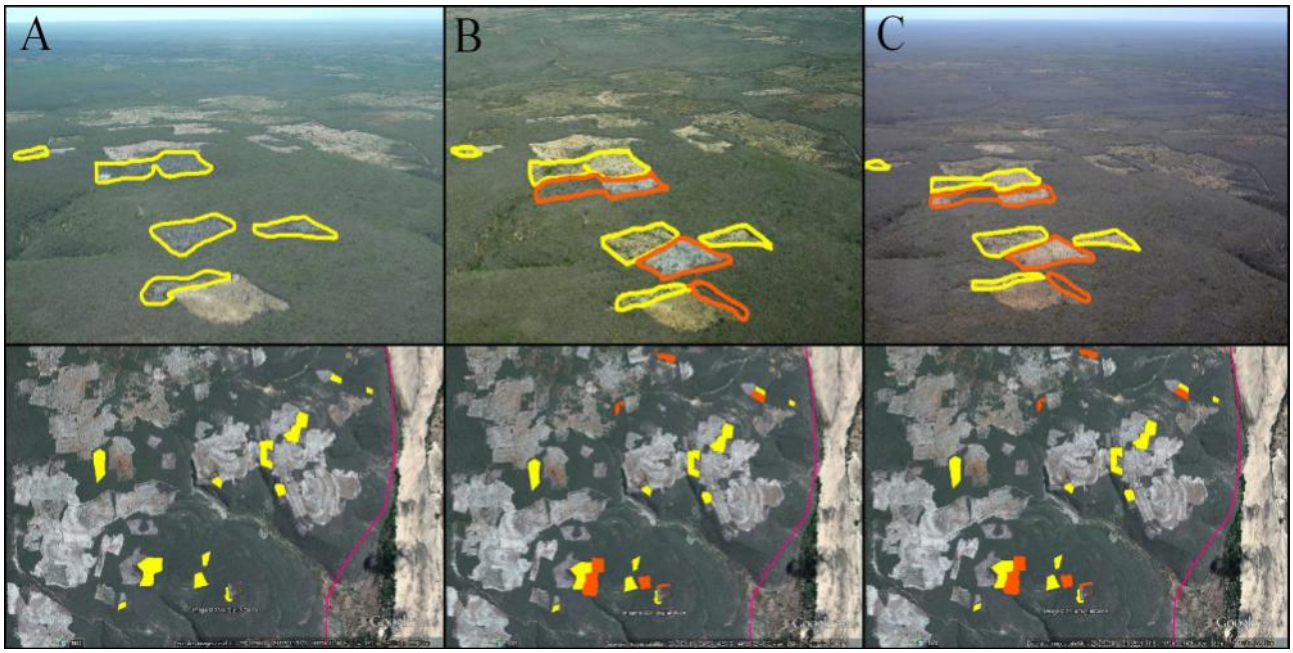

Figure 4 Time series of oblique aerial photographs (upper row) and satellite images from Google Earth (bottom row) of the southern extent of Tsimanampesotse National Park. Images are from (A) November 2010, (B) November 2011 and (C) November 2012. New clearings from 2010 are outlined in yellow and clearings from 2011 in orange: there were no new clearings in this area in 2012. (Lower row images produced on Google Earth, upper row by Xavier Vincke)

3.5 ha in 2012 (Fig. 4), a reduction of 82.5 per cent, while deforestation rates halved in Ranobe PK32 over the same period (the total area of new deforestation falling from 4,121.3 ha in 2010 to 2,020.5 ha in 2012). The observed declines in deforestation may be the result of the direct dissuasive effect of aerial surveillance and associated foot patrols on communities of shifting cultivators. However, it is difficult to attribute causality because many factors may contribute to the observed decreases, including other management interventions of the protected areas managers (such as alternative livelihoods programmes in surrounding areas) or wider socio-economic changes that may have reduced the attractiveness of shifting cultivation as a livelihood.

Further, rather than focusing only on the aggregate deforestation rates, it is also possible to calculate mean and median values for the size of individual cropland clearings through aerial image analysis using Google Earth Pro, and the number of new clearings established each season. This is important because it gives an indication of the number of farmers involved in shifting cultivation in different parts of protected areas, as well as an understanding of the methods used (e.g. large scale or small scale). For example, our results indicate that migrants, paid by local residents, generally practise large scale shifting agriculture in more remote areas, while local residents clear smaller plots in less remote areas. Such an understanding allows for a more targeted approach to conservation management with local resource users.

DISCUSSION

- **Role of oblique aerial photography in protected area management**

Since many of Madagascar's protected areas (both new, multiple-use sites and established strict protected areas) and their surrounding landscapes are home to large numbers of poor, rural people that depend to some extent on natural resources (including land) for their income, the managers of these sites face an enormous challenge – to conserve biodiversity without negatively impacting the capacity of local communities to meet their household needs. Thus management approaches have largely focused on reducing the impacts of existing resource use practices, and the development of more productive and sustainable forms of land use, such as improved agriculture and alternative livelihoods, designed to reduce the dependence of rural communities on forests and other ecosystems (Gardner et al., 2013). However, such poverty alleviation strategies ('distraction activities' (Milner-Gulland & Rowcliffe, 2007)) do not necessarily result in conservation gains, because beneficiaries may use their new income to invest in better tools and/or more labour with which to carry out even more shifting cultivation (Kull, 2000; Sievanen et al., 2005; St John et al., 2013). Thus livelihood/ distraction interventions implemented by protected area managers must be accompanied by robust resource management rules, and these rules must be effectively enforced. Oblique aerial photography provides a comparatively cheap, rapid and effective tool to facilitate rule enforcement (although it is not currently used for

Table 1: Cost in Euro of a single aerial surveillance campaign over i) Tsimanampesotse National Park and ii) a suite of four protected areas in southwest Madagascar. The cost for Tsimanampesotse National Park as part of a multiple protected area campaign was calculated as total cost multiplied by the proportional area of the site to total area surveyed.

Flight	Single protected area campaign					Multiple protected area campaign				
	FLIGHT COSTS									
	Area (ha)	Distance flown (km)	Price/hour (Euro)	Flight duration (hours)	Total cost	Area (ha)	Distance flown (km)	Price/ hour (Euro)	Flight duration (hours)	Total cost
Tsimanampesotse overflight	203,744	951	360	4.32	1,556	203,744	951	360	4.32	1,556
Toliara-Tsimanampesotse (x2)	-	284	360	1.29	465	-	284	360	1.29	465
Amoron'i Onilahy overflight	-	-	-	-	-	158,194	815	360	3.7	1,334
Toliara-Amoron'i Onilahy (x2)	-	-	-	-	-	-	140	360	0.64	229
Ranobe PK32 overflight	-	-	-	-	-	168,500	754	360	3.43	1,234
Toliara-Ranobe PK32 (x2)	-	-	-	-	-	-	127	360	0.58	208
Mikea overflight	-	-	-	-	-	184,639	991	360	4.5	1,622
Toliara-Mikea (x2)	-	-	-	-	-	-	416	360	1.89	681
Antananarivo-Toliara (x2)	-	1,500	360	6.82	2,455	-	1,500	360	6.82	2,455
Total	**203,744**	**2,735**		**12.43**	**4,476**	**715,077**	**5,978**		**27.17**	**9,784**
	FIXED COSTS									
	Unit cost (Euro)		No. Units	Total cost (Euro)		Unit cost (Euro)		No. Units		Total cost (Euro)
Per Diem and accommodation - Pilot	75		3	225		75		10		750
Landing tax and airport parking	21		1	21		21		5		105
Flight insurance	175		1	175		175		1		175
Total fixed costs (Euro)				**421**						**1,030**
Total flight + fixed costs (Euro)				**4,897**						**10,814**
Cost for Tsimanampesotse (Euro)				**4,897**						**3,081**
Cost/ha (Euro)				**0.024**						**0.015**

this purpose outside MNP-managed sites), and could also be used to evaluate the performance of management in competitive or contractual community-management initiatives such as management transfers or conservation contracts/direct conservation payments (Sommerville et al., 2010; Sommerville et al., 2011).

- **Strengths and weaknesses of aerial photography as a monitoring and management tool**

Aerial photography has been widely used in ecological research and conservation, for example to classify and map vegetation and habitat types over land and shallow seas (Zharikov et al., 2005; Cassata & Collins, 2008; Bradter et al., 2011), to track habitat or land cover change over long time periods (Asmamaw et al., 2011; Kull, 2012; Bailey & Inkpen, 2013), to estimate the density of focal species (Jansen et al., 2008; Buckland et al., 2012) and to detect advancing threats such as invasive species (Haby et al., 2010) and aquaculture (Bendell & Wan, 2011). Aerial surveys (which may or may not involve photography) are also widely used to monitor a range of animal species (Bouché et al., 2010; Parker et al., 2010; Kantar & Cumberland, 2013). However, we are not aware of any literature on the use of aerial photography to detect and monitor deforestation in and around protected areas, despite a number of practical advantages conveyed by the method. We suggest that oblique aerial photography has four main advantages compared with alternative remote sensing methods.

Cost

The cost of one annual surveillance flight of Tsimanampesotse National Park, excluding personnel time, is €4,897, or €0.024/ha (Table 1). However, since half of this cost is spent on flying the plane from the

Aerial photographs from WWF's programme have been used in a number of ways beyond surveillance and monitoring, including a travelling exhibition highlighting the impacts of shifting cultivation © Louise Jasper

capital Antananarivo to the centre of operations Toliara, important cost reductions can be made by carrying out the surveillance flight as part of a larger campaign over four protected areas; in this case the cost for Tsimanampesotse National Park declines to €3,081, or €0.015/ha, a reduction of 37.1 per cent. For this reason, WWF/ASF-B surveillance flights are always carried out over multiple protected areas in a single campaign.

For comparison, the cost of high-resolution satellite imagery lies in the range of €0.10/ha (EROS) to €0.22/ha (Kompsat) (although this is dependent on a range of specifications): the required imagery for Tsimanampesotse National Park would therefore cost €20,990-44,980, or 6.8 to 14.6 times the cost of aerial surveillance carried out as part of a multiple protected area campaign. However, we note that the costs of plane hire may be highly variable in different parts of the world, and that the costs of satellite imagery may decline in future.

Simplicity and ease of use

The oblique aerial photography method is simple and easy to use at every stage, facilitating its adoption and use by protected area management agencies in tropical developing countries worldwide. The rented plane does not need to be equipped with special photographic equipment, as is needed for vertical photography. The photography itself requires only a 30-minute training session since all camera settings are pre-set and unvarying, while the analysis of images requires only minimal training in the use of Google Earth and GIS software. In total a computer-literate person can become highly competent in image analysis following one day of training and one week of practice to develop the necessary skills. In contrast, the analysis of satellite imagery requires advanced technical knowhow that is beyond the capacity of most protected area management agencies in Madagascar and worldwide, and could therefore be expected to entail greater personnel costs.

Real-time data

Deforestation analyses based on satellite imagery cannot be performed until the requisite images are commercially available, which may be more than two months from the date of the image. This limits their utility to protected area managers, who may require real-time understanding of land use change within their sites for rapid intervention in the field. With oblique aerial photography, observers are able to pinpoint important

sites of deforestation during the flight itself and, by selectively processing images from key sites first, can have the information necessary to support foot patrols available within 24 hours if required. However such rapid response is not usually required in the management of Madagascar's new protected areas, since farmers remain tied to their cleared lands for several months following surveillance flights, which take place at the start of the planting season.

Easy to interpret and versatile outputs

Oblique aerial images are intuitively easy to interpret compared to maps and satellite imagery, because they show objects (buildings, trees, landforms) from an angle which people can easily recognize. As a result, the images are not limited to deforestation analyses but can be used in a range of communications tools designed for different audiences. As well as providing a powerful tool for mutual learning and participatory decision-making between protected area managers and rural resource users, aerial photography generated by the surveillance programme has been used by WWF and its partners in i) lobbying regional decision-makers, ii) education of Malagasy children and the general public through travelling public exhibitions and use in the children's environmental magazine *Vintsy*, and iii) education and marketing aimed at foreign audiences, including funders, supporters and the general public, through varied media including calendars and posters, social media, and a forthcoming coffee table book. The images offer a powerful, striking and immediate illustration of the severity of Madagascar's environmental crisis and the urgency of taking action.

- **Constraints, caveats and further research**

In our experience, the use of oblique aerial photography for surveillance and monitoring of protected areas has several minor drawbacks. First, and like satellite imagery, the flights themselves require calm and cloud-free weather conditions: while this is generally the case in sub-arid southwest Madagascar where the surveillance programme has largely been carried out, adverse weather has proved problematic for the surveillance of mountainous sites in the country's humid regions. The problem has been largely overcome by altering flight routes to circumnavigate mountainous protected areas rather than (or in addition to) traversing them. Second, the analysis of imagery can be time consuming because many thousands of photographs are generated in a single surveillance flight and treatment time is proportional to the number of clearings observed. In general an experienced analyst can treat about 15 clearances in a day and can complete analysis of a protected area such as Tsimanampesotse National Park in six days: however, we are unable to generate comparable time estimates for the use of satellite imagery because such information is rarely published in research papers. Third, the treatment of images requires good spatial awareness, a characteristic that must be tested during recruitment for the post. Finally, the localization of clearings on Google Earth can be difficult if they occur in an area without recognizable landmarks, such as landforms or older clearings; however the vast majority of clearings occur at the forest frontier rather than within large blocks of homogeneous forest, and can thus be easily located in relation to older clearings.

Although oblique aerial photography is just a tool, the uses to which it is put may have major effects on both the effectiveness of protected area management and the wellbeing of shifting cultivator communities, topics which therefore warrant further investigation. Understanding how shifting cultivator communities respond to over-flights and associated patrols when these are used for i) law enforcement in strict protected areas and ii) discussions (but not law enforcement) in multiple -use protected areas, will require much further research, but would provide important contributions to debates on the social impacts of protected areas and the relative effectiveness of strict versus multiple-use protected area models. For example, it is important to know whether farmers no longer practising shifting cultivation within participating protected areas are displacing their agriculture elsewhere (Ewers & Rodrigues, 2008), intensifying their cultivation of existing farmland (Pollini, 2012), or abandoning the livelihood in favour of other activities (including opportunities arising from protected area-related projects). In addition, and in the context of recent discussions on the use of drones in conservation (Duffy, 2014; Humle et al., 2014), it would be interesting to compare the impact of aerial photography versus drones on the attitudes and behaviour of rural communities, since this will affect the outcomes and effectiveness of future management interventions.

CONCLUSIONS

WWF, ASF-B, SAPM and MNP have been carrying out oblique aerial photography over national parks and new protected areas in Madagascar's sub-arid spiny forests since 2010 and humid forests since 2011. The programme has provided protected area managers with a powerful new tool with which to tackle their greatest immediate challenge, deforestation from shifting cultivation. As well as providing quantitative data on deforestation rates, the programme has facilitated an

Aerial photography allows the real-time identification of major deforestation incidents, allowing protected area managers to rapidly respond with foot patrols © Louise Jasper

increased understanding by managers of shifting cultivation as a social process, and improved dialogue with cultivating communities and other stakeholders, thus contributing to more effective co-management. Our comparative data show that oblique aerial photography offers excellent value for money compared to the use of high definition satellite imagery, as well as conferring other benefits, and additionally can facilitate conservation communication of various forms. Oblique photography is relatively cheap, simple and easy to use, and we therefore believe it has great potential to contribute to protected area management efforts in tropical developing countries worldwide, when accompanied by appropriate actions on the ground.

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RESUMEN

Las áreas protegidas son nuestra principal estrategia de conservación, pero precisan de vigilancia y monitoreo para una gestión eficaz. Muchas se ven amenazadas por la agricultura itinerante, una práctica que es difícil de detectar con precisión mediante imágenes de satélite y que suele llevarse a cabo de manera clandestina en zonas aisladas. Desde 2010, se ha estado utilizando la fotografía aérea oblicua para detectar, comprender y reaccionar con rapidez a la agricultura itinerante en los parques nacionales y en las nuevas áreas protegidas en Madagascar. Las áreas protegidas se sobrevuelan anualmente a 500 m de altura sobre el suelo a lo largo de transectos determinados de 3 o 6 kilómetros: la comparación entre imágenes revela los nuevos despejes que se localizan y miden con exactitud mediante Google Earth y el Sistema de Información Geográfica (SIG). Las imágenes aéreas son utilizadas por las patrullas a pie para localizar los despejes y hacer cumplir las normas (en los parques nacionales) o mejorar el diálogo entre los administradores de áreas protegidas y los agricultores itinerantes (en las nuevas áreas protegidas). Las imágenes oblicuas son de fácil entendimiento por lo que constituyen una herramienta eficaz para las discusiones con los usuarios de los recursos y otros interesados en procura de una gestión participativa. El método utilizado es significativamente más barato que el uso de imágenes de satélite y requiere una capacitación mínima, por lo que puede así prestar apoyo a las agencias de gestión de áreas protegidas en todo el mundo.

RÉSUMÉ

Les aires protégées sont au cœur de notre stratégie de conservation, mais leur gestion efficace nécessite surveillance et suivi. De nombreuses aires protégées sont menacées par les cultures itinérantes, une pratique difficile à détecter avec précision avec l'imagerie satellite et généralement effectuée clandestinement dans des régions isolées. Depuis 2010, les photographies aériennes obliques ont été utilisées à Madagascar pour détecter, comprendre et s'adapter rapidement aux changements de culture dans les parcs nationaux et les nouvelles aires protégées. Des survols annuels de ces zones ont lieu à une altitude de 500 m le long de pans-de-terre linéaires à intervalles de 3 km ou de 6 km. La comparaison d'images entre les années révèle de nouvelles clairières, qui sont situées avec précision et mesurées à l'aide des logiciels Google Earth et SIG. Les patrouilles à pied se servent de ces images aériennes afin de localiser les clairières sur le terrain pour faire respecter les règles (dans les parcs nationaux) ou pour améliorer le dialogue entre les gestionnaires d'aires protégées et les cultivateurs itinérants (dans les nouvelles aires protégées). Les images obliques sont faciles à comprendre de manière intuitive et constituent ainsi un outil puissant lors de discussions avec les utilisateurs des ressources et autres intervenants afin de faciliter la gestion participative. Cette méthode est nettement moins chère que les images satellitaires et ne nécessite qu'une formation minimale, elle peut donc être utilisée par les organismes de gestion des aires protégées dans le monde entier.

WESTERN SYDNEY PARKLANDS: AUSTRALIA'S LARGEST URBAN PARK

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ABSTRACT

The important role of large urban parks in biodiversity conservation is becoming more widely recognized. Because many large urban parks contain substantial areas that meet the IUCN definition of 'protected area' there is an urgent need for management to protect them from threats posed by more intense recreation uses and a range of environmental impacts. Sustainable development principles applied to the management of large urban parks can achieve a balance between protecting biodiversity values and providing opportunities for visitors to engage with, enjoy and appreciate nature. This paper makes the argument for greater recognition of the need to incorporate sustainable development principles in the planning, design, development and management of large urban parks to achieve a balance between biodiversity conservation and the wide range of other roles and functions they are required to perform. The 5,280 ha Western Sydney Parklands provide valuable lessons on how sustainable development principles can be applied to protect and manage biodiversity values while offering a diverse range of recreation facilities to meet the needs of a rapidly growing population in western Sydney. The Parklands also demonstrate a model for economic sustainability that could be relevant to other large urban parks located in major cities.

Key words: Large urban parks, sustainable development principles, biodiversity conservation, management model

INTRODUCTION

The conservation values associated with large urban parks are becoming more widely recognized and understood (IUCN, 2014). Many large urban parks contain substantial areas that could meet the IUCN definition of 'protected area'; primarily habitat/species management areas which relate to management category IV (Dudley, 2008). In addition to protecting biodiversity values large urban parks can play a valuable role in allowing large numbers of urban dwellers to experience nature (Trzyna, 2014). However, 'protected areas' in large urban parks are increasingly threatened by more intense recreation uses and environmental impacts from weeds, feral animals and wildfires.

A key challenge for management of large urban parks is to achieve a sustainable balance between protecting biodiversity values and providing opportunities for visitors to enjoy and appreciate nature. Meeting this challenge requires careful consideration of the physical form of fixed park facilities in contrast to the open ended character of ecological systems and cultural values (Czerniak & Hargreaves, 2007).

There is growing recognition of the need to integrate sustainable development principles with biodiversity conservation in planning and managing protected areas (Ervin, 2013). To achieve this goal requires a balance between ecological, social and economic values through a multi-disciplinary approach that draws on the knowledge and creativity of community members, park managers, design professionals and decision makers. This paper makes the argument for greater recognition of the need to incorporate sustainable development principles into the planning, design, development and management of large urban parks to achieve a balance between the conservation of biodiversity and the public recreation and cultural facilities that are provided.

Western Sydney Parklands[1] provides a model for the retention and management of biodiversity values in areas that could be defined as 'protected areas' within a large urban park located in a rapidly developing area of a major city. Primarily comprised of former rural land, the Parklands now incorporate areas of remnant native woodland, replanted and regenerating native vegetation, together with recreation and sporting facilities and infrastructure.

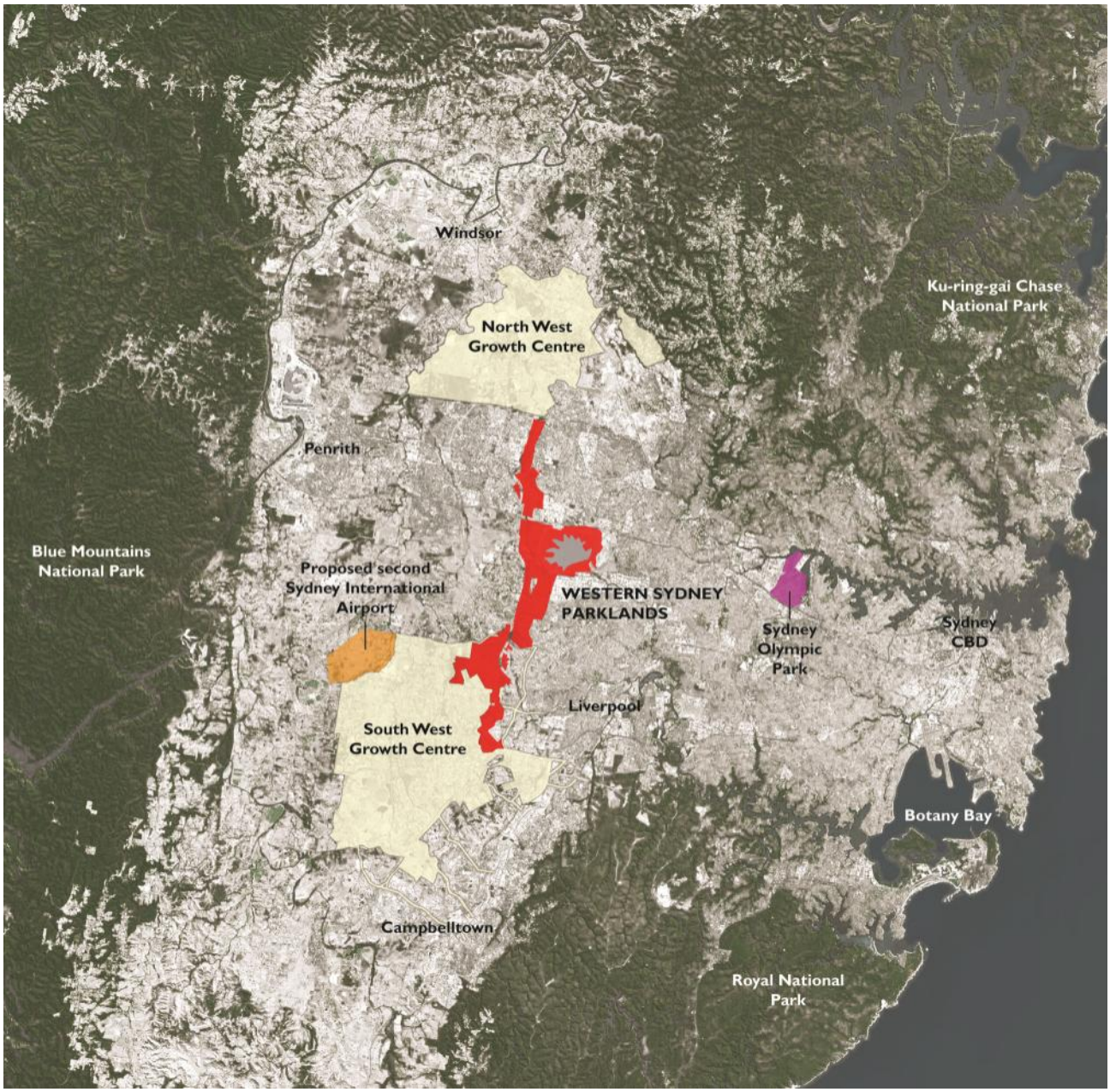

Figure 1: Context of the Western Sydney Parklands. Ariel Source: Bing Maps

CONTEXT OF THE PARKLANDS

Covering some 5,280 ha and extending for 25 km the Parklands constitute the largest area of urban parkland in Australia. The relative scale of the Parklands is indicated by a comparison with Central Park in New York City which covers 341 ha, Hyde Park in London 253 ha and Sydney Olympic Park 430 ha. Figure 1 illustrates the context of the Parklands, showing the metropolitan area's two major urban growth centres and the proposed location of a second international airport for Sydney. The current Western Sydney population of 2 million is predicted to grow to 2.92 million by 2031 and will represent 50 per cent of the capital city's population (NSW DP&E, 2014). The Western Sydney Parklands will provide the primary open space recreation area for local residents while serving the broader metropolitan region.

The Parklands form part of a network of public lands that includes National Parks covering approximately 39,680 ha to the north, west and south of the Sydney metropolitan area. The generally rural landscape character of the Parklands contains significant areas of remnant Cumberland Plain Woodland. Classified as a threatened ecological community (Australian Government Department of Environment, 2014), the Cumberland Plain Woodland patches are likely to meet the IUCN definition of a protected area (Dudley, 2008; Trzyna, 2014). These remnant vegetation areas form the basis for a system of ecological corridors that are being created throughout the Parklands. However, fragmentation of remnant vegetation poses a major challenge to achieving sustainability outcomes (Forman, 2008).

Recreation areas and sporting facilities within the Parklands are generally located near the boundaries to aid accessibility from the network of highways and local roads. The M7 Motorway running along the edge of the Parklands is connected to the Sydney motorway network. Public transport access is provided by railway stations near the northern and southern ends of the Parklands.

CREATION OF THE PARKLANDS

The story of how the Parklands were created is a long and intriguing one. It had its genesis in the New South Wales County of Cumberland Planning Scheme (Cumberland County Council, 1948), which incorporated the concept of a wide 'green belt' defining the future western edge of urban development (Evans & Freestone, 2009). As the population of Sydney grew and urban development expanded, the 'green belt' was pushed farther west and significantly reduced in width before forming the basis of the Western Sydney Parklands (Abercrombie, 2008).

The concept of a major regional open space corridor in western Sydney was suggested in the 1968 Sydney Region Outline Plan. The corridor was to accommodate high voltage power lines, gas pipelines and communications and provide sites for public institutional facilities while providing regional open space and recreation as the population of Sydney increased (State Planning Authority of New South Wales, 1968). In 1989 the NSW Government provided for development of key recreational facilities within the Parklands, which included the Eastern Creek International Raceway, through the creation of *State Environmental Planning Policy No 29—Western Sydney Recreation Area* (New South Wales Government, 2009a). The Parklands also provided event venues for the Sydney 2000 Olympic Games, including equestrian, shooting, baseball/softball and mountain biking facilities. Gazettal of the *Sydney Regional Environmental Plan (SREP) No 31—Regional Parklands* (New South Wales Government, 2001) created a framework for management of land uses throughout the Parklands.

In 2004 the Department of Infrastructure, Planning and Natural Resources (DIPNR) engaged consultants to prepare *The Western Sydney Parklands Management Vision and Concept Plan Options* (URS, 2004), which provided the framework for planning and management of the Parklands. The multidisciplinary project team led by landscape architects included specialists in ecology, Aboriginal archaeology and cultural heritage. Development of the Parklands Management Vision was overseen by an Advisory Group comprising representatives from key state agencies and the three local government areas in which the Parklands are located. A series of visioning workshops engaged the Advisory Group with experts in park planning and management.

Remnant Cumberland Plain Woodland © Noel Corkery

A discussion paper prepared ahead of the workshops presented a review of large parks around the world to identify key issues and trends (Corkery, 2003). The paper provided a focus for discussions between participants who came with diverse backgrounds, knowledge and experience. Some key trends were identified in the discussion paper as follows. There is a significant move away from preparing traditional rigid master plans towards more flexible strategies and frameworks to allow the evolution of large urban parks in response to changing community expectations, availability of resources and new knowledge. Ecologically -based large urban parks are preferred over traditional 'fixed-in-time' landscapes that typically adopted a pastoral aesthetic and required resource intensive maintenance. There is recognition of the link between human health and environmental sustainability. Cultural heritage values are finding expression through the design of natural and cultural landscapes within urban parks; while the development of a unique aesthetic quality for individual precincts throughout urban parks has been found to contribute to their overall identity. Finally, the discussion paper recognized the critical need for robust management structures to ensure sustainable long-term commitment to implementation of the vision adopted for individual urban parks.

These trends informed the discussion about future directions for the Parklands. The following principles emerged to guide the Parklands Management Vision (URS, 2004):

- Achieve a balance between ecological conservation, recreation facilities and cultural values

Figure 2: View south over northern portion of Parklands

- Recognize the link between community health and ecological systems health
- Develop a clear image and branding for the Parklands
- Create opportunities for sustainable agriculture within the Parklands together with defined public access rights
- Enhance the potential for commercial recreation and tourism facilities
- Involve the community in determining the programme of uses throughout the Parklands
- Establish future 'virtual' links between the Parklands and people through the application of communications technology
- Encourage industry sponsorship, partnerships, alliances and stewardship within the Parklands
- Investigate the potential for Biosphere Reserve designation as a management strategy
- Consider opportunities for environmental offset allowances
- Explore options for management structures and funding.

There was general acknowledgement that development of the Western Sydney Parklands was a long-term project extending over 30 to 50 years that demanded commitment to a clear and shared vision. The over-arching Management Vision developed in the workshops was that: 'The Western Sydney Parklands will form a unique component of the Sydney metropolitan open space system, linked to surrounding areas and providing a diverse range of recreation and cultural learning experiences integrated with the natural and cultural values of the land' (URS, 2004).

The Western Sydney Parklands were created in 2006 by the Western Sydney Parklands Act (NSW State Government, 2006) together with the Western Sydney Parklands Trust with management responsibility. Creation of the Parklands stands as a rare example of long-term commitment by state government over a period of 30 years that resulted in the assembly of 5,500 ha of public land from which the Parklands were created. It is particularly remarkable given the contemporary political and economic climate in which assembling a similar area of public open space within the urban context of a major Australian city would be problematic.

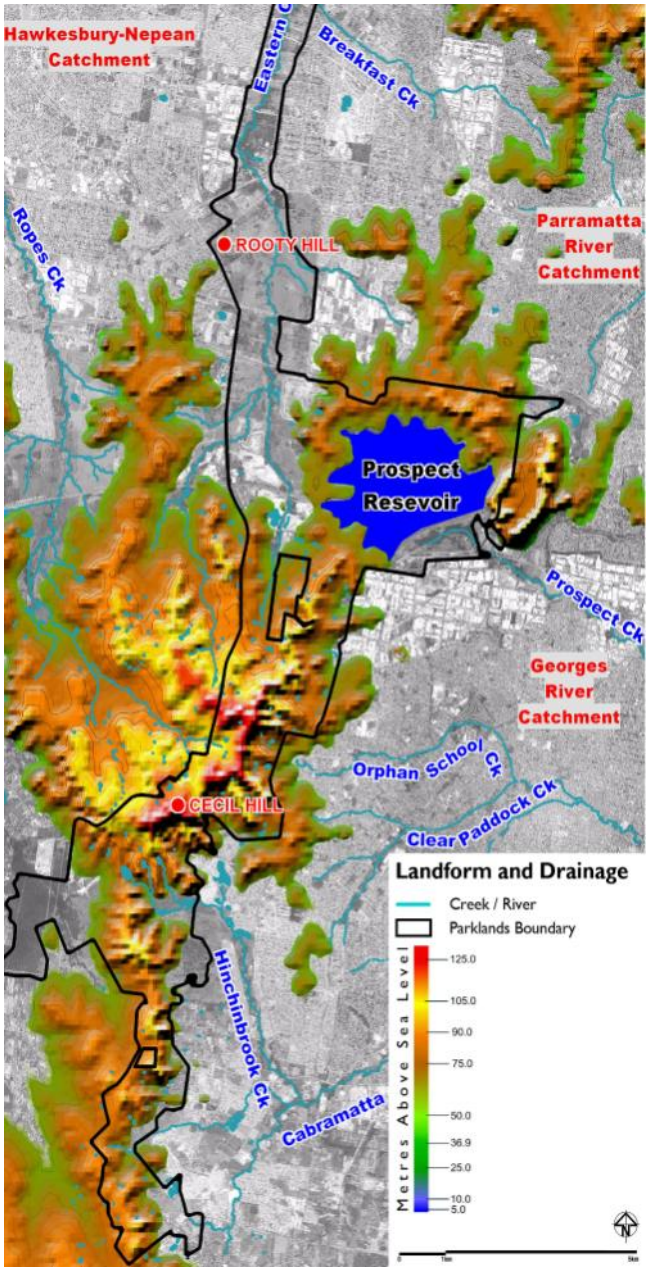

Figure 3: Landform and drainage catchments. Source: URS & Turf Design Studio

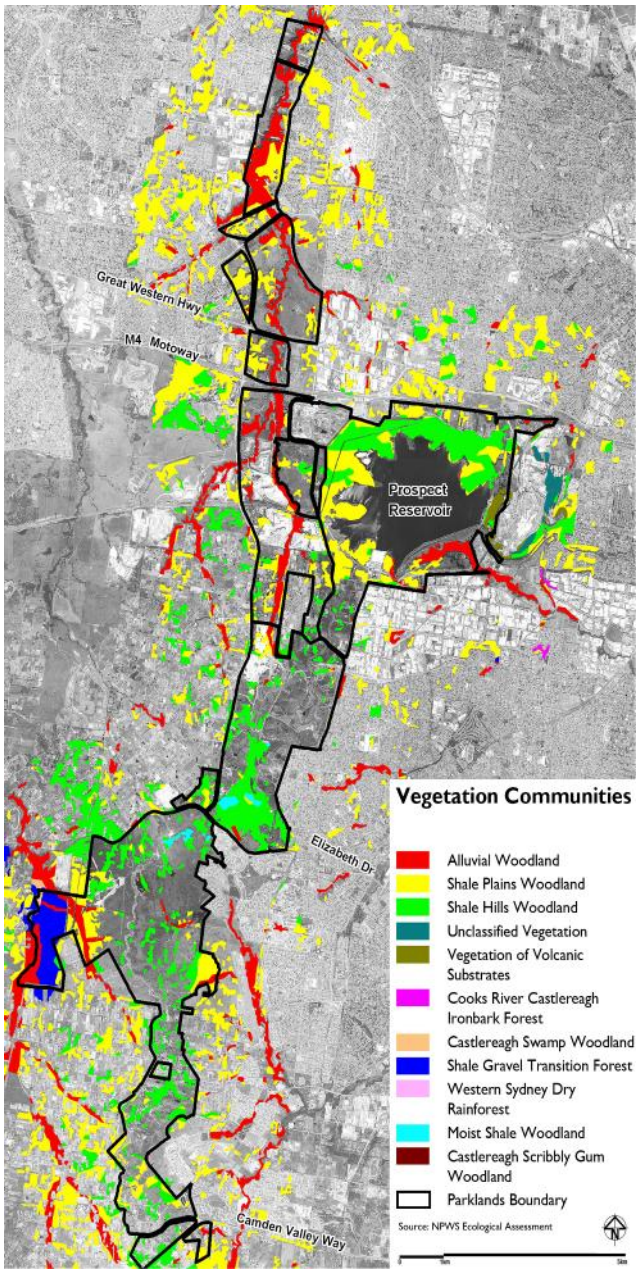

Figure 4: Vegetation communities mapping. Source: URS & Turf Design Studio

The generally rural landscape character of the Parklands is illustrated in Figure 2, which shows the northern portion of the Parklands. Substantial remnant vegetation is present along the South Creek corridor while urban development adjoins both sides and the M7 Motorway runs along the western edge.

REGIONAL DRAINAGE CATCHMENTS

The Parklands are located on the catchment boundary between the Hawkesbury-Nepean River to the west, Georges River to the east and Parramatta River to the north east, which are shown in Figure 3. This location along catchment boundaries provides an opportunity for the Parklands to play a key role in improving water quality and raising community awareness of water resources within the Sydney Region.

VEGETATION COMMUNITIES

The fragmented pattern of remnant native vegetation illustrated in Figure 4 is the result of agricultural land uses and urban development. The mapping was based on data from a number of sources (Perkins, 2004: National Parks & Wildlife Service, 2003) and showed the major components included: Shale Plains Woodland and Shale Hills Woodland components of the Cumberland Plain Woodlands, which is listed under both the NSW Threatened Species Conservation Act 1995 (TSC Act) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act); and Alluvial Woodland component of the Sydney Coastal River Flat Forest, which is listed under the NSW Threatened Species Conservation (TSC) Act 1995.

Cumberland Plain Woodland © Noel Corkery

The TSC Act includes provision for the preparation of recovery plans to provide for the long-term protection of the listed threatened ecological communities. The Cumberland Plain Recovery (NSW DECCW, 2011) prepared under both the EPBC Act and the TSC Act applies to remnant vegetation throughout the Western Sydney Parklands. Part 7A of the TSC Act established a Biodiversity Banking and Offsets Scheme that provides for the establishment of biodiversity banking sites, creation and trading of biodiversity credits to offset the impact of development on biodiversity values.

PARKLANDS STRUCTURE PLAN

A key component of the Management Vision was preparation of the Structure Plan presented in Figure 5 that achieved the sustainable management of Parklands through the integration of: Ecological Corridors—protecting extant core habitat, areas of ecological restoration to link core habitat areas and buffer zones to protect the core habitat; Park Use Areas—providing for various recreation uses outside of the ecological corridors; and the Road and Path Network—including the M7 Motorway and pedestrian and cycle paths linking facilities along the Parklands corridor to improve access from adjoining urban areas.

Reconnecting fragmented areas of Cumberland Plain Woodland through a programme of ecological restoration involved the adoption of a well established biodiversity conservation strategy (Bennett, 2003). The Western Sydney Parklands Biodiversity Strategy 2012-2020 (WSPT, 2013) identifies a programme of biodiversity restoration and management to the year 2020. The Structure Plan identified a series of separate precincts throughout the Parklands, described the character of each and defined the desired future character to be achieved. A matrix illustrated potential suitable uses within each precinct. This framework provided flexibility in planning and development of facilities to respond to changing requirements as the population of western Sydney grows.

MANAGEMENT STRUCTURE

The crucial importance of establishing an effective management structure for the Parklands was realized early on in preparing the Management Vision. Options evaluated during the workshops included: assigning management responsibility to a single existing state government department; establishing a trust as a State-owned authority with legislated authority to manage the Parklands; appointing an existing state management

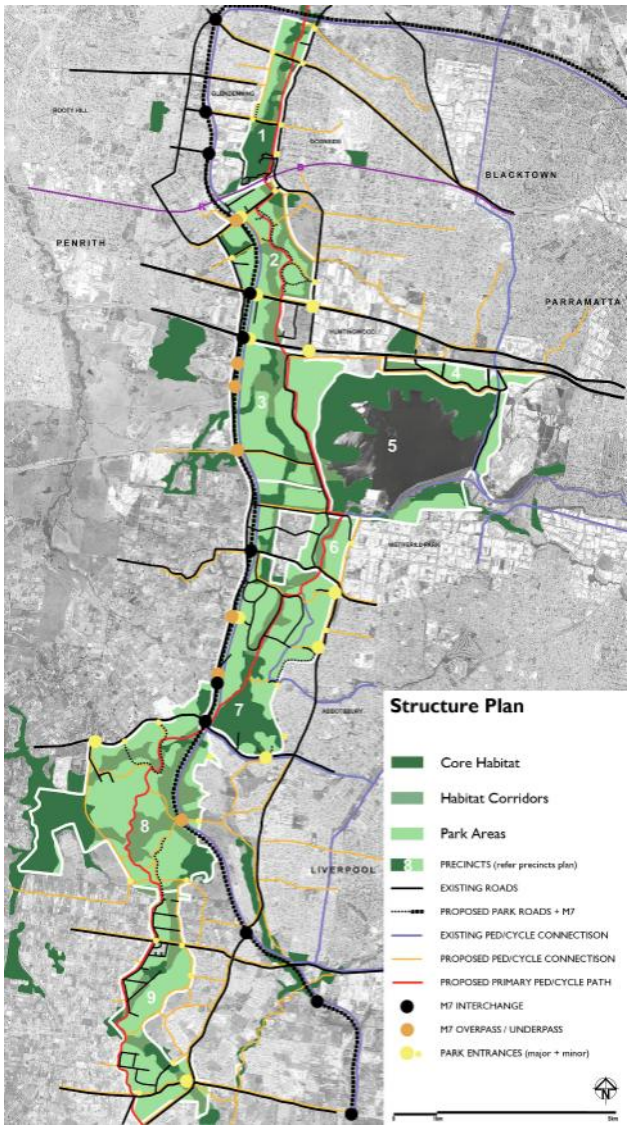

Figure 5: Parklands Structure Plan. Source: URS & Turf Design Studio

agency; establishing a community-based management organization; or dispersing management responsibilities between the three local government areas in which the Parklands are located.

Establishment of a State-owned enterprise was considered to be the most effective option because it would allow clearly defined accountability and provide focus. Creating a board structure would allow broader governance skills to be engaged. A State-owned enterprise would have the potential to create a high profile in the community. Lastly, it could provide the context for a business plan that focused on resources and outcomes, including revenue generation and budget control for the development and management of the Parklands.

Adoption of the trust management structure led to the creation of the Western Sydney Parklands Trust by the *Western Sydney Parklands Act* (NSW State Government, 2006). The boundaries of the Parklands were also defined by the Act which also transferred to the Trust approximately 3000 ha of land previously owned by the Department of Planning. The Act provided the Trust with statutory authority to develop and manage the Parklands in partnership with other state and local government agencies. The *State Environmental Planning Policy (SEPP) Western Sydney Parkland* (NSW State Government, 2009b) provided the necessary land use flexibility to implement the Trust's mandate under the Act and assign the primary planning approval role to the State planning agency rather than to local governments. The Trust prepared a Plan of Management (WSPT, 2011) to guide the development of facilities and programmes and a financially sustainable business strategy for the Parklands to 2020. The strategy was further developed in a Plan of Management Supplement prepared by the Trust in 2014, which provided more details on how the Trust intended to establish revenue streams to fund management of the Parklands (WSPT, 2014)[2].

Adoption of the *Western Sydney Parklands Regulation* (NSW State Government, 2013b) allowed the Trust to protect its natural and cultural values; assist the equitable enjoyment of the Parklands by promoting visitor safety, providing new facilities and protecting cultural and ecological values; and to facilitate organized events and charge a fee for commercial activities in the Parklands. Emphasis is placed on the provision of access to the natural environment for children and families as a learning experience and engagement with nature, including involvement in ecological restoration activities throughout the Parklands.

LESSONS LEARNT

A decade on from the creation of the Parklands Management Vision in 2004 and subsequent formation of the Western Sydney Parklands Trust it is timely to reflect on what has been achieved and the lessons learnt. It is also an opportunity consider where the Parklands are headed over the coming decades.

- **Strategic direction**

Given the scale of the Parklands and their significance at both the Sydney regional and national levels, the knowledge emerging from the first decade of development and management is valuable. It is particularly relevant to professionals and decision makers engaged in planning, design and management of other large urban parks within the context of major cities. The relevance of this knowledge will become increasingly apparent as current government policy focuses on greater urban density aimed at making more efficient use of infrastructure. A major consequence of

Lizard Log play space within remnant woodland and planted indigenous trees © Noel Corkery

Plough & Harrow picnic facilities and planted indigenous tree © Noel Corkery

this policy is an increasing demand for use of public open space. Within large urban parks effective management will be required to protect biodiversity and cultural values as public use increases. The resilience of urban parks to withstand the pressures of increased public usage will need to be strengthened and take account of climate change.

In 2010 the Trust committed to the implementation of a Plan of Management that sets out a ten year programme of development within the Parklands (WSPT, 2011). The Plan defines the target percentage cover of land uses to be achieved by 2020: native vegetation communities 37 per cent; sport and recreation 25 per cent; interim and long-term infrastructure 24 per cent; urban farming 10 per cent; business hubs 2 per cent; tourism 1 per cent; and community uses 1 per cent.

Although this clearly precludes the whole area of the Parklands being considered as a protected area under the IUCN definition (where at least 75 per cent of the area must be set aside for the conservation of nature), several areas within the Parklands could certainly be managed as protected areas within the larger Parklands landscape.

The targets form a clear basis for ongoing development and management of the Parklands. A significant aspect of social sustainability of the Parklands is the incorporation of employment and training opportunities that include tourism, recreation and environment management. These opportunities are expected to grow as new facilities are developed and the intensity of management is increased throughout the Parklands. Extensive areas within the Parklands are leased by the Trust for a variety of uses, which include agriculture, motor sports, field sports, tourism, theme parks and rural residential.

- **Involvement of landscape architects**

Landscape architects have played a key role in the planning and development of the Parklands, including preparation of the initial Management Vision (URS, 2004) and the subsequent Plan of Management (WSPT, 2011). The role of landscape architects has continued through the design of new facilities and ongoing management of the Parklands. This has involved working in collaboration with a range of other professions that include ecologists, fire management experts, artists, cultural heritage and community consultation specialists.

- **Recreation facilities**

The Trust has overseen development of a number of new facilities throughout the Parklands, all within the framework of the Plan of Management. Access between these facilities is provided by an extensive network of walking and cycling tracks. When the Parklands were officially established in 2006 they contained an equestrian centre, shooting centre, baseball and mountain bike facilities developed for the Sydney 2000 Olympics together with motor racing venues, a city farm, sports fields and recreation areas. The Plough and Harrow recreation area was developed using funds provided by the Roads and Traffic Authority as an offset to construction of the section of the M7 Motorway that runs along the boundary of the Parklands. A commercially operated Tree Top Adventure Park allows children and adults to move through tree tops on suspension bridges up to 20 m above the ground. Lizard Log Recreation Area was developed as a major new recreation facility with opportunities for children to engage in adventure play within a playground that is integrated with the natural landscape setting of the site. Other facilities developed by the Trust include a 12 km long international standards mountain bike trail. Recreation cyclists and walkers can access the whole

length of the Parklands along the Parklands Track, which connects to the street network in areas adjoining the Parklands. The rich indigenous and non-indigenous cultural heritage of this site is being protected and incorporated into the design of the new facilities.

About 40 per cent of the Parklands remain to be developed for long-term purposes in accordance with the Plan of Management. Consequently they currently have interim land uses, such as rural residential or they remain vacant. This land bank provides the Trust with a valuable level of flexibility to respond to changing community expectations and future needs over the coming decades.

- **Ecological restoration and monitoring**

While there are no sites within the Parklands listed on the World Database on Protected Areas, there are significant areas of native vegetation that are likely to meet the IUCN definition of a protected area as 'A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.' (Dudley, 2008). These include areas of endangered vegetation communities that are protected under state and federal legislation.

Priority conservation areas identified in the Cumberland Plain Recovery Plan (NSW DECCW, 2011) that are located in the Parklands include Prospect Reservoir (325 ha), Bungarribee Precinct (137 ha), Kemps Creek Nature Reserve (129 ha), Nurragingy Reserve (90 ha) and Hoxton Park Woodlands (41 ha). In addition smaller areas of endangered vegetation communities throughout the Parklands are also protected by legislation.

Vegetation monitoring carried out on 56 sites in 2012 compared them to the baseline surveys carried out in 2008 and 2010 (SMEC, 2012). Results of the monitoring indicated that more than 70 per cent of the sites had native grass cover within or above maximum benchmark values; herbaceous (non-grass) native ground cover was below benchmark values in over 70 per cent of the sites; and in regeneration areas the biodiversity condition of the over storey was low in all vegetation types.

The Western Sydney Parklands Biodiversity Strategy 2012-2020 (WSPT, 2013) provides a framework in which the biodiversity enhancement works are carried out. While about 1,000 ha of remnant Cumberland Plain Woodland is currently managed within the Parklands, the Trust plans to double the area by 2020 to achieve the 37 per cent target set by the Plan of Management. This will involve a financial investment of Aus$10 million together with the participation of community volunteers and corporate groups to assist with tree planting and maintenance of native vegetation areas.

A current planting programme involves the Trust providing bus transport between schools and the Parklands for students and young people who are engaged in ecological restoration work. Planting of indigenous vegetation by the students is not only expanding the extent of native vegetation but also fostering a sense of engagement and attachment with the Parklands as well as enjoyment of nature. These ecological restoration works are consistent with the Cumberland Plain Recovery Plan (NSW DECCW, 2011).

Funding sources for biodiversity enhancement projects currently include: revenue from commercial activities of the Trust through leases and licences that will provide Aus$500,000 per annum for ecological restoration until 2018; bio-banking and biodiversity offsets; government grants that include funding from the Commonwealth Biodiversity Fund to 2018 and short-term funding from the Catchment Management Authority.

Partnerships have been established between the Trust and education and training institutions as well as NGOs that provide training and 'transition to work' for unemployed and special needs groups via social procurement contracts.

- **Economic sustainability**

A key aspect of the economic sustainability of the Parklands is the capacity of the Trust to generate revenue and manage its own budget. This allows the establishment of a sustainable income stream to fund operations and invest in the development of new facilities and infrastructure. In 2012-2013 the total revenue of the Trust was Aus$24.7 million (NSW State Government, 2013a), which included: income from the Office of Strategic Lands (Aus$11.77 million that was the Trust's 25 per cent share of land sale proceeds provided in accordance with Government decisions made when the Trust was established); grants and contributions (Aus$5.9 million); rental income (Aus$2.5 million); compensation for infrastructure easements (Aus$2.1 million); and bio-banking Trust Fund Interest (Aus$0.24 million).

Expenses in 2012-2013 were Aus$9.1 million and the Trust held financial assets valued at Aus$22.46 million. Other assets included land and buildings (Aus$489 million); infrastructure systems (Aus$41.4 million);

Plough & Harrow pond and wildlife observation deck © Noel Corkery

environment and natural assets (Aus$2.1 million) and plant and equipment (Aus$0.78 million). The Trust facilitates public and private investment for the development and promotion of sport, recreation and tourism in the Parklands. By managing its own commercial activities and making land available for lease to private organizations, the Trust is able to achieve economic sustainability.

- **Management research and monitoring**

Management of the Parklands continues to be informed by ongoing research and monitoring. This includes user surveys and a focus on human health and wellbeing. Results of the research are providing a new perspective on the role of the Parklands by confirming the benefits they deliver to community health and wellbeing (Marshall & Corkery, 2009).

The Parklands provide a very relevant example of how to combine recreation facilities and health benefits together with the protection and management of biodiversity values within a large urban park. Opportunities and facilities for individuals to improve physical, emotional and spiritual health are provided throughout the Parklands. Given the very large scale of the Parklands these benefits are delivered in a diverse range of spatial and environmental settings.

Total visitation to the Parklands reached 3.5 million in 2014. This included visitors to various commercial recreation facilities that include a water play park, motor raceway, equestrian centre and sports fields. Annual surveys carried out by the Trust indicate that visitation to the picnic facilities, walking/cycle tracks and other informal recreation opportunities throughout the Parklands has increased by 20 per cent every year since 2007, reaching more than 1.3 million visitors in 2013-2014 (NSW State Government, 2013a). The surveys also show that visitors: represent diverse multicultural backgrounds; mostly come from local areas surrounding the Parklands; generally travel by motor vehicle to the Parklands; are predominantly between 20 and 40 years of age; mostly come to the Parklands on a regular basis, between two and 12 times a year; and predominantly engage in picnics and barbecues in groups of 10 or more, usually with family members and/or friends.

These user profile findings are consistent with the results of research carried out on visitors to the Georges River National Park located approximately 20 km south east of the Parklands (Byrne & Goodall, 2013).

In promoting diverse uses throughout the Parklands, the Trust is placing increased focus on health and wellbeing benefits working in partnership with other agencies and

user groups that include NSW Health. Community engagement involving consultation and programmed events is providing an effective means of raising awareness of the benefits that can be gained from a balance between human needs, economic factors and biodiversity values.

- **Future directions**

The Trust will respond to a range of factors that will influence future development and management of the Parklands. These include urban development in areas adjoining the Parklands, particularly the two major growth centres located at each end of the Parklands' corridor that will significantly increase the number of visitors. Development of additional facilities will be required to increase the capacity of the Parklands to accommodate the higher level of usage while protecting the cultural and biodiversity values.

The proposed second Sydney international airport development together with major new transport infrastructure required to service it, will have significant implications for the Parklands. Aircraft noise is likely to impact users of the Parkland while the airport and overflying aircraft will be visible from within the Parklands.

Although a sound funding structure is being established by the Trust, it has the potential to be impacted by broader economic factors beyond the control of the Trust. The risk associated with these factors will be reduced by diversifying revenue sources over time.

Community engagement will become increasingly significant as urban development occurs in areas adjoining the Parklands and the diversity of user groups broadens. The level of community engagement is expected to expand in relation to cultural and environmental issues that include education, food production, markets, arts, performances and festivals. Another aspect of community engagement will be the opportunity for the Trust to interact with professional and non-profit organizations. These include landscape architects, ecologists, horticulturalists, recreation planners, artists, archaeologists, heritage advisors, property development and asset managers. Such engagement will broaden and deepen the knowledge and understanding that the Trust can draw upon in relation to integration of sustainable development and biodiversity conservation. Engagement with these organizations may also assist the Trust to address political issues such as proposed new legislation or amendments to existing legislation that have implications for management of the Parklands.

CONCLUSION

This paper makes the argument for greater recognition of the need to incorporate sustainable development principles into the planning, design, development and management of large urban parks to achieve a balance between the conservation of biodiversity and provision of public recreation and cultural facilities.

Western Sydney Parklands provides a model for the retention and management of biodiversity values within large urban parks located near a major city. A key lesson to be taken from the creation of the Parklands includes the importance of establishing a sound management structure. The Trust is a corporate structure in which revenue is generated and invested in development and management of the Parklands in accordance with objectives clearly articulated in legislation and the Parklands Plan of Management. The Parklands also demonstrate the importance of flexibility within a well conceived management strategy to allow adaptation to changing social and economic context while maintaining a strong commitment to an agreed management vision. Planning and development of a programme of uses and facilities throughout the Parklands is an ongoing process that requires guidance from an agreed set of clearly articulated goals and procedures. Preferred activities and facilities are regional in nature and take advantage of the unique character of the site on which they are located. The Parklands provide an excellent venue for long-term research and monitoring that involves collaboration between the Trust, academic institutions and other organizations and authorities. The value of user surveys has been demonstrated by identifying the profiles of different user groups and understanding their needs and expectations as input to the planning and design of facilities.

A significant aspect of the Parklands development has been the key role played by landscape architects in contributing to the successful development and management of the Parklands, commencing with preparation of the Management Vision and Plan of Management and continuing through the design of award winning new facilities. This contribution includes the current Trust Director and a significant number of the management team.

The Parklands provide many valuable lessons for the establishment and management of large urban parks that incorporate areas of high biodiversity together with recreation and cultural facilities. These lessons begin with the importance of thoroughly understanding the bio -physical, cultural, social, economic and ecological context of the park as the basis for defining a clear vision

Bungarribee recreation area walking track © Noel Corkery

for its planning, development and management. Defining such a vision needs to draw on a diverse range of expertise and perspectives in an open and creative process. Translating the vision into the creation of a viable urban park requires not only perseverance but also the application of sustainable development principles to achieve a balance between social/cultural, environmental, ecological and economic values.

To achieve such a balance demands a management structure that incorporates diverse but complementary skills together with the statutory authority to generate revenue and directly manage a budget. A significant degree of flexibility is also required to allow urban park managers to respond to evolving circumstance together with new information gained from monitoring and research. Ongoing discussions and exchange of ideas and information will ensure the knowledge gained from the Western Sydney Parklands is available to assist others involved in the sustainable development and management of large urban parks in other cities.

ENDNOTES

[1] The term 'parklands' is used to denote that this contiguous land comprises multiple landscapes that form a series of connected parks and conservation areas that are managed by one authority.

[2] The Western Sydney Parklands Plan of Management can be accessed at: www.westernsydneyparklands.com.au/assets/Uploads/244.pdf

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Noel Corkery is Managing Director of Corkery Consulting, urban design and landscape architecture consultants. He is a Registered Landscape Architect, Fellow and Past National President of AILA, with qualifications in Landscape Architecture (Cornell), Forestry (ANU), Business Administration (AGSM) and Cross-disciplinary Art & Design (UNSW). Noel has over 30 years of project experience throughout Australia and Asia, managing multi-disciplinary teams and applying his expertise in landscape analysis, visual assessment, master planning, urban design, landscape design of parks, open spaces, infrastructure and site restoration. Noel led the project team that prepared the Western Sydney Regional Parklands Management Vision and Concept Plan Options.

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RESUMEN

La importancia de los grandes parques urbanos en la conservación de la biodiversidad es reconocida de manera cada vez más amplia. Por cuanto muchos parques urbanos grandes contienen zonas extensas que cumplen con la definición de "área protegida" de la UICN, es imperativo protegerlos de las amenazas que suponen tanto los usos de recreación más intensos como el amplio abanico de repercusiones ambientales. Los principios del desarrollo sostenible aplicados a la gestión de los grandes parques urbanos pueden lograr un equilibrio entre la protección de los valores de la biodiversidad y la creación de oportunidades para que los visitantes puedan disfrutar, apreciar e interactuar con la naturaleza. Este documento presenta un poderoso argumento en defensa de un mayor reconocimiento de la necesidad de incorporar los principios del desarrollo sostenible en la planificación, diseño, desarrollo y gestión de los grandes parques urbanos con el fin de lograr un equilibrio entre la conservación de la biodiversidad y la amplia gama de otros papeles y funciones que deben desempeñar. Las 5280 hectáreas de parques de la región de Sídney occidental aportan experiencias valiosas sobre cómo se pueden aplicar los principios del desarrollo sostenible para proteger y gestionar los valores de la biodiversidad al tiempo que se ofrece una amplia gama de instalaciones de esparcimiento para satisfacer las necesidades de una población en rápido crecimiento en la parte occidental de Sídney. Estos parques también demuestran un modelo de sostenibilidad económica que podría ser de interés para otros grandes parques urbanos situados en grandes ciudades.

RÉSUMÉ

Le rôle important des grands parcs urbains pour la conservation de la biodiversité est de plus en plus largement reconnu. De nombreux grands parcs urbains comportent des zones considérables qui répondent à la définition de l'UICN de «zone protégée», et il existe un besoin urgent de gestion pour les défendre contre les menaces posées par une utilisation récréative plus intense et par toute une série d'impacts environnementaux. En appliquant les principes de développement durable à la gestion des grands parcs urbains, il est possible de parvenir à un équilibre entre la protection des valeurs de la biodiversité et les opportunités pour les visiteurs de profiter de la nature et de l'apprécier. Ce document met en avant le besoin d'une plus grande reconnaissance de la nécessité d'intégrer les principes de développement durable dans la planification, la conception, le développement et la gestion des grands parcs urbains, afin d'atteindre un équilibre entre la conservation de la biodiversité et le large éventail d'autres rôles et fonctions qu'ils sont tenus d'effectuer. Le parc à l'ouest de Sydney (Western Sydney Parklands) qui s'étend sur 5280 hectares, fournit de précieuses leçons sur la façon dont les principes du développement durable peuvent s'appliquer à la protection et à la gestion des valeurs de biodiversité, tout en offrant une vaste gamme d'installations de loisirs pour répondre aux besoins d'une population en croissance rapide dans l'ouest de Sydney. Ce parc constitue un modèle de durabilité économique qui pourrait être utile à d'autres grands parcs urbains situés dans les grandes villes.

RAPID ASSESSMENT OF MANAGEMENT EFFECTIVENESS OF THE ZHANGYE NATIONAL WETLAND PARK, GANSU PROVINCE, PEOPLE'S REPUBLIC OF CHINA

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ABSTRACT

A rapid assessment of management effectiveness was undertaken for the Zhangye National Wetland Park, a small, remote protected area in Gansu Province, the People's Republic of China (PRC). During site visits and a workshop with park personnel in 2011, park management activities were documented and the first baseline score of management effectiveness was derived. The park exhibits similar trends to many other protected areas in the PRC and globally, with legal establishment, design and objectives, and economic benefits reported as management strengths, and budget security, monitoring and evaluation, and law enforcement reported as management weaknesses. Specific challenges for the park include a need to balance the development of tourism infrastructure with biodiversity conservation, and to develop quantitative management targets linked to conservation objectives.

Key words: wetland, park management, METT, Zhangye, Gansu, China

INTRODUCTION

Protected areas are a principal tool in most national strategies to conserve biodiversity, yet many are ineffectively managed (Leverington et al., 2010). Assessing the management effectiveness of a protected area is a critical element towards achieving responsive, pro-active management, and is defined as evaluating 'the extent to which management is protecting values and achieving goals and objectives' (Hockings et al., 2006: xiii). The People's Republic of China (hereafter 'PRC') has at least 2,697 protected areas, covering 146.3 million ha (MEP, 2014), but few published assessments of management effectiveness are available. Notable exceptions are three studies (Ervin, 2003; Quan et al., 2009, 2011; Xu et al., 2012) which examine trends in management performance in multiple protected areas (ranging from 88 to 535), and reviews for individual protected areas (e.g. Zhou & Grumbine, 2011; He et al., 2012). These studies identified strengths and weaknesses in protected area management and highlight the need for review of the PRC's other protected areas. This paper describes the first assessment of management effectiveness for a small protected area in western PRC, the Zhangye National Wetland Park (ZNWP).

STUDY AREA

National Wetland Parks (NWPs) are multiple-use protected areas managed for ecological and human benefit (State Forestry Administration, 2010). The ZNWP (N38°57'41''–N39°02'27'' E100°24'30''–E100°28'53"; 4,602 ha; elevation 1,440–1,474 m), is located in the municipality of Zhangye City, Gansu Province, and was established in 2009 (ZCG, 2009). It is situated along the Heihe, the PRC's second longest inland-draining river, beside a city of over 0.5 million residents (ZCG, 2010). The river is bordered by arid plains, sand dunes, and rocky gorges, and supports restricted wetland habitats and internationally significant biodiversity, including migratory waterbirds (ZCG, 2010; Bezuijen, 2013). The region is part of the historic Silk Road trade route and has been inhabited for many centuries. Recent industrial and agricultural development has resulted in declining water tables, vegetation dieback, pollution, and salinization (Qi & Luo, 2006). The ZNWP was designated for wetland rehabilitation, biodiversity conservation, and ecotourism (ZCG, 2009). It comprises an 'inner' (695 ha) and 'outer' (3,907 ha) area (ZCG, 2009), both modified by long-term human activities. The inner area supports

'Inner area', Zhangye National Wetland Park, People's Republic of China. Top left: Restored reed beds *Phragmites* on former farmland (summer). Top right: Constructed lake, access road, and tourism complex. A culvert and sluice gate (foreground) regulate water flow from the lake to the adjacent wetland. Bottom left: Elevated boardwalk within dry reed beds and woodland (winter). Bottom right: Education centre, under construction 2011 © ADB/Mark R. Bezuijen

large restored beds of reeds *Phragmites* and reedmace *Typha*, woodland, agricultural land, and constructed lakes connected by water channels (see pictures above). The inner area previously supported small settlements, but from 2009–2011 these were relocated to the outer area. The outer area encompasses 9 km of the Heihe, here a shallow, braided channel 100–400 m wide, with agricultural land, woodland, townships, and roads (see pictures overleaf). In 2013, about 20 settlements with <50,000 people were present in the outer area. The ZNWP partly overlaps with another protected area, the Gansu Zhangye Heihe Wetland National Nature Reserve (41,164 ha), which extends further north along the Heihe (ZCG, 2010). The ZNWP is generally equivalent to an IUCN Category V protected area ('protected landscape'; Dudley, 2008: 20–21), based on its modified nature, multiple-use objectives, and scenic value.

METHODS

Information on the ZNWP was collected during site visits and discussions with park agencies in July and October–November 2011. River dimensions and the extent of park infrastructure in the inner area were estimated from Google Earth satellite imagery. A one-day workshop (3 November) was held in Zhangye City to derive a baseline score of management effectiveness, using the Management Effectiveness Tracking Tool (METT) (Stolton et al., 2005). The METT comprises 30 core questions, each scored from 0 (poor) to 3 (excellent), and six supplementary questions, each scoring up to one point (Stolton et al., 2005). Although many protected area assessment methodologies are available, the METT was selected due to the limited need for training, ease of replication, and low cost (no specialized equipment required). It has also been applied elsewhere in the PRC (e.g. Quan et al., 2011). The workshop was facilitated by the author and attended by 16 park staff including the vice-director. Due to time constraints, a larger workshop involving local communities and other stakeholders could not be organized. Questions were scored by the staff through group discussion and consensus. One question (*Do indigenous and traditional peoples resident or regularly using the protected area have input to management decisions?*) was excluded, as no indigenous groups occur in the ZNWP. In total 35 questions, including all supplementary questions, were answered, yielding a maximum possible score of 93 points (100 per cent).

RESULTS

- **Park establishment and management**

The ZNWP is managed by a municipal committee with representatives from the ZNWP Construction and Management Committee, Zhangye Binhe New District, and Ganzhou Wetland Bureau. Other bureaus, including forestry, environmental protection, and land resources, give input to park management. For park designation, baseline surveys of ecology and hydrology were conducted (2007–2008) and a 10-year (2009–2018) park master plan was prepared (ZCG, 2009). The plan articulates a vision ('to establish the park as the identity of Zhangye City, promote the culture of the Heihe basin, promote education and research, and establish a masterpiece of ecotourism') and objectives ('to protect and utilize wetlands, improve wetland ecological function, and enable scientific research and education') for the ZNWP (ZCG, 2009). From 2009–2011, management focused on the development of tourism facilities and wetland protection in the inner area. By 2011, three tourism complexes, three lakes and linking canals, three park entrances and car parks, viewing pavilions, 21.8 km of access roads, and 4.8 km of boardwalk had been constructed; visitor signs and trails, resting points, portable toilets, electric tour cars and bicycle hire had been installed; and guided tours by trained local guides were available (MRB pers. obs.). Entry to the park is free. Wetland protection initiated included: a 'farmland to wetland' restoration programme (by 2011, at least 80 ha of reed beds had been established); installation of concrete boundary markers and signs; and, routine safety patrols by local police. Approximately 172 staff (22 permanent and 150 temporary, the latter mainly construction workers) had been employed. In 2011, the park received 300,000 visitors; by 2014, this had increased to 550,000 per year (ZNWP committee in litt.). The park is described by local agencies as a 'green lung' for Zhangye City, and which helps improve water and air quality, water retention, and benefits for society.

In 2011, the government also designed a five-year project to support implementation of the park master plan. The project comprises three components, 'wetland protection' (construction of watch-towers, guard posts, offices for research, monitoring and education, and remaining boundary delineation; staff training; community outreach programmes; wetland monitoring), 'restoration' (rehabilitation of 1,480 ha wetlands in the outer area), and 'sustainable economic development' (more tourism facilities in the inner area – viewing pavilions, kiosks, car parks, public toilets, and another 11 km of roads and 4 km of boardwalk). The project began in 2013 and is partly supported by a loan from the Asian Development Bank.[1]

- **Threats**

No systematic threat assessment was conducted for this study. Water supply from the Heihe is the critical basis for the wetland ecological function and tourism values of the ZNWP, but has been reduced by upstream dams and barrages and intensive water extraction for agricultural, domestic and industrial use. The latter has resulted in depressed water tables near the park (ZCG, 2009). Water quality is impacted by the discharge of untreated industrial effluent from nearby factories, and the extensive use of agricultural chemicals for farming within and near the park (ZCG, 2009). In the outer area, population growth and construction of residential buildings is causing increasing pressure on wetland habitats. Some management actions also present a risk to the park. In 2011, park tourism infrastructure occupied 17-24 ha of the inner area (2.5–3.4 per cent) and another 68 ha (9.8 per cent) is planned (total 85–92 ha; 12–14 per cent): a large footprint for this small area. This does not account for indirect construction impacts such as local changes in hydrology and vegetation. Roads in the inner area constructed perpendicular to the natural direction of water flow have caused water logging and woodland dieback (MRB pers. obs.). The partial overlap of the ZNWP with another protected area (see Study Area) has institutional implications, yet is not mentioned in the ZNWP master plan. Workshop participants listed the two greatest threats to the ZNWP as climate change ('reduced water supply') and unregulated water extraction by local communities.

- **Management effectiveness in 2011**

A score of 67 per cent management effectiveness was derived for the ZNWP. Scores assigned by workshop participants were '1' (N=6), '2' (N=18) and '3' (N=5) for core questions and '0.5' (N=1) and '1' (N=5) for supplementary questions (Table 1). No question was scored zero. Activities that scored lowest (and the reasons given) were *law enforcement* ('limited staff capacity'), *boundary delineation* ('incomplete', 'low community awareness of boundaries', 'markers not durable'), *stakeholder opportunity to influence the management plan* ('limited community input'), *current budget* ('inadequate'), *security of budget* ('dependent on insecure fund sources'), *equipment* ('insufficient'), and *visitor facilities* ('inadequate'). Actions scored highest were *legal status* ('park is gazetted'), *regulations* ('are being implemented'), *resource management* ('ecological values are being protected'), *commercial tourism* ('excellent cooperation with operators'), and *economic benefit* ('most employees are from local communities'). Positive examples of management cited were the closure of two factories that were discharging effluent into the ZNWP, the conversion of farmland to reed beds, and

employment of local residents. Challenges cited were a skewed management focus toward the inner area, dealing with agricultural non-point source pollution, and limited funding. Important management activities were stated as maintaining the security of water releases from upstream dams, construction of a water storage dam within the park, and increasing the management effort in the outer area.

DISCUSSION

This study provides a baseline score of management effectiveness for the ZNWP, two years after park establishment. The baseline score (67 per cent) reflects the considerable management efforts undertaken between 2009 and 2011, when a functioning management framework was established. It may also indicate some over-scoring; nearly one-third of questions (N=10; 29 per cent) were assigned maximum scores and most (N=28; 80 per cent) were scored moderate or higher (Table 1). Three questions about adaptive management and monitoring were assigned maximum scores (7b–c, 11; Table 1), yet monitoring programmes for water and biodiversity, quantitative management targets for conservation and tourism, and feedback mechanisms, had not been implemented at the time of assessment. Reasons for over-scoring may be numerous, including the challenge of translating technical discussions, knowledge gaps, differing perspectives, group consensus rather than individual scoring, as well as bias. Park managers may be a valuable source of information about the sites they manage (Cook et al., 2014), and the ZNWP personnel were clearly familiar with local management issues. Nonetheless, the lack of involvement of other park stakeholders, especially communities (see Methods), is a key limitation which may have contributed to the high scoring, as demonstrated by studies elsewhere (e.g. Carbutt & Goodman, 2013).

Key areas of concern revealed by the study were (i) heavy management bias toward one portion of the park, the inner area, despite the outer area being over five times larger and supporting the largest habitats and human populations, (ii) potentially excessive tourism infrastructure development in the inner area, (iii) lack of quantitative management targets, (iv) lack of environmental monitoring programmes and feedback mechanisms for management, and (v) institutional overlap with another protected area. National regulations for NWPs require that economic development is sustainable (State Forestry Administration, 2010), yet the sustainability of infrastructure development in the inner area, and continuing population growth in the outer area, is unclear. Against the ZNWP 'vision' and 'objectives' (Results), the park's tourism infrastructure may fulfil the goals for tourism and education, but unless closely managed, could be counter-productive for biodiversity and wetland protection.

The ZNWP management score of 67 per cent is high compared with a mean score of 52 per cent for 535 other protected areas in the PRC assessed using the same method (Quan et al., 2009). Similar to these other protected areas, the ZNWP scored higher in resource management and lower in community input to management, budget, and equipment needs. In contrast, in the ZNWP, progress with boundary delineation was scored low, and management systems and regulations were scored high (Table 1), the opposite of findings by Quan et al. (2009, 2011). Compared with the management performance of two other protected areas in different geographic settings, the Yellow River Delta National Nature Reserve (a coastal wetland in eastern PRC; He et al., 2012) and Pudacuo National Park (a forested mountain region in south-western PRC; Zhou & Grumbine, 2011), the ZNWP showed similar trends, with most government attention focused on tourism, limited or no biodiversity monitoring, incomplete boundary demarcation, and/or the possibility that some economic development may not comply with protected area regulations. Elsewhere in the PRC, unregulated mass tourism and infrastructure (Li & Han, 2001; Ervin, 2003; Xu et al., 2012) and overlapping jurisdictions with other land tenure (Kram et al., 2012) are symptomatic of many protected areas, and have resulted in impacts to biodiversity (e.g. Shen, 2011). Such issues are of particular concern for wetlands in the PRC, where the area of protected natural wetlands is declining while the area of protected artificial wetlands is increasing (Zheng et al., 2012). Globally, findings for the ZNWP are mostly similar to world-wide trends for protected areas, with legal establishment, design and objectives, resource inventory, and economic benefits reported as management strengths, and budget security, monitoring and evaluation, and law enforcement reported as management weaknesses (Leverington et al., 2010).

Prior to the workshop, ZNWP personnel were unaware of global methods to assess management effectiveness, and the study provided the opportunity for informal training. Limitations of the METT were discussed, including its limited scope, subjective nature of some questions, and the lack of explicit links between management effectiveness and conservation outcomes (Stolton et al., 2005). The workshop illustrated the strength of the tool for facilitating discussion and identifying perspectives, yet the over-scoring of some questions also indicated some weakness for objective assessment. Based on the

Table 1. Baseline scores of management effectiveness for the Zhangye National Wetland Park, Gansu Province, People's Republic of China, applying the METT (Stolton et al., 2005).

Variable	Max. score	Score 2011	Comments – workshop participants
Legislation and regulations	**6**	**6**	
1. Legal status - does the park have legal status?	3	3	Yes
2. Park regulations - inappropriate activities (e.g. poaching) controlled?	3	3	Regulations being implemented
Enforcement	**3**	**1**	
3. Law enforcement - can staff enforce park rules well enough?	3	1	Hindered by limited resources
Management planning	**18**	**11.5**	
4. Park objectives - have objectives been agreed?	3	2	Objectives are only partly implemented
5. Park design - park need enlarging, corridors, etc to meet its objectives?	3	2	Park design could be improved
6. Park boundary demarcation - boundary known and demarcated?	3	1	Incomplete. Low community awareness
7. Management plan - is there a plan and is it being implemented?	3	2	Little management in outer area
a. Can stakeholders influence the management plan?	1	0.5	District agencies review master plan
b. Is there an established schedule/process for review and updating the plan?	1	1	Plan is 'regularly' reviewed
c. Results of monitoring, research and evaluation incorporated into planning?	1	1	Resulted in closure of two factories
8. Regular work plan - is there an annual work plan?	3	2	Yes, but not fully implemented
Information, research and data requirements for management	**9**	**7**	
9. Resource inventory - is there enough information to manage the area?	3	2	Baseline data available, but no new research
10. Is there a programme of management-orientated survey and research work?	3	2	Limited current research
11. Resource management - is the park adequately managed?	3	3	
Staff numbers, training and management	**9**	**6**	
12. Staff numbers - are enough people employed to manage the park?	3	2	Insufficient staff for outer area
13. Personnel management - are the staff managed well enough?	3	2	
14. Staff training - is there enough training for staff?	3	2	
Budget	**9**	**4**	
15. Current budget - is it sufficient?	3	1	
16. Security of budget - is the budget secure?	3	1	
17. Management - budget managed to meet important management needs?	3	2	More allocation for staff training required
Equipment	**6**	**3**	
18. Equipment - is equipment sufficient?	3	1	Insufficient equipment
19. Maintenance of equipment - is equipment adequately maintained?	3	2	
Working with stakeholders and the general public	**20**	**14**	
20. Education and awareness - is there a planned education programme?	3	2	Programmes for TV, radio, schools planned
21. State and commercial neighbours - co-operation with adjacent land users?	3	2	'Good' co-op with townships, industry
22. Indigenous people - have input to management decisions?	N/a	N/a	None in park - question excluded
23. Local communities - have input to management decisions?	3	2	Village leaders participate in decisions
a. Open communication and trust between community and park managers?	1	1	Relocated residents were compensated
b. Are programmes to enhance community welfare being implemented?	1	1	Residents involved in park management
24. Visitor facilities - are they good enough?	3	1	Insufficient to meet expected demand
25. Commercial tourism - do operators contribute to park management?	3	3	ZNWP assists operators for park visits
26. Fees - if applied, do they help park management?	3	2	Yes - supports park management
Condition and access assessment	**7**	**5**	
27. Condition assessment - park being managed consistent to its objectives?	3	2	
a. Active restoration programmes for degraded areas in park and/or buffer zone?	1	1	
28. Access assessment - is access/resource use sufficiently controlled?	3	2	Insufficient patrol of outer area
Economic benefits to local communities	**3**	**3**	
29. Economic benefit assessment - does the park benefit communities?	3	3	Most park staff are from local communities
Monitoring and evaluation (M&E)	**3**	**2**	
30. Are management activities monitored against performance?	3	2	'Some' monitoring but is irregular
Total score	**93**	**62.5**	

'Outer area', Zhangye National Wetland Park, People's Republic of China. Top left: Heihe river and adjacent cultivation (mainly corn) and riparian corridor. Top right: Farmland, with inset showing fertilizer applied to crops, a key source of non-point source pollution to local water quality. Bottom left: New residential construction. Bottom right: Industrial complex at eastern border of the park © ADB/Mark R. Bezuijen

workshop and study outcomes, the following recommendations were identified for the ZNWP: (i) initiate regular (e.g. annual) participatory assessment of management effectiveness, (ii) conduct a systematic threat assessment, to help link METT outcomes to conservation outcomes, (iii) increase management efforts in the ZNWP outer area, particularly for wetland restoration, tourism, and land planning, (iv) implement monitoring programmes for water resources and biodiversity, and (v) clarify the institutional and management links between the ZNWP and an overlapping protected area. Most of these points remain pending, although since 2011, awareness raising activities have been conducted and a water quality monitoring programme began in 2014.

ENDNOTES

[1] www.adb.org/projects/44020-013/main
ADB recognizes 'China' as 'the People's Republic of China.'

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RESUMEN

Se acometió una evaluación rápida de la eficacia en la gestión del Parque Nacional del Humedal Zhangye, una pequeña zona remota protegida en la provincia de Gansu, República Popular de China (RPC). Durante las visitas y un taller con personal del parque en el año 2011, se documentaron las actividades de gestión del parque y se obtuvo la primera base de referencia sobre la eficacia de la gestión. El parque exhibe tendencias similares a muchas otras áreas protegidas en la RPC y en el mundo, consignándose la constitución legal, el diseño y objetivos, y los beneficios económicos como fortalezas de gestión, y la seguridad presupuestaria, el monitoreo y evaluación, y la aplicación de la ley como deficiencias de gestión. Entre los desafíos específicos para el parque se incluye la necesidad de equilibrar el desarrollo de la infraestructura turística con la conservación de la biodiversidad, y de formular objetivos cuantitativos de gestión vinculados a los objetivos de conservación.

RÉSUMÉ

Nous avons entrepris une évaluation rapide de l'efficacité de gestion au parc nationale de Zhangye, une petite zone humide protégée et isolée dans la province de Gansu, au République Populaire de Chine (RPC). Lors de visites du site et d'une réunion de travail avec le personnel du parc en 2011, nous avons examiné les méthodes de gestion et sommes parvenus à un premier résultat qui sert de base pour mesurer son efficacité. Les orientations de ce parc sont en de nombreux points similaires aux autres aires protégées de la République Populaire de Chine, et dans le monde. Il en sort des points forts tels la conformité de sa constitution, de sa conception et de ses objectifs, ainsi que ses avantages économiques, et puis des faiblesses de gestion tels le manque de maîtrise de son budget, de la surveillance et de l'évaluation, ainsi que dans l'application de la loi. Ce parc présente des défis notamment autour de l'infrastructure touristique face aux besoins de conservation de la biodiversité, et du développement d'objectifs quantitatifs liés à ses objectifs de conservation.

FINDING SPACE FOR WILDLIFE BEYOND NATIONAL PARKS AND REDUCING CONFLICT THROUGH COMMUNITY-BASED CONSERVATION: THE KENYA EXPERIENCE

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ABSTRACT

Protected area coverage has expanded rapidly in the last few decades and is set to span 17 per cent of the world's terrestrial area by 2020. Despite the conservation gains, biodiversity is declining and human-wildlife conflict (HWC) is increasing, especially in Africa. Recognizing that vertebrates require far more space than the protected areas cover and that most biodiversity resides in human-modified landscapes, conservation efforts are turning to rural landscapes. Biodiversity conservation in rural lands hinges on landowners accommodating wildlife, and resolving HWC that undermines their willingness to conserve. We look at policies and practices embedded in community-based conservation in Kenya that address HWC through devolved rights and responsibilities for wildlife management dating from the 1970s, drawing on lessons from traditional practices rooted in coexistence.

Key words: human-wildlife conflict, Kenya, community-based conservation, protected areas policy and practice

INTRODUCTION

The loss of wildlife and natural habitat over the last century has been tempered in part by growing sensibilities for nature, the birth of environmental sciences, national conservation policies and a widening variety of land use practices. The modern conservation movement spawned by environmentalism in the early 20th century was founded on setting aside protected areas and sustaining open space and natural habitat for outdoor pursuits (Hays, 1999). The protected area system has shown remarkable success in expanding the terrestrial area coverage from 10 to 15.4 per cent since the launch of the World Conservation Strategy (IUCN/ WWF/UNEP, 1980; Bertzky et al., 2012; Venter et al., 2014; World Parks Congress, 2014; Juffe-Bignoli et al., 2014). In large part, the expansion has occurred by widening the early preservationist goals of parks to include a variety of other values such as economic benefits, ecosystem services and human wellbeing.

The prospects of expanding space for wildlife through coexistence in human-dominated landscapes were largely ignored in the course of the national parks movement because of the prevailing sentiment that parks should remove all human influence except tourism and research (Parker & Bleazard, 2001). The prevalent biological view that human modified areas afforded little scope for wildlife also thwarted efforts to conserve wildlife in human-dominated landscapes. HWC has, as a result, been treated as an unwelcomed and unwanted by-product of protectionist and utilization policies and tackled as an animal control problem through displacement, deterrence and destruction (Western & Waithaka, 2005). Strategies and methods that have been used to address HWC have varied depending on the species, nature, extent, intensity and impact of conflict and a variety of other social, economic and political circumstances (Nelson & Sillero-Zubiri, 2003; Madden, 2004; Woodroffe et al., 2005; Western & Waithaka, 2005; WWF, 2008).

There is now a growing recognition of the scope for conserving wildlife in the rural landscape (UNEP, 1988; McNeely & Keeton, 1995; Biodiversity in Development, 2001; Leibel, 2012; Jonas et al., 2014). Several factors contribute to the prospects for wildlife and biodiversity

Community members meet to discuss the importance of Maasai culture in conserving their livestock economy, wildlife and the health of the land © David Western

conservation beyond protected areas. They include biological sciences highlighting the need for ever larger areas and spatial connectivity to conserve viable populations; the inadequacy of protected area design and coverage; the expanded goals of conservation to protect all forms of life, ecosystem functions and ecological services; and finally a growing recognition that most biodiversity lies outside protected areas in human-modified landscapes. Whereas protected areas conserve a less altered more confined nature, the rural landscape offers great scope for a more altered largely unconfined nature (Western, 1989; Butchart et al., 2012; Jonas et al., 2014; Kullberg & Molainen, 2014; WWF, 2014). Other factors add urgency to finding space for wildlife in the human-dominated realm. They include evidence that the goals and strategies set by the Convention on Biological Diversity (CBD, 2002; UNEP, 2002) failed to halt the decline in biodiversity by focusing on the symptoms rather than causes of loss (CBD, 2010a, b); by findings that parks are also losing biodiversity and wildlife populations (Craigie et al., 2010); mapping exercises showing the majority of the biodiversity falling outside protected areas; dwindling government resources in the face of a growing raft of conservation challenges; a rising tide of democracy, rights and demands for locally-based conservation initiatives; the diversity of views and interest groups vying for their special conservation interests, and climate change.

These among other factors call for the integration of conservation and development (UN, 1992; Biodiversity in Development, 2001; MEA, 2005; IUCN, 2005; UNEP, 2012; UN, 2014), a landscape and regional approach to biodiversity conservation, and the need to address the causes of decline rooted in poverty, inequality and the lack of means and opportunity to benefit from biodiversity (Western, 1994; Mittermeier et al., 2003; Turner et al., 2012). Expanding the arena of conservation is vital to buffering protected areas from extrinsic human impact, conserving biodiversity and ecological services on a large scale and in addressing the root cause of ecosystem breakdown and species loss (IUCN, 2005; Mora & Sale, 2011; Jonas et al., 2014). Scaling up biodiversity conservation to the rural landscape also calls for minimizing HWC using principles, policies and practices that promote coexistence through expanded benefits and offsetting the losses to those living with wildlife. Key to coexistence, minimizing conflict and the need for direct control of wildlife has been the emergence and evolution of community-based conservation (CBC) and community-based natural resource management (CBNRM) in Africa (Western et al., 1994; Hulme & Murphree, 2001; Borrini-Feyarabend et al., 2004). Both have become paradigms for pluralistic, inclusive and integrative conservation approaches to winning space and a place for wildlife and biodiversity in the rural landscape.

This paper looks at the expanding policies, strategies and approaches to conservation beyond protected areas first raised at the World Parks Congress in Bali in 1982 under the rubric 'Parks for Sustainable Development'. We specifically draw on Amboseli National Park in Kenya as a pioneering effort to develop a CBC approach and look at the subsequent evolution of policies and practices aimed at devolving the rights and responsibilities for wildlife conservation and management.

EVOLVING PLURALISM AND DISTRIBUTED CONSERVATION

Although eastern Africa has retained the richest wildlife herds on Earth, most still occur outside protected areas in the pastoral regions (Western et al., 2009) and populations have fallen steeply (Ogutu et al., 2011). Conflict with rural populations has also risen sharply in recent decades (KWS, 1995a; Western & Waithaka, 2005; Okech, 2011; KWS, 2012a). The strong upsurge in pro-wildlife sentiments in Kenya, spurred by a burgeoning urban and youthful population seldom encountering wild animals, has masked the growing intolerance of rural communities gaining no benefits from wildlife and having little say in national policy (Akama et al., 1995; Western, 2001, Munira & Udoto, 2012). The focus of influential international conservation and animal rights organizations on poaching and tougher wildlife protection has further detracted attention from HWC as a serious threat to conservation (Bonner, 1993; Conover, 2002; Clarke, 2013).

The threat posed by the growing intolerance of wildlife was recognized by Daniel Sindiyo (Sindiyo, 1968), a game warden from a pastoral background. Sindiyo advocated conserving wildlife by revitalizing customary values and the skills of coexistence lost by colonial conservation policies. The earliest steps to conserve wildlife at an ecosystem scale and engage local communities in sharing the benefits was undertaken in Amboseli National Park in the early 1970s (Western, 1982). An annual grazing fee, now called Payment for Ecosystem Services (UNEP, 2008), was paid to the surrounding pastoral community commensurate for supporting the migratory wildlife herds. The community was encouraged to set up tourist accommodation on its lands to derive direct benefits and secure conservation coverage of the entire Amboseli ecosystem (Western, 1982).

An immediate measure of success of the Amboseli CBC initiative was a halt to ivory poaching that had reduced the Amboseli elephant population from 1,500 to 500 between 1972 and 1977 due to a ten-fold increase in the price of ivory (Western, 1994). Despite the continued loss of elephants in adjacent Tsavo National Park and across Kenya that saw the national population fall from 167,000 to 19,000 by 1989 when a CITES ivory ban halted the slaughter, the Amboseli elephant herd doubled over the same period. Wildlife populations grew steadily across the ecosystem following the engagement of the Amboseli communities (Western, 1994; Kioko et al., 2006).

The principle behind the Amboseli initiative was to turn wildlife from a liability to an asset for local communities in wildlife rich areas. The Amboseli experiment was adopted as national policy in 1977, aimed at expanding the protection of protected areas to an ecosystem scale and encouraging community-based conservation. Similar policies and practices became widespread across Africa and internationally in the 1980s and 1990s (Hulme & Murphree, 2001) and were promulgated by the CBD in the form of recognizing indigenous interests and equity in biodiversity conservation and benefits (IIED, 1994; CBD, 2002).

Adoption of the wildlife policies in Kenya in 1977 led to the amalgamation of the former National Parks and Game Department under the Wildlife Conservation and Management Department (WCMD), aimed at integrating wildlife conservation and management beyond park boundaries and across ecosystems. As a government department low on the development totem pole, WCMD was given a paltry subvention by Treasury and failed to arrest the steep rise in poaching, HWC and abuses of wildlife compensation claims. In 1989, WCMD was replaced by the Kenya Wildlife Service (KWS), a semi-autonomous agency under a board of trustees charged with conserving and managing parks and collecting wildlife income without reversion to Treasury.

The first steps taken by KWS were to launch a new policy framework with a strong commitment to CBC and integrated conservation planning on a national scale (KWS, 1990). A community Wildlife Development Fund (WDF) was established to support conservation and development initiatives in prime wildlife areas. Although WDF did much to promote CBC, it failed to address HWC, made worse by the repeal of wildlife compensation and by elephant populations spreading into agricultural areas in the aftermath of the ivory ban of 1989 (KWS, 2012a). Communities and politicians complained that KWS was more responsive to elephant poaching than the rising number of people killed by elephants.

To address the growing national problem of HWC, KWS undertook a countrywide public review of HWC in 1994 to understand the view of communities and stakeholders throughout Kenya on the nature and causes of conflict

Maasai herder in southern Kenya © Equilibrium Research

and to gather views on mitigation policies and practices (KWS, 1995a). The underlying principle of the recommendations in the HWC review lay in lowering the cost of conflict by raising the direct benefits communities could gain from wildlife, and by devolving the rights and responsibilities for conservation action to the lowest effective and accountable levels. Special attention was given to important wildlife areas around and beyond national parks. A Minimum Viable Conservation Area (MVCA) framework was adopted in 1997 for conserving wildlife and biodiversity nationwide and as the basis for ecosystem planning, HWC management, community engagement and integrating national parks into the wider landscape (Western & Waithaka, 2005).

To further promote protected areas, which had largely been viewed by Kenyans as tourism destinations, KWS launched a 'Parks for Kenyans' campaign in 1997 to promote citizen visitation and a 'Parks Beyond Parks' campaign to encourage local conservation initiatives outside parks and promote ecotourism (KWS, 1997). The Parks Beyond Parks campaign was bolstered by two trust funds established by the European Union, the first a Biodiversity Conservation Program (BCP), the second a Tourism Trust Fund (TTF). The funds were available on a competitive basis to communities wishing to establish and manage their own wildlife conservancies and tourism enterprises within the MVCA network. Landowner associations were free to form partnerships with tour operators, investors, NGOs, KWS or other organizations on a voluntary collaborative basis in order to set up ecotourism enterprises, hire and train community scouts and implement conservation and management plans. The underlying goal of the trust funds was to promote new collaborative ventures and innovative conservation measures. The first community wildlife sanctuary (later dubbed conservancies) was established in 1997 at Kimana, near Amboseli, based on the foundational CBC programme established around the national park.

Following the recommendations of the HWC report, KWS established a training programme for community scouts as a means of devolving security and HWC skills and management capacity to wildlife associations and conservancies. The rights and responsibilities were based on the classification of species. Endangered and threatened species remained the responsibility of KWS and KWS established a Problem Animal Management Unit (PAMU) for dealing with species beyond the scope of communities (Western & Waithaka, 2005). PAMU focused on HWC hotspots identified by national surveys (KWS, 1995b). The aim of the wildlife policy was to devolve as much opportunity and responsibility to landowners and their partners as possible, and to reduce the need for destructive animal control measures.

A detailed analysis of the outcome of the policies for reducing HWC in Kenya and winning space for wildlife beyond protected areas has been conducted by Western and Waithaka (2005). The study showed that tolerance of problem animals rose and conflict fell in response to the wildlife benefits accrued and conflict mitigation measures, leading to fewer animals killed in reprisal.

CASCADING CONSERVATION DOWNWARDS

Although KWS created an enabling environment for mitigating HWC through community engagement, the real momentum and innovation emerged from a medley

of collaborative ventures on the ground. The KWS Wildlife Development Fund (WDF) gave the initial impetus to community initiatives, but the far larger TTF and BCP funds soon replaced and far exceeded the WDF stimulus. Most grants were awarded for setting up conservancies and to ecotourism enterprises. The Parks Beyond Parks campaign was buoyed by national and community based institutions such as Ecotourism Kenya[1] and a growing number of wildlife and landowner associations. NGOs found a new conservation lease of life in supporting CBC initiatives. The national and local associations became the mainstay in building up community capacity in business enterprises, security operations and conservation planning and management.

In reality the devolution of rights and responsibility for conservation added very modestly to existing livelihoods of landowners (Homewood et al., 2009). In most wildlife areas the primary source of community livelihoods remains livestock, though small-scale farming is rising in significance in wetter regions. The opportunity to derive wildlife incomes without sacrificing their major livelihoods has seen private landowners and communities incorporate conservation enterprises into their land use practices (Waithaka, 2004). As a result, the early initiatives in setting aside small wildlife exclusive sanctuaries have given way to far larger conservancies practising rotational grazing and grass banking to sustain mixed herds of wildlife and livestock through droughts[2].

Community scouts trained by KWS initially played a vital role in giving landowner associations the capacity to patrol and protect their own wildlife and natural resources, provide security for tourists and tackle HWC that does not call on the specialized skills of the KWS's PAMU. The scouts have given communities a strong sense of control and pride in their own capacity to benefit from wildlife and ability to anticipate and manage HWC. As the number of trained scouts has grown, NGOs with the funding and requisite skills, including Big Life[3] and landowners associations such as the Northern Rangeland Trust (NRT)[4], have taken on an ever larger role in training community scouts and diversifying their functions.

A second cadre of local conservation agents, the resource assessors (RAs), has emerged from the devolution of rights and responsibilities for wildlife management and the information demands of better planning and management. The RAs draw on the role that young lale'enok Maasai scouts traditionally played in pastoral communities. The lale'enok scouts monitored all aspects of range condition, wildlife distribution and pending threats in order to make informed collective decisions on livestock deployment, health and protection. Trained by scientists attached to NGOs such as the African Conservation Centre, and community associations such as the South Rift Association of Land Owners (SORALO) [2], the contemporary RA scouts collect and feed information on rangeland conditions, opportunities and threats directly to the community for herd deployment and land use planning. Information on likely conflicts with wild herbivores and predators helps in designing strategies for HWC mitigation. The growing importance of the RAs has led to the creation of community knowledge-action centres which bring together RAs, scouts and scientists to pool, communicate and act on shared information[2].

NRT, SORALO, Laikipia Wildlife Forum (LWF)[5], the Maasai Mara Management Association and the Amboseli Ecosystem Trust (AET) are some of the many landowner associations that now play the primary role in conserving and protecting wildlife outside national parks, addressing HWC and integrated wildlife and land use planning. In an innovative step for local conservation stewardship, AET in 2014 undertook a Strategic Environmental Assessment (SEA) of an Amboseli Ecosystem Management Plan (AEMP), drawn up in collaboration with conservation partners. The approval of AEMP by the SEA process sets the stage for legal gazettement of the plan by the National Environmental Management Agency.

The CBC initiatives are matched by a national effort to map biodiversity, assess the conservation threats and opportunities, value and assess ecosystem services and set up a national framework to audit and monitor Kenya's natural capital (Kenya's Natural Capital, 2015). The national initiative will encourage and complement devolved and collaborative policies that stimulate local conservation practices, complement national parks and reduce HWC. The passage of a new Wildlife Act in 2013, in line with the Kenya Constitution 2010, explicitly devolves wildlife management responsibilities to county governments, landowners associations and their representative bodies.

THE GROWING IMPACT OF CBC

How effective has CBC been in Kenya, based on the growth of the movement and its success in engaging communities and conserving wildlife?

Measures of conservation success can be gauged by various indicators (Margoulis & Salafsky, 1998). Here we use direct measures of the success of CBC initiatives drawn from the area set aside as conservancies, wildlife

Table 1. Percentages of wildlife found in areas of differing conservation status averaged for the 1990s based on Western et al., 2009.

Conservation Status	Wildlife totals	% of all wildlife
National Parks	83,633	10
Maasai Mara National Reserve	214,045	25
Privately Protected Areas	334,263	40
Remaining populations (non-protected areas)	214,711	25
Total National Population	**846,652**	**100**

trends, and local engagement using the growth in community scouts, community-based organizations and ecotourism facilities as a measure of employment.

Since 1991, when KWS formally began promoting community-based conservation, the number of conservancies has grown from fewer than 10, all on private ranches, to 230 in 2014, most on community lands. Over the same period the area under conservancies has grown from some 100 km² to 43,600 km² (Kenya Wildlife Service, pers. com). The current area of conservancies includes 7.5 per cent of the land surface area of Kenya compared to 7.9 per cent under national parks and reserves. The growth of conservancies coincided with the levelling off of protected area set-asides (Kenya's Natural Capital, 2015) and is likely to exceed them within the next few years, based on current rates of growth. The status of wildlife in conservancies compared to national protected areas and non-protected areas is presented in Table 1.

National parks account for approximately 10 per cent of all Kenya's wildlife and national parks and reserves for 35 per cent of the total (Western et al., 2009). Private and community conservancies account for 40 per cent of all wildlife, more than all nationally protected areas combined.

Wildlife trends in national parks and reserves declined by 38 per cent over the three decades from the late 1970s (Grundbatt et al., 1995) to early 2000s, roughly matching the national decline of 41 per cent (Western et al., 2009; Ogutu et al., 2011). The only comparative data available on wildlife in private and community conservancies show most to be holding their own or increasing (Western et al., 2007).

Indirect measures also testify to the growing importance and engagement of private and community initiatives in conservation. The first 15 community scouts were established by the Amboseli Tsavo Group Ranch Conservation Association in 1991. The scouts were poorly trained and managed and proved ineffective. In 1997 KWS trained 60 community scouts at its Manyani field training centre[6], deployed them to community areas and forged close communications and operational links. The community scouts soon proved effective in combating rustlers and poachers and became a vanguard of security for communities across Kenya. The number of scouts had grown to some 2,200 by 2014, compared to some 3,000 KWS rangers on active field duty. The number of community scouts is likely to exceed KWS rangers in the next few years, supported entirely by community revenues, NGOs and multilateral agencies. The community scouts have become highly effective in combating poachers.

The growth in community-based organizations, landowner associations and national organizations also testifies to the success of CBC. Since the first CBC organization, the Kitengela Landowners Association, was established in 1990, a large number of community-based organizations (CBOs) have been established. A number of umbrella bodies such as the Kenya Wildlife Conservation Association (KWCA)[7] and the Rangelands Association of Kenya (RAK) have been set up to represent the CBOs nationally and have strongly influenced wildlife legislation.

Tourist lodges and camps on wildlife lands outside national parks provide a measure of the growth in wildlife tourism enterprises set up by communities in collaboration with the tour industry and NGOs. From the first ecotourism lodge, Ol Doinyo Uas, established in the Amboseli ecosystem in 1985, the number has since grown to 15 facilities outside the park, compared to two lodges inside Amboseli National Park. In the Maasai Mara ecosystem 140 lodges and campsites are spread across private and communal lands in the ecosystem compared to seven inside the Maasai Mara National Reserve.

DEVOLVING HWC RESOLUTION

The growth of private and community engagement in conservation bears directly on the extent and nature of HWC and on how it is viewed and managed nationally and locally. Ironically, as tolerance of wildlife grows with changing values and widening benefits, conflict increases due to greater protection, habituation and encroachment into human-dominated landscapes (Sterba, 2012). The

Over 2,500 community scouts are now deployed in protecting wildlife and averting human wildlife conflict in the 150 conservancies in Kenya © John Kamanga

intensified conflict between elephants and people following the CITES ivory ban has been well documented in Kenya (Western & Waithaka, 2005). The conflict was aggravated by a vacuum in policy for mitigating conflict and slow response times. HWC mitigation has been further hampered by a poor understanding of animal-human interactions on the one hand and, on the other, more commitment to protecting elephants from poachers than people from wildlife (KWS, 1995a; KWS 2005; KWS 2012b; Martin 2012; Capoccia, 2013). KWS has also shown reluctance to take early action on problem animals for fear of publicity backlash from protectionist groups and the media.

Devolving mitigation measures from centralized control is inevitable in view of the expanding scale and scope of wildlife conservation, deepening HWC, the shrinking capacity of government and the rising tide of democracy and rights fostering local decisions. The biggest challenge to devolved action lies in reversing decades of reliance on government to deal with HWC and the loss of traditional skills for coexisting with wildlife. With government efforts primarily devoted to control and compensation, scant attention has been given to the root cause of HWC and the skills of living with wildlife. Such skills reside in communities, not government agencies.

NGOs working in collaboration with communities have begun to fill the HWC void in light of conservation devolution and limited capacity and skills of government agencies. Kenya has seen a rapid growth in NGO and community efforts to protect threatened and endangered species by averting conflict in non-destructive ways. These include Living with Lions[8], Lion Guardians[9], Rebuilding the Pride[10], Big Life[3] and Space for Giants[11]. Increasingly, CBOs such as NRT, LWF, AET and SORALO are taking on responsibility for tackling all forms of HWC by deploying specialized scouts, engaging researchers, planning and managing land uses and developing and deploying techniques to avoid and tackle conflict. These decentralized conservation initiatives, coupled with a rising tolerance of wildlife and willingness of CBOs to suffer some losses as a *quid pro quo* for more rights and responsibilities, is leading to a better understanding of human-wildlife interactions. Such understanding is based on new methods of mapping and detecting potential threats and conflict, and using scouts and RAs to map and disseminate information on aversive measures using social media and CBO networks.

Out of necessity and opportunity, devolution of conservation rights and responsibilities is moving HWC from a one-size-fits all approach to wildlife control to

new collaborative and locally-based approaches. The Borderlands Conservation Initiative[12] for example, has forged a collaborative arrangement between government agencies, CBOs, NGOs and researchers in the 120,000 km² Tanzania-Kenya borderlands to conserve viable meta-populations of elephants and lions by connecting protected areas across community lands.

Despite such advances, HWC remains more of an afterthought than centrepiece of national conservation policies and strategies. Little attention is given to the largely traditional and rapidly disappearing skills that foster coexistence (Finger & Schuler, 2004; Vira & Kontoleon, 2010). In the concluding section we look at a few examples of traditional knowledge and practices, drawing heavily on our collective experience working within and among communities to point to a new horizon for coexistence principles rather than control as a central tenet of HWC aversion.

THE NEXT HORIZON

Understanding the perceptions of communities towards wildlife is essential for successful CBC. In general, perceptions of wildlife range from threatening to useful and neutral (Brown-Nunez & Jonker, 2008), and vary with circumstance and location. Devolving and localizing HWC mitigation calls for an understanding of coexistence and how it varies with context, species, attitudes and society (Waithaka, 2012; Weller, 1931). The varied circumstances call for pluralistic and locally adaptive solutions, rather than a uniform prescriptive approach that has typified centralized conservation policy and responses.

Little attention has been given to traditional skills of coexistence, most of which have been lost as societies have transitioned to market economies. In East Africa, pastoral communities held a mixed and varying view of species, depending on their perceived threat, utility and symbolism (Roque de Pinho, 2009; Brown-Nunez & Jonker, 2008; Goldman et al., 2010). On balance, wildlife was abundant because its benefits in complementing livestock production greatly outweighed losses. There is, however, little information in literature on the ecological and behavioural basis of coexistence, excepting some insights on the relationship between lions and Maasai (Hazzah et al., 2009; Western, 2012). We draw on our first-hand knowledge of growing up in a traditional pastoral community (JK), research and management of human-wildlife conflict (JW) and long-term research on human-wildlife interactions (DW) to highlight salient factors explaining coexistence. Losses were seen as the inevitable cost of living with wildlife that, among the Maasai, were considered as second cattle (Western, 1997) because of the many material and cultural values that were derived from wildlife. These ranged from food, to medicines, clothing, housing, weapons, environmental indicators and totems. Pastoral communities in particular saw wildlife as cohabitants of their living space and foraging range and communities used an array of techniques for averting conflict when possible and managing, deterring and controlling it when necessary. Above all, an intimate knowledge of animal movements and behaviour was crucial to sharing living space with minimum threat and loss.

Techniques for containing conflict ranged from seasonal migrations to daily herding and husbandry practices that limited threatening contact. Other techniques include, the protection of herds through vigilance, routing patterns, aggregating herds, collective guarding, night corralling, and ritual deterrents. As a last resort, threatening animals were pursued and killed, continually reinforcing the fear that high-threat species had of humans. Lions and elephants can distinguish Maasai from other peoples and show an elevated fear and escape response (JK pers. ob.). Personal responsibility for avoiding and deterring predator attacks on livestock was reinforced by group sanctions to prevent carnivores from becoming habitual killers and attacking livestock of fellow herders.

With the assumption of wildlife control by the state and prohibitions against traditional uses and deterrence, wild animals lost the many customary values they held and were regarded as government cattle (Western, 1997). HWC rose steeply once government took responsibility for wildlife protection and problem animal control, leading to a loss of traditional knowledge, the skills for coexistence and tolerance of wildlife.

Policies for devolving rights and responsibilities for wildlife use and management back to communities should therefore re-establish the underlying principles that fostered coexistence and contained HWC. They include the varied traditional values of wildlife that were sustainable and socially acceptable nationally; new values such as ecotourism and sustainable consumptive utilization; collaborative natural resource management on a scale sufficient to sustain viable wildlife populations, and conservation education, including traditional knowledge and skills for coexistence. Offsetting losses through compensation, deterrence and control should be considered within the larger context of coexistence and localized and internalized as far as possible, excepting threatened and endangered species and those calling for specialized skills.

The erosion of traditional values raises the spectre of wildlife being viewed entirely negatively (Akama & Burnett, 1995), leading to growing intolerance and deepening HWC. The negativity can, however be offset where tourism and other new wildlife values contribute significantly to livelihoods and welfare (Githaiga, 1998; Western & Nightingale, 2004; Waithaka, 2004; Homewood et al., 2009; Glew et al., 2010). Nevertheless, development of tourism and other wildlife-related enterprises and programmes is more feasible in pastoral areas than in agro-pastoral or crop farming situations due to high human populations and incompatible land use practices.

CONCLUSION

HWC has been largely ignored in policy and tackled mainly through deterrence and control by government personnel poorly trained and usually ill-equipped to respond in a timely fashion. HWC has become a focal point of interest in wildlife conservation in recent years (IUCN, 2005), spurred in part by the realization that protected areas, however vital, have limited capacity to protect all wildlife and conserve biodiversity. The necessity of, and scope for, conserving biodiversity in the human realm has drawn conservation interest in the last three decades, leading to the growth of community-based conservation (Western et al., 1994; Hulme & Murphree, 2001). Turning wildlife from a liability into an asset reduces the perception that the conservation interests of the state are at odds with primary livelihoods of communities. Devolving the rights and responsibilities for biodiversity conservation from national to local levels calls for resuscitating the incentives and skills for making wildlife an important component of livelihoods, based on maximizing the benefits and minimizing the costs and conflicts. Paradoxically, such devolution draws the focus of conservation back to the skills and methods of coexistence traditionally residing in communities which is not available to or considered by national agencies and NGOs.

ENDNOTES

[1] www.ecotourismkenya.org
[2] www.Soralo.org
[3] www.biglife.org/
[4] www.nrt-kenya.org
[5] www.laikipia.org/
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RESUMEN

La cobertura de áreas protegidas se ha expandido rápidamente en las últimas décadas y se espera que para el año 2020 abarque el 17 por ciento de la superficie terrestre del mundo. A pesar de los beneficios de la conservación, la biodiversidad está disminuyendo y los conflictos entre los seres humanos y la vida silvestre (HWC) son cada vez mayores, sobre todo en África. Reconociendo que los vertebrados requieren mucho más espacio del que cubren las áreas protegidas y que la mayor parte de la biodiversidad reside en paisajes modificados por el hombre, los esfuerzos de conservación se están desplegando hacia los paisajes rurales. La conservación de la biodiversidad en las tierras rurales depende de propietarios de tierras que den cabida a la vida silvestre y de la resolución de los conflictos HWC que obstaculizan su disposición a conservar. Consideramos las políticas y prácticas incrustadas en la conservación comunitaria en Kenia que abordan HWC a través de la delegación de derechos y responsabilidades para la gestión de la vida silvestre que datan de la década de 1970, extrayendo las enseñanzas derivadas de las prácticas tradicionales arraigadas en la coexistencia.

RÉSUMÉ

Les dernières décennies ont connu une accroissement rapide de la superficie des aires protégées et il est prévu d'ici à 2020 que ces zones atteignent 17 pour cent de la surface terrestre de la planète. Malgré ces gains de conservation, la biodiversité est en déclin et les conflits entre l'homme et l'habitat sauvage sont en augmentation, en particulier en Afrique. Conscients que les vertébrés ont besoin de bien plus d'espace que n'en offrent les aires protégées et que la biodiversité subsiste surtout dans les paysages modifiés par l'homme, les conversationnistes orientent leurs efforts vers les zones rurales. La conservation de la biodiversité dans ces zones repose sur la volonté des propriétaires terriens à accepter la faune, et à résoudre les conflits qui compromettent leur volonté de préservation. Nous examinons les règles et les coutumes de conservation observées par les communautés au Kenya qui abordent ces conflits en tenant compte de droits en matière de gestion de la faune datant des années 1970, et tirons des leçons à partir de pratiques traditionnelles enracinées dans la coexistence de l'homme et de son habitat.

OBSERVATIONS AND PRELIMINARY TESTING OF JAGUAR DEPREDATION REDUCTION TECHNIQUES IN AND BETWEEN CORE JAGUAR POPULATIONS

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ABSTRACT

Due largely to their success in undisturbed areas, the conservation of large carnivores is tied to protected areas. However, because of their large area requirements, large carnivores – and their conservation – will also always be linked to areas outside of protected areas. Retaliatory killing of jaguars near reserves and in corridors between reserves threatens to severely decrease jaguar populations in protected areas and their corridors, thus decreasing the ecological viability of protected areas for the species. Resolving this conflict will allow jaguars to utilize the human-dominated landscape, provide opportunities for corridor conservation, and enhance the effectiveness of protected areas. We review methods to reduce depredation of livestock and prevent lethal control of jaguars. Approaches to mitigate conflict include insurance schemes, management of wild prey, and above all, improving livestock husbandry and management. Improvements that are recommended for specific problem farms and ranches might include electric fencing, night enclosures, designs for newborn holding pens, the use of guard animals, and partial herd immersion of creole cattle races or water buffalo. We describe multiple testing scenarios and results from throughout Latin America for reducing livestock depredation across protected areas and agricultural landscapes.

Key words: Jaguar, carnivore conflict, livestock conflict, Latin America

INTRODUCTION

The management and conservation of large carnivores is one of the most challenging wildlife conservation issues of our time. The global decline of large carnivores is tied to the direct hunting of carnivores and their prey, along with the loss and degradation of their habitat (Nowell & Jackson, 1996; Hilty et al., 2006; Foster et al., 2010; Estes et al., 2011; Ripple et al., 2014; Rabinowitz, 2015). Whether the loss of large carnivores is direct or indirect, and whether their loss is intentional or unintentional, the effect on the communities in which they were resident can have both immediate and long-term impacts (Estes et al., 2011).

Protected areas play an important role in the conservation of large carnivore populations by supporting a wild prey base and often providing refuge from direct persecution by people. However, large carnivores range widely, often beyond the boundaries of protected areas, where they may threaten livestock and thus face increased risk of lethal control (Mills, 1991; Woodroffe & Ginsberg, 1998; Payan et al., 2013). The backlash from human residents near the protected areas in such situations can be harmful to the conservation of the carnivore population in the protected area, and it can threaten the acceptance and purpose of the protected area by local communities, who are mostly engaged in

Jaguars still occur over more than 40 per cent of their historic range, and more than 50 per cent of that range is in or within 10 km of protected areas. Retaliatory killing of jaguars, due to their killing of livestock, is one of the most important threats to jaguar existence in Latin American ecosystems © S. Winter, Panthera

economic production unrelated to conservation (Treves, 2008). The resolution of this human-wildlife conflict issue is dependent on the development of strategies to decrease the conflict that carnivores create in the landscapes surrounding protected areas. In Latin America, there is a pressing need for solutions to conflicts created by jaguars (*Panthera onca*) in the landscapes surrounding protected areas.

Jaguars are the largest felid in Latin America. They currently exist over more than 40 per cent of their historic range (Rabinowitz & Zeller, 2010), much of which is encompassed within protected areas, or near them. In fact, our analysis, using the new IUCN range map for jaguars[1] and World Database on Protected Areas (UNEP-WCMC, 2014) indicates that just over 50 per cent of jaguar range is in protected areas or within 10 km of a protected area (Petracca et al., unpublished data). Thus, for both jaguars and humans, the mutually beneficial results of reducing jaguar–human conflict in and around protected areas can affect a large portion of Latin America. The most prevalent and direct source of conflict is between jaguars and livestock producers; most jaguars are killed in retaliation for livestock depredation, or the perceived threat of it (Rabinowitz, 1984; Marchini & Macdonald, 2012; Zarco-Gonzalez et al., 2013). The losses of these jaguars – particularly those that are resident in both the protected area and the surrounding multi-use lands – threaten the integrity of the natural communities of flora and fauna the protected areas are designed to protect. Other primary reasons for jaguar loss are habitat loss and opportunistic hunting (Nowell & Jackson, 1996).

In this paper, we address the questions surrounding jaguar survival in and around protected areas, particularly those landscapes in which livestock production is an important human activity. Using preliminary data from farms currently being monitored, plus a literature review, we attempt to offer solutions to jaguar depredation questions, especially as they relate to areas near protected areas. We also address two questions: what actions can be taken to reduce jaguar-livestock conflict, and how can these actions be facilitated by protected area managers?

METHODS

This paper is a summary of depredation solutions observed by the authors on more than 120 ranch sites, ongoing research on 30 ranches (in Belize, Costa Rica, Colombia and Brazil), and supporting data from additional publications (Rosas-Rosas et al., 2008; Salom

-Perez, unpublished; Foster, 2008; Hoogesteijn & Hoogesteijn, 2014[2]). Geographic variation was not considered to be an important influence in the assessment of solution effectiveness in the depredation solution observations; however, for the current assessment of the ongoing research on 30 pilot ranches, data on rainfall, vegetation composition, and additional physical and biological characteristics are recorded.

Data were compiled through two approaches. First, observations were made on ranches with and without jaguar depredation issues; some ranches were visited due to depredation activity; other ranches were visited because they were in important jaguar areas. Second, ranches with depredation histories were selected for application of livestock management modifications. Depredation activity after these modifications was monitored. In nearly all cases specific information on ranch operations were collected (e.g. number of livestock, water sources, forested area, fencing design, etc.) and this information was related to depredation incidents and observations of the area. Prior to 2008, a large amount of the data collected was collected opportunistically. For instance, a depredation increase or decrease was associated with some aspect of livestock husbandry; additional applications of that method produced similar results, and the method was termed successful. Since 2008, 30 ranches have been assessed and monitoring of depredation has taken place in a regular and systematic fashion. At the 30 ranches experimental applications include: electrical fencing on 12 ranches, night enclosures on 22 ranches, eight separate new-born enclosures, two ranches with creole cattle and two with water buffalo. Camera traps are deployed to detect the presence of jaguars and other predators.

RESULTS

To compile observations of depredation solutions, the findings of more than 120 ranch visits over a period of nearly twenty years were combined with monitoring data from the 30 ranches. From this compilation more than a dozen ranch modifications were tested and found effective in reducing jaguar depredation or were highly correlated with reduced jaguar depredation (see discussion). Preliminary results are supported of previous works of the authors (e.g. Hoogesteijn & Hoogesteijn, 2014) and others (Rosas-Rosas et al., 2008). Although data are still being collected, the 15 farms in Costa Rica, with electric fencing and night pens, experienced no depredation during the first two years of monitoring; six farms in Belize experienced no depredation over 15 months of monitoring, with guard animals and improved fencing; night pens in 14 Brazil farms took depredation from six events to one over a period of 18 months; and four farms using water buffalo or creole breeds (Costa Rica, Colombia, and Brazil) experienced no predation from herds monitored from six months to four years. All of the above farms had experience some level of jaguar attacks prior to the application of depredation remedies.

DISCUSSION

Results from currently monitored farms display high potential for reducing jaguar depredation. Although the list of activities that help reduce depredation is an extensive one, and the list is expected to become more extensive and more detailed, below a reduced set of activities that have been found to be particularly successful is presented. These individual activities still require further testing in a variety of conditions. What works in one environment, might not work in another (for instance, in our research, guard donkeys were inexpensive and very effective in preventing jaguar depredation in Belize, but in Costa Rica they were prohibitively expensive even for testing). However, the following were tested and found effective not only in the current research, but in previous work (e.g. Salom-Perez, unpublished; Foster, 2008; Hoogesteijn & Hoogesteijn, 2014).

- **Electric fences**

One of the most important and effective tools available to prevent predation by wild felids on cattle, sheep, pigs, goats and fowl, is the use of electric fencing specifically designed to repel predator attacks; we are currently monitoring seven farms that have had no depredation over two years; all of these farms had experienced depredation losses prior to the implementation of electric fencing. The specific designs of electric fencing applications appear to effect results. Scognamillo et al. (2002) used three strands at 30, 60 and 90 cm high charged with 3,000 volts as being less effective than when the system was charged with 4,500 to 5,000 volts; eight attacks occurred in the former design and no attacks occurred in the latter design.

Until now, the use of electric fencing has not been widely used as a predator deterrent in Latin America. More often, it has been used to keep domestic animals in rather than keeping wild animals out. It is very important to note that electric fences for livestock control, with one or two strands of electrified wire, prevents cattle from moving from one pasture to another, but is not effective in preventing predator attacks. Fences must be specifically designed to prevent the entry of jaguars. They

Electric fencing, even in very rudimentary forms, can be an effective deterrent to jaguar predation on livestock © Hoogesteijn & Corrales, Panthera

are therefore particularly useful when used in smaller areas, such as corrals used as night enclosures, or smaller pastures such as those used for late-stage pregnant cows or newborn calves and their dams. Electric fences have also been used to surround all the pastures of a farm, especially when small, or around areas known to be at high predation risk.

In the Venezuelan Llanos, Scognamillo et al. (2002) initially tested a design with three strands of electric wire. An 18 ha calving paddock with a 1,697 m perimeter was surrounded with strands arranged at 30, 60 and 90 cm from the ground. Strands were charged with 2,500 to 3,000 volts. Felines were however not deterred by this design. Subsequently, an additional negative strand was

added at 85 cm from the ground, and voltage was increased to 4,500-5,000 volts. With these modifications the attacks ceased.

Another trial was conducted in the Brazilian Pantanal (Cavalcanti et al., 2011). The fence consisted of two electrified wires at 25 and 50 cm in height with a 5,000 to 7,000 volts charge. The perimeter was approximately 14 km, enclosing several pastures. The fence was regularly checked to prevent leakages of energy or faulty wiring. Additionally, the fence and sleeping areas of the herds were monitored during the night by a ranch employee equipped with a powerful spotlight and explosive deterrents. This system was shown to be effective and decreased predation losses over several years. However, the results suggested that enclosing smaller pastures might have been even more effective.

- **Night enclosures**

A very effective action in areas with intense predation is to enclose domestic animals in corrals, pens or small pastures near human habitation during night time. If the night enclosure has lights or is located near human habitation with dogs, it is even more effective. These night enclosures can also be provided with electric fencing. The animals (whether cattle, pigs, sheep or goats) are easily habituated to enter the corrals. The action reduces predation impacts significantly but necessitates a slight increase in farm labour and operating costs. This action can also enhance animal nutrition because concentrated feed and supplements can be supplied within the enclosure.

These night enclosures have been tried in different sized farms and various ecological settings. For example, in Costa Rica, in the Nairi Awari Indigenous Reservation on the Talamanca Mountains, jaguars and pumas (*Puma concolor*) attacked and consumed domestic pigs that freely foraged in the forests. When enclosed at night, there was initially a significant decrease in attacks (from several in previous years plus a jaguar killed in retaliation), to zero attacks in the final year of the project (Salom-Pérez, unpublished data). Along with the pens bio-digesters were built to produce biogas from the faeces of the animals locked-in at night. The use of biogas eliminated the need to collect firewood, thus minimizing 'wood collection time' in exchange for 'pig collection time' and can reduce forest destruction in and around protected areas. Additionally this practice had the positive side effect of reducing harmful smoke exposure from the wood stoves (Salom-Pérez, unpublished data).

- **Control of breeding and protection of young**

One critical element that can be integrated with all of the solutions presented here is the control of breeding within livestock herds. The control of breeding is an essential starting point in the reduction of jaguar depredation. Despite the fact that jaguars can kill prey much larger than themselves (including adult cattle) smaller, younger individuals are particularly vulnerable. Controlling the time in which these individuals are present in the landscape helps managers improve their safety. Conversely, if breeding takes place year round, farmers are constantly attempting to secure and care for newly-born young. With the young, vulnerable individuals presenting themselves during one particular period of the year farmers can provide more easily for their safety in a more efficient and focused manner.

The most effective management strategy is to keep calves, calves and mothers and late-pregnancy livestock in special holding pens. Holding pens should not be pastures containing forested areas or be adjacent to forested areas (Cavalcanti et al., 2011). Cows should be placed in open pasture areas, and preferably close to human dwellings. This countermeasure is easily applied in small and medium-sized ranches, especially those that are well organized and have a 3-4 months breeding season, which limits the calving season to 4-5 months in the year. Added protection can be afforded through the use of electric fencing.

In Costa Rica, a combination of night enclosures and electric fences for birthing areas eliminated predation on young calves. This work was performed in twelve small experimental farms located at the Barbilla-Destierro Biological Sub-corridor and the San Juan–La Selva Biological Corridor (D. Corrales and Panthera Costa Rica Team, unpublished data).

- **Guard animals**

Guard animals can take several forms. They can be older animals within a herd, or they can be other species that are placed in the herd to prevent attack. Preliminary data from field experiments indicates that experienced older animals (bulls, steers or older cows with horns) will often confront predators, as evidenced by marks from injuries on these animals, sustained by felids. Therefore, a certain percentage of these animals should be retained in the herd. These animals teach defensive grouping behaviour to the younger animals thus reducing predation. Tortato et al., (in press) documented this on a ranch in the Brazilian Pantanal. The ranch had high frequency jaguar and puma predation. A larger proportion of older animals in the herds diminished losses. Between January 2006 and September 2010, 73 per cent of the deaths

A young boy leads goats into an enclosure for the night. These enclosures, if used properly, can reduce jaguar predation on a wide variety of domestic livestock © Hoogesteijn & Payan, Panthera

caused by jaguars and pumas happened when the proportion of adults in the herd was lower than 60 per cent. The authors (Tortato et al., in press) point out that this is a less aggressive alternative to predator removal or relocation that produces economic benefits in herd production.

Additional protection can be provided with guard animals. Guard donkeys (*Equus asinus*), grazing with herds of cattle, have been effective in reducing jaguar predation in Belize (S. Juan, pers. comm.) due to their aggressive braying and their tendency to confront threats. This experience is being tested experimentally, with promising preliminary results in Belize (R. Foster & Panthera Belize Team, unpublished data).

- **Creole cattle**

The majority of cattle in tropical America are zebu (*Bos indicus*) pure- or cross-bred with varying admixtures of European breeds (*B. taurus*) introduced into the Americas by Europeans in the 17th Century. Although high proportions of adults, especially males, in a herd of zebu can reduce predation (see above; due to size, awareness and defensiveness), the original European breeds (e.g. Nelore breed) retained a stronger, innate defensive response to threats. For example, cows have highly defensive reactions against predators and protect their newborn from attacks while zebu breeds stampede in the presence of a predator, leaving small calves alone, disoriented and prone to attack.

Several hardy breeds of *B. taurus* are however notable for their adaptation to New World wildlife, plants, parasites, etc. and in particular to the harsh conditions of the flooded savannahs of the Neotropics. Two of these are the Creole/Criollo Llanero and the Pantaneiro breeds, in the Colombian and Venezuelan Llanos and the Brazilian Pantanal, respectively. Most of these breeds have an inherent ability to defend themselves from predator attacks (Calzadilla Valdés, 2007), and demonstrate a gregarious herd behaviour similar to the one exhibited by the Asian water buffalo (described below). Most of these breeds however do not have the good carcass conformation for meat production demanded by modern markets. Consequently, they almost disappeared.

Experimental use of these breeds is currently underway to scientifically document their predation-deterring capabilities, along with their rescue and recovery for potential use in areas of high jaguar predation. Preliminary results indicate the Creole breed effectively reduced jaguar predation in herds totally made up of Creole cattle (San Martiniero breed, Colombia; no predation over a two-year period), in herds with only a percentage of Creole cattle (San Mariniero breed mixed herds, Colombia, no predation over two-year period; Pantaneiro breed mixed herds, Brazil, no predation over one-year period), and potentially in herds of first generation crosses (F1 offspring) of Creole cattle with

zebu cattle, thus enhancing carcass and meat quality and conserving the defensive traits. This latter experiment is still underway, attempting to produce increased meat production while observing if anti-predation behaviours are retained. First-generation offspring are displaying defensive behaviours when approached; depredation on these individuals, in paired comparisons with zebu breeds, will measure differences in field conditions.

- **Water buffalo**

The Asian water buffalo (*Bubalus bubalis*) originates from Southeast Asia and was domesticated nearly 5,000 years ago. Having evolved in the presence of a large predator, the tiger (*P. tigris*), they exhibit gregarious behaviour. When under a perceived threat, females form a circle around their calves, while the bulls walk around this circle, actively looking for predators. Buffaloes tend to graze in closed groups never straying far away from each other and aiding any member of the herd that calls in distress.

A study conducted in four Venezuelan ranches which held cattle and buffaloes together (Hoogesteijn & Hoogesteijn, 2008) compared predation mortality between the two species held in equal conditions. The results found that the likelihood of cattle being preyed upon by jaguars or pumas was 25 times higher than for buffaloes. Buffalo had the same protective reaction toward predator attacks, regardless of circumstances or management systems in which the herds were kept.

The use of water buffalo is expanding in the Llanos of Colombia and Venezuela. It is a more efficient and profitable species than cattle in flooded savannahs, or very moist environments, containing poor quality forage. Buffalo are highly desired for their gentleness when properly managed, plus their productivity, disease resistance, and defensive behaviour are all qualities which make them desirable over cattle. Their growth curve, fertility and longevity are also better than those of cattle under similar conditions. Although some management requirements of the species must be strictly adhered to (e.g. managing at or below pasture carrying capacity, providing regular contact so as to maintain docile temperament, etc.), dramatic reductions in jaguar predation can be obtained with both full and mixed herds of water buffalo. In Costa Rica, a group of six water buffalo were introduced to a ranch that had recently suffered attacks on livestock. In six months, no attacks have occurred in the mixed group of cattle and buffalo, while there have been two attacks in neighbouring ranches (D. Corrales, unpublished data).

- **Hunting management**

Human hunting of both jaguars and their prey can influence jaguar depredation. First, the indiscriminate and opportunistic hunting of jaguars can produce crippled individuals that are not able to hunt their natural prey, and thus they turn to the killing of livestock (Rabinowitz, 1986). Second, and more importantly, studies in several different environments have found a positive correlation between the overhunting of game species by humans and elevated levels of jaguar depredation (see Polisar et al., 2003). In areas where hunting is legal, strict enforcement of sustainable harvest is essential. Especially in areas of South America in which subsistence harvesting of wildlife is present, it might be necessary to prohibit hunting if the enforcement of harvesting quotas is not effective. Most importantly for jaguars, these restrictions should also be in place for such species as spectacled caiman (*Caiman crocodilus*), capybaras (*Hydrochoerus hydrochaeris),* peccaries (*Tayassu tajacu* and *T. peccary*) and pacas (*Agouti paca*).

CONCLUSIONS

The seven actions suggested above are those we (the authors) felt are most easily applied and most effective in reducing jaguar depredation, supported by the literature and on-going data collection. However, given the loss of jaguars due to retaliatory killing, and the effects of that killing on the integrity of protected areas, additional resources must be brought to bear to enhance known solutions, and new solutions. One critical element that integrates with all of the above is the control of breeding within the livestock herds, and is thus an essential starting point in the reduction of jaguar depredation. Despite the fact that jaguars can kill prey much larger than themselves, including adult cattle, smaller, young individuals are particularly vulnerable. Lastly, the application of the above findings will require outreach and education in the communities surrounding protected areas if human wildlife conflict related to jaguars is to be reduced and the acceptance of protected areas by communities enhanced (see Wells & Brandon, 1992). In all jaguar range countries, governments have the legal oversight of wildlife and natural resources, including jaguars. Likewise, the establishment and oversight of protected areas is also directed by government. Commonly, these two government responsibilities are under one government agency or institution. In addition, in most jaguar range countries, agricultural ministries oversee the health and production of livestock, especially herds that are supplying livestock products (e.g. meat, milk, etc.) to the general public. Involving all these government entities, and integrating their policies in anti

Asian water buffalo are an important alternative to domestic cattle in some areas of Latin America due to their ability to use marginal and wetland pastures, their productivity of meat and young, and their anti-predator defence behaviours that make them less vulnerable to jaguar predation than cattle © Hoogesteijn, Panthera

-predation activities is an important – if not essential – part of the long-term reduction of jaguar depredation in and near protected areas. Governments are becoming more aware of the pervasiveness of the jaguar-livestock conflict issue. At the same time, they are also becoming aware that the problem is not solved by the constant killing of depredating individuals. In addition, the growing ecotourism industry in Latin America (Wallace, 1993; Stonza & Durham, 2008) provides added economic incentives for maintaining complete assemblages of native vertebrates, including large predators. Foster (2008) analyzed the survival potential of jaguars in a Belizean landscape and found that the current two protected areas had the potential of supporting isolated jaguar populations, but the probability of all populations persisting for 100 years was approximately 50 per cent unless dispersers from the core protected areas exceeded 12 percent per year. Thus, these landscapes and the jaguar populations they support are dependent on the interactions between protected areas and the more human dominated landscape around them.

FOOTNOTES

[1] http://maps.iucnredlist.org/map.html?id=15953
[2] http://www.panthera.org/species/jaguar

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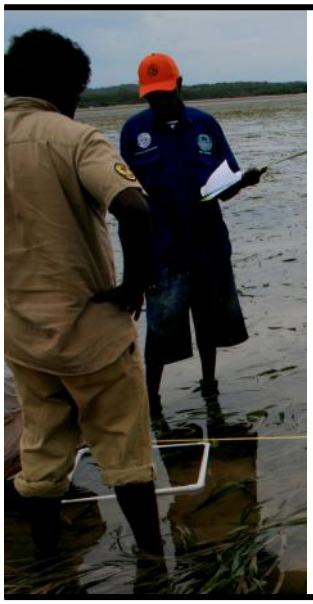
RESUMEN

Debido en gran parte a su éxito en áreas no perturbadas, la conservación de los grandes carnívoros está ligada a las áreas protegidas. Sin embargo, debido a su necesidad de superficies extensas, los grandes carnívoros –y su conservación– siempre estarán vinculados a zonas fuera de las áreas protegidas. La matanza en represalia de jaguares cerca de las reservas y en los corredores entre reservas amenaza con disminuir severamente las poblaciones de jaguares en las áreas protegidas y en sus corredores, con la consiguiente reducción de la viabilidad ecológica de las áreas protegidas para la especie. La resolución de este conflicto permitirá a los jaguares utilizar el paisaje dominado por humanos, deparará oportunidades para la conservación de los corredores, y mejorará la eficacia de las áreas protegidas. Examinamos los métodos para reducir la depredación de ganado y evitar el control letal de jaguares. Entre los enfoques para mitigar los conflictos cabe señalar los planes de seguros, la gestión de presas silvestres, y –sobre todo– la mejora de la cría y la gestión ganadera. Las mejoras que se recomiendan para problemas específicos en granjas agrícolas y ganaderas pueden incluir cercas eléctricas, recintos nocturnos, diseños de corrales para recién nacidos, el uso de animales de guardia, y la sumersión parcial de razas criollas de ganado o búfalos de agua. Describimos múltiples escenarios de prueba y los resultados de toda América Latina para reducir la depredación de ganado en áreas protegidas y paisajes agrícolas.

RÉSUMÉ

Due en grande partie aux succès remportés dans les zones non perturbées, la conservation de grands carnivores est associée aux aires protégées. Toutefois, en raison de leurs exigences de matière d'espace, la conservation de grands carnivores sera toujours liée aux régions à l'extérieur des aires protégées. L'abattage de jaguars, en tant que mesure de représailles, se passe à proximité des réserves et dans les couloirs entre les réserves et constitue une grave menace pour les populations de jaguar dans les aires protégées et leurs couloirs, diminuant ainsi la viabilité écologique des aires protégées pour l'espèce. Seule une résolution de ce conflit permettra aux jaguars de se déplacer à travers les territoires dominés par l'homme, ouvrira la possibilité de mesures de conservation dans les couloirs et renforcera l'efficacité des aires protégées. Nous examinons les méthodes permettant de réduire la déprédation du bétail et empêcher le contrôle létal de jaguars. Les conflits humains-faune peuvent être gérés grâce à des approches variées tels des systèmes d'assurance, la gestion des proies sauvages et surtout l'amélioration des techniques d'élevage. Certaines améliorations recommandées pour les fermes et les ranches sont, par exemple, des clôtures électriques, des enclos de nuit, des enclos d'hébergement pour nouveau-nés, la présence d'animaux de garde, et l'incorporation partielle du bétail créole ou des buffles d'eau à l'intérieur de troupeaux. Nous présentons les résultats de plusieurs tests en situation réelle à travers l'Amérique Latine destinés à réduire la déprédation du bétail dans les aires protégées et les terrains agricoles.



MIXING WATERS: A CROSS CULTURAL APPROACH TO DEVELOPING GUIDELINES FOR FISHERS AND BOATERS IN THE DHIMURRU INDIGENOUS PROTECTED AREA, AUSTRALIA

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ABSTRACT

This article demonstrates the importance of indigenous ontologies in cross-cultural or 'both ways' coastal conservation management of the Dhimurru Indigenous Protected Area in north east Arnhem Land, Australia. In this action research, selected Yolŋu individuals identified concerns regarding recreational fishing and boating practices of non-Yolŋu. Yolŋu engaged in a discussion of the issues and the subsequent formulation of indigenous management responses. This led to the development of locally relevant guidelines for fishers and boaters with potentially broader applications in other Indigenous Protected Areas and beyond. We explore the 'both ways' approach adopted by the Dhimurru Aboriginal Corporation that guides collaboration between Yolŋu and non-Yolŋu. We illustrate how the approach facilitates indigenous ontologies to co-create conservation approaches together with contemporary conservation efforts informed by Western science. We further explore the disjunctures and synergies between the two and argue that these mix and can be compatible as part of the 'both ways' approach. In learning from this action research, we reflect on the process of cross-cultural learning and the role of researchers in the cross-cultural co-production of knowledge and the formulation of guidelines for fishers and boaters.

Key words: Cultural values, traditional knowledge, coastal zone policy, fisheries, Yolŋu Aboriginal, cross-cultural learning, indigenous protected area.

INTRODUCTION

Indigenous people have long managed and governed the landscapes they inhabit in order to sustain their livelihoods and cultures. Conservationists[1] are often drawn to the variety of ecosystems and high levels of biodiversity maintained within these landscapes. Increasingly, and in response to a greater appreciation of interdisciplinary approaches, conservationists seek to take the interests and knowledge systems of local people into account by attempting to integrate successful aspects of traditional knowledge into their contemporary conservation management (Redford, 2011; Waltner-Toews et al., 2003). However, they often overlook the socio-cultural and political context within which they are embedded and practised (Wilshusen & Brechin, 2011). Indigenous knowledge is not the same as a 'separate' scientific discipline but rather a body of knowledge that reflects a particular worldview based on its own ontological premises (Muller, 2012). The failure to put indigenous ontologies on a par with 'Western'[2] knowledge is increasingly viewed as an underlying cause for political, economic, religious and educational inequities and the disempowerment of indigenous peoples (Hunt, 2013; Verran, 1998). These inequities can also be seen as a schism between different and, at times, competing and conflicting worldviews. In the realm of conservation, the failure to recognize this disconnect is likely to jeopardize conservation outcomes such as the protection of biodiversity and ecosystems (Blaser, 2009; Reyers et al., 2010).

Historically, contemporary conservation approaches were less concerned with and informed about indigenous management and governance practices. In particular, the intangible cultural, spiritual and sacred values that are an integral part of indigenous ontologies were poorly

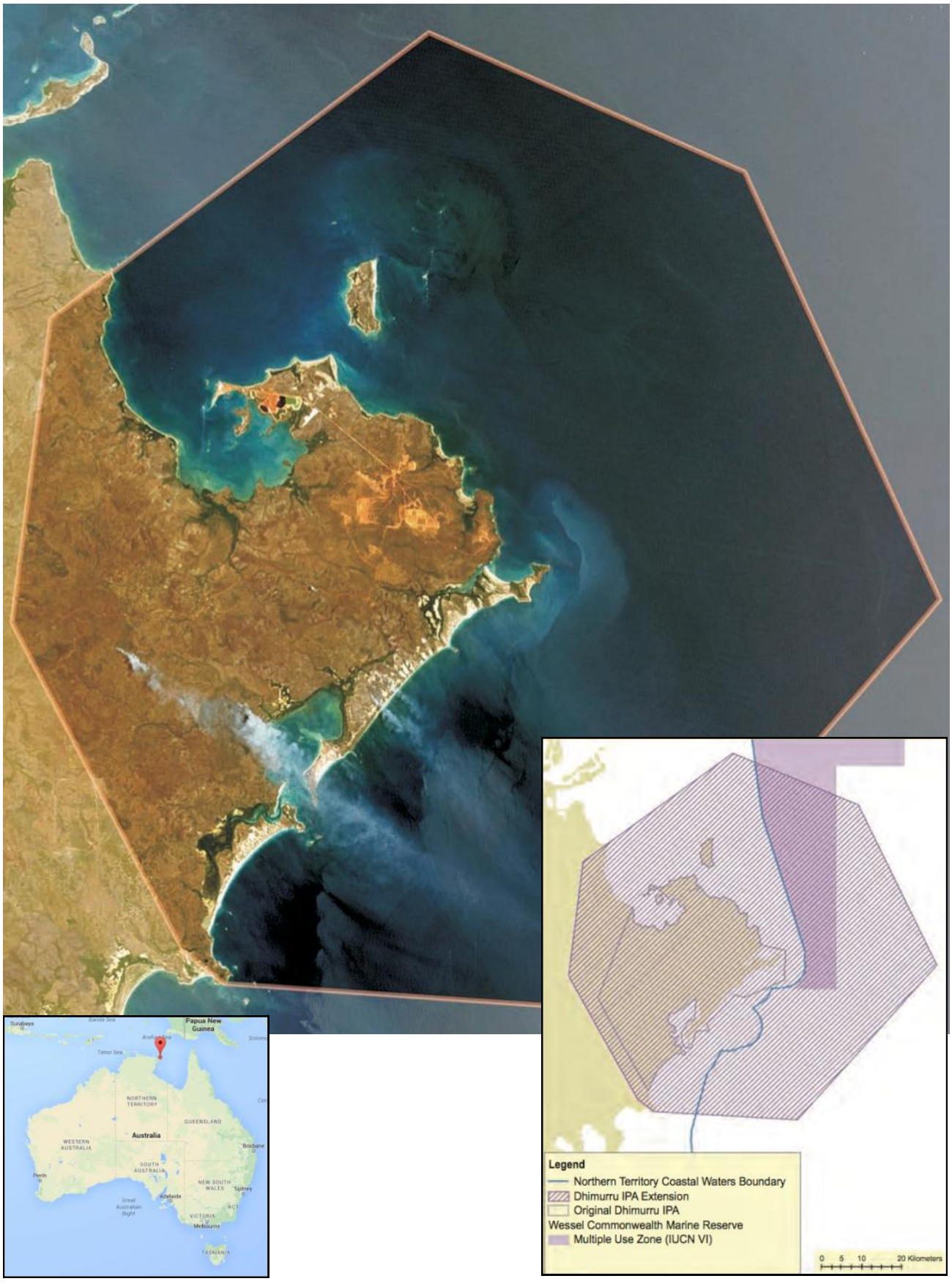

Figure 1: Satellite view of the expanded Dhimurru Indigenous Protected Area. Source: Dhimurru IPA Sea Country Management Plan 2013-2015, based on: Landsat 5: US Geological Survey 2011, Tablelands Regional Council 2013. Inset left: Map situating Dhimurru IPA in north east Arnhem Land. Source: Map data © GBRMPA, Google. Inset right: Dhimurru IPA with the 2013 MPA extension shared with the Commonwealth Wessels Marine Reserve. Source: Dhimurru IPA Sea Country Management Plan 2013 -2015.

understood and often dismissed on the basis of being irrelevant to conservation (which mostly took its merit from Western science). As a result, many Western-trained conservationists and policy-makers remain unable or even unwilling to acknowledge the indigenous ontologies that shape the areas they are required to manage (Atran et al., 2004; Berkes & Turner, 2006; Blaser, 2009). This is lamentable given that a growing body of research shows that indigenous ontologies can be legitimized within Western scientific approaches; examples of this are the 'Two-Eyed Seeing' in Canada (Bartlett et al., 2012) and the 'Two-Ways' management in Australia (Hoffmann et al., 2012; Muller, 2012). However, the legitimization of indigenous knowledge by Western science should not be considered a precondition for its utility to conservation or as a prerequisite for engaging with indigenous groups.

In this paper, we identify some of the ontological differences between contemporary Western conservation and the worldviews harboured by the Yolŋu Aboriginal people of northeast Arnhem Land, Australia and explore how these may be reconciled. We first explore the history and meaning of the 'both ways' approach (also called two -ways management) and provide examples of its application within the Dhimurru Indigenous Protected Area (IPA). Using the 'both ways' process we identify potential synergies between Yolŋu and non-Yolŋu 'ways of doing' as a basis for finding desired solutions to fisheries problems identified by Yolŋu. We outline how we conducted this action research in order to formulate practical guidelines for recreational fishers and boaters. The results describe the outcomes of the action research such as the cultural relevance of species, the problems and management issues that Yolŋu identified and the responses they formulated in an effort to create and manage a common ground for Yolŋu and non-Yolŋu fishers and boaters. The results also include ethnographic data on the disjunctures and synergies between Yolŋu and non-Yolŋu that were encountered during the research process. The conclusion reflects on lessons learned in working within the 'both ways' approach as part of the process of developing the guidelines for recreational fishers and boaters.

ORIGINS OF THE 'BOTH WAYS' APPROACH

The term 'both ways' originally emerged as a concept known as 'two-way schooling' which referred to drawing from two separate domains of knowledge derived from both Yolŋu and Western culture (Harris, 1990). Harris maintained that 'Aboriginal people today are increasingly interested both in being empowered in terms of the Western world and in retaining or rebuilding Aboriginal identity as a primary identity' (Harris, 1990: p. 84). Later, the 'both ways' approach came to signify the acceptance of a mixing of Western and indigenous knowledge (Marika et al., 2009). The 'both ways' approach has been applied across many areas of Yolŋu knowledge as well as non-Yolŋu domains. Examples are scientific disciplines or professions such as education and teaching (Harris, 1990) nursing, medicine and healthcare (Kendall et al., 2011) as well as land and sea management (Ens & McDonald, 2012; Hoffmann et al., 2012; Marika et al., 2009; Yunupingu & Muller, 2009). The cultural meaning of the 'both ways' approach stems from the word Ganma: 'Ganma has many meanings, one of which is a place where fresh and salt water meet and mix. The fresh water and the salt water refer to parallel systems of knowledge' (Muller, 2012, p. 61). The 'both ways' approach therefore allows for taking an ontological approach to management issues.

THE 'BOTH WAYS' APPROACH IN THE DHIMURRU INDIGENOUS PROTECTED AREA

We applied the 'both ways' approach in formulating the *Guidelines for Fishers and Boaters*. This was carried out in response to Yolŋu expressing a need to mitigate impacts arising from fisheries activities occurring on their traditional land and sea estates, presently situated within the Dhimurru IPA. The Dhimurru IPA is legally owned by Yolŋu people under the Northern Territory Aboriginal Land Rights Act of 1976. Established in 1992, the Dhimurru IPA, is based on a voluntary management agreement with the Australian Government (Dhimurru, 2008). A Yolŋu community-owned land and sea management organization called the Dhimurru Aboriginal Corporation (referred to hereafter as Dhimurru) manages the IPA. This is done in accordance with IUCN Protected Area Category V where the focus of management is on the interaction between people and nature, including all relevant cultural and recreational activities.

The total area of the Dhimurru IPA is approximately 920 km² of which almost 90 km² consists of coastal waters (Dhimurru, 2008) that were extended into a much larger marine IPA in 2013 (Dhimurru, 2013). Given the extent of coastal areas under management by Dhimurru, it is not surprising that fishing and boating activities may affect culturally significant coastal biodiversity and ecosystems in accordance with Yolŋu law and belief systems. In order to aid management, Yolŋu believe that culturally appropriate responses are required in order to mitigate these impacts and curb the behaviours that drive them. Importantly, management responses also need to be embedded within a strategy geared to sensitizing non-Yolŋu to Yolŋu culture: 'When ŋäpaki [non- Yolŋu people] come here …fish and stay on country

Fishers enjoying the evening in one of the Dhimurru's recreational areas © Bas Verschuuren

we want them to understand our rom [law] and dhäwu [creation story] so they see it and respect that djalkiri there [sacred site, also foundation].' (Yolŋu interviewee, pers. comm.).

Dhimurru encourages a 'both ways' approach to land and sea management by utilizing both Western and indigenous knowledge systems and mixing them into a new and fluid domain. However, the sole management responsibility remains in the hands of the Traditional Owners – in line with the vision expressed by the Yolŋu elders (Dhimurru, 2008; Yunupingu & Muller, 2009). Yolŋu elders state in Dhimurru's constitution that: 'We envisage working together with the Parks and Wildlife Commission [Northern Territory][3]; we need their help in making our vision a reality, but the only people who make decisions about the land are those who own the law, the people who own the creation stories, the people whose lives are governed by Yolŋu law and belief.' (Dhimurru, 2008: p. 4).

In staying true to its foundations, Dhimurru has been pursuing the 'both ways' approach in order to develop constructive cross-cultural working relationships with conservation, government agencies, universities and other organizations.

Partnerships in the spirit of the 'both ways' approach extend to collaborations with scientists from different disciplines. For example, anthropologists have mapped the stories (dhäwu), songs (manikay) and art (miny'tji) related to the sacred sites (djalkiri) in the Yolŋu coastal zone (Leo, 2010) and ecologists have investigated and mitigated the presence of invasive species such as the Cane Toad (Rhinella marina, formerly Bufo marinus) (Boll, 2006) and the Yellow Crazy Ant (Anoplolepis gracilipes) (Hoffmann et al., 2012). Scientists who have collaborated within the 'both ways' framework recognize its potential in allowing Dhimurru and other indigenous land management organizations across northern Australia to effectively combine Yolŋu knowledge and practices with conservation management and planning (Christie, 1991; Ens & McDonald, 2012; Hoffmann et al., 2012). However, experiences of scientists and Yolŋu struggling with the deeper ontological implications of working with the 'both ways' approach have also been cited (Muller, 2012).

THE YOLŊU, SALTWATER PEOPLE LIVING ON SEA COUNTRY

The Yolŋu, like many Aboriginal people living in the coastal areas of northern Australia, refer to themselves as Saltwater People (Drill Hall Gallery & Buku-Larrngay

Mulka Centre, 1999; Williams, 1986). In the Yolŋu worldview, the land and sea are inextricably linked and Yolŋu attachment to the sea is just as great as that to the land (Yunupingu & Muller, 2009). Because of the absence of a distinct divide between land and sea environments, sea can be referred to by Yolŋu interchangeably as sea country, saltwater country or simply country (McNiven, 2004; Williams, 1986). This holistic view has its origins in the creation stories and the Yolŋu law Rom as is illustrated by the following: 'This water is saltwater.... And in that water lays our sacred Law. Not just near the foreshore. We sing from the shore to where the clouds rise on the horizon.... Everything that exists in the sea has a place in the sacred songs... seaweed, floating anemones, turtle, fish etc. The songs follow them out from the deep water into the beach.' (Drill Hall Gallery & Buku-Larrngay Mulka Centre, 1999).

Like on land, the seabed and the intertidal zone contain similar Dreaming tracks related to sites of special cultural significance known as djalkiri sacred sites, all of which are protected under the Northern Territory Sacred Sites Act (Northern Territory of Australia, 2013). Dreaming Tracks are routes walked by Waŋgarr, ancestral 'mythological' beings such as the Rainbow Serpent, the Dugong, the Groper and the Shark during the Dreamtime period. These 'mythological' beings created the land, sea and everything in it and they laid down the Rom for Yolŋu people. The records of their actions have been passed on over generations through cultural concepts such as story dhäwu, song manikay, art miny'tji, and ceremony buŋggul, and are intrinsically linked to the Yolŋu spiritscape (McNiven, 2004). The Yolŋu also link social groups through an intricate kinship system named gurruṯu, which are in turn linked to geographical areas of land and sea country termed Wäŋa (Williams, 1986).

In Yolŋu ontology, these cultural and spiritual concepts also link terrestrial and marine environments and have therefore been incorporated in Dhimurru's Plan of Management (Dhimurru, 2008) as well as the sea country management plan (Dhimurru, 2006, 2013). They are reflected in Yolŋu perspectives on policy affecting the intertidal zone as well as the *Guidelines for Fishers and Boaters* (Dhimurru, 2010), as the culmination and output of this research. Indigenous perspectives of law or policy are often distinguished from those of most contemporary policy makers whose notions of law are typically based on state law which in turn is rooted firmly in colonial law (Marika et al., 2009; Verran, 1998). An example of this is the public right to navigate versus the traditional Yolŋu system of asking permission to access or harvest from sea country in a manner that is cognizant of its cultural significance, e.g. being mindful of sacred sites and creation stories. This differentiation is also expressed in the *Dhimurru Sea Country Plan* (Dhimurru, 2006, p. 4): 'There are inconsistencies between our rights and responsibilities under our customary law and those recognised under contemporary Australian law. We are struggling to have our sea rights recognised in the same way as our rights on the land are recognised. While that struggle is continuing, we take this opportunity to present our plan regarding the use, conservation and management of the sea.'

However, in a relatively recent ruling, the Yolŋu won legal recognition over the intertidal zone based on their intergenerational cultural occupation and spiritual affiliation with this zone (Federal Court of Australia, 2007). The evidence of Yolŋu ownership and occupation of the coastal zone was based on dhäwu, manikay and miny'tji as established and brokered by anthropologists and recognized by the Federal Court (Barber, 2005; Morphy & Morphy, 2006).

METHODS

Research was carried out over two to three month periods in 2007, 2008, 2009 and a shorter period in 2011. We applied an action research approach using ethnographic methods, including a review of the scientific literature and relevant management and policy documents from sources such as government agency websites, files made available by Dhimurru and the Buku -Larrngay Multimedia Art Centre. According to McNiff and Whitehead (2006), action research is about doing research through active participation in a dynamic and evolving reality, whilst being part of an existing organization. In conducting action research as part of the 'both ways' approach, the process was greatly enhanced by being able to engage in participatory observation and in-situ learning opportunities when assisting Dhimurru rangers with land and sea management activities (e.g. coastal patrols and monitoring, marine debris clean-ups, ethno-ecological surveys, stakeholder liaison) or accompanying other Yolŋu on traditional fishing outings.

Interviewees were identified using snowball sampling and selected according to their role in IPA management or planning as well as their culturally defined responsibilities such as the ability to be able to 'speak for' sea country (Bernard, 2006). We used free listing exercises in order to elicit the cultural significance of species and habitats and semi-structured interviews for gaining insight into the boating and fisheries-related issues that Yolŋu perceived to be of concern to sea country (Bernard, 2006). Semi-structured interviews were held with 29 informants with an initial interview

Sea Country Rangers Balupalu Yunupingu (left) and Partick White are on patrol to ensure that fishers have a safe time on the water and that rocky outcrops, often known sacred sites, are left undisturbed © Bas Verschuuren

guide of 18 questions being used. Three senior Yolŋu acted as key informants and allowed extensive interviews in order to facilitate in-depth understanding of the cultural context, knowledge and the management implications. This approach assisted with the triangulation of information in order to understand the extent to which identified issues were shared across geographic areas and clan groups (Bernard, 2006). Validated information was subsequently listed in an 'issues and management implications matrix' (see table 1) to allow grouping of the perceived issues and management implications suggested by the participants. Guidelines were then developed based on these groupings, with additional feedback from Yolŋu and non-Yolŋu staff within the Dhimurru Aboriginal Corporation.

This action research approach allowed Yolŋu to participate throughout the full research process (from design to implementation and analysis) in a way that guaranteed that their original concerns were addressed. This approach is also supported by others such as Denscombe (2010, p. 6) who states that; 'action research aims to solve a particular problem in a practical context and to produce guidelines for best practice'. In our case, the particular problem is the social-ecological impact on the coastal zone as perceived by Yolŋu and the best practice relates to the *Guidelines for Fishers and Boaters* that were collaboratively developed for the Dhimurru IPA.

RESULTS

Initial results identified the species and areas in the coastal zone that are important for Yolŋu day-to-day life and sea country management (see next section). Subsequent findings were based on Yolŋu perceptions of fisheries issues and their cultural relevance, such as impacts on sacred sites, totem animals and creation stories (see table 1; two left-hand columns). These concerns were then linked to the management implications and management responses that Yolŋu and Dhimurru IPA staff identified (see table 1; two right-hand columns).

These results subsequently formed the basis of the applied research output which was the *Guidelines for Fishers and Boaters* (Dhimurru, 2010). A further outcome of this action research is evaluative in terms of reflecting on our roles as researchers in the cross-cultural process that is part of working within the 'both ways' approach underlying the development of the *Guidelines for Fishers and Boaters* (see table 2).

The results are presented in the following paragraphs and should be interpreted with an understanding that all 'country' (sea, sky, estuaries, beach etc.), living and non-living, is important to Yolŋu, and that all aspects come with a deep sense of cultural and spiritual custodianship, sacredness and bestow identity upon Yolŋu.

SPECIES AND AREAS OF IMPORTANCE TO YOLŊU AND IPA MANAGEMENT

Associations with plant and animal species are key to Yolŋu worldviews and cosmologies. Therefore, the initial phase of the research primarily focused on Yolŋu traditional knowledge. Yolŋu identified species and habitats of importance, and seasonal (phenological) indicators that assist sea country management processes and practices. During the course of this research, Yolŋu individuals identified 50 marine species of importance; however, we believe that this list is not exhaustive. Species included eight turtles (Miyapunu), one reptile (crocodile, Baru), two mammals (Djunuŋgayŋu), eight shellfish (Djiny), one sea urchin (Dharnpa), twenty-two fish (Guya), four stingray (Gurrtjpi) and four sharks (Mäna). Yolŋu names have been verified using Barber (2005).

When inviting Yolŋu to identify which species are of importance and why, they mentioned the species' role in creation stories (dhäwu) or as a totem animal and, to a lesser degree, their function as a flagship species in conservation management. Flagship species are often species at risk of extinction; they play a key ecological role and have charismatic appeal in the public domain (Bowen-Jones & Entwistle, 2002). Yolŋu usually did not assign flagship status to a species, with the exception of sea turtle and dugong (*Dugong dugong*) which Yolŋu know enjoy (inter)national interest and also have prominence in Dhimurru's nature conservation projects: 'We know all the fish and this country, we sing them. That Miyapunu [sea turtle]… …we also hunt. So ŋäpaki [non-aboriginal person] like that Miyapunu too, he worries! We go [satellite] track that Miyapunu with Rod [a sea turtle researcher], it goes all the way to Queensland!' (Yolŋu interviewee, pers. comm.).

Many recreational fishers also view sea turtles and dugong as important and express willingness to assist with their conservation. These species become an ideal vehicle for educating both Yolŋu and non-Yolŋu recreational fishers about the underlying threats to their populations and the role that Dhimurru plays in their conservation. For this reason, turtles and dugong have been given appropriate attention in the *Dhimurru Sea Country Plan* (Dhimurru, 2006, 2013) and also in the *Guidelines for Fishers and Boaters* (Dhimurru, 2010). The importance of a given species is very tightly bound to Yolŋu culture and examples of cultural values and appropriate cultural behaviour were also provided: 'If someone passes away, [one] cannot catch that fish or cannot eat octopus as it has a certain relation to them. [It is also] dependent on your relationship to that species.' (Yolŋu interviewee, pers. comm.).

Other factors about individual animals that were culturally significant are the size of the animal and whether a female is carrying progeny or not. Specific species were mentioned for their cultural significance or particular management concern. The challenge for

Table 1. Perceived environmental issues, impacts, cultural importance and management implications.

Perceived Issues	Impacts	Cultural Relevance	Management Implications
	Speed, Noise and Boat Strikes		
Propeller damage to sea grass in shallow waters.	Dugong feeding grounds, sea grass (indicator species) damaged.	Affects wild food source (dugong); Induces a concern or 'worry' about the dugong's well-being.	Habitat mapping, surveying and long-term monitoring, Speed of boats urged to slow down in indicated areas;
Boat strike of dugong and sea turtle; Wash-up of dead or injured dugong from boat strike.	(Fatal) injuries to and decreasing dugong and sea turtle populations.	Affects availability of wild food source (dugong, turtle) and harms species considered to be of sacred or totemic importance.	Regulate boat access and speeding in indicated areas; Yolŋu to survey for injured animals.
Noise from outboard motors.	General noise pollution; Disturbance of marine species populations and sacred sites or ceremonies.	Desecration of sacred sites and ceremonial areas; Disruption of tranquil areas	Zoning; 'no go' or sacred zones; Engage in education and signage.
Boat speed.	Damage to sea grass and marine species; Increased chance of boat strike or propeller damage.	Affects availability of wild food source (dugong, turtle); Harms or kills species considered to be of sacred or totemic importance.	Zoning; 'go slow' zones; Impose speed limits; Engage in education and signage.
Commercial trawling over sea grass areas.	Damage to sea grass areas; Dugong feeding grounds affected; Damage to sacred sites, crocodile and shark dreaming.	Affects wild food source (dugong). Induces concern about the dugongs and desecration of sacred sites.	Work with fishers to identify areas of concern and possible options; Enforce Sacred Sites Act over Crocodile Dreaming or other sacred sites.

Continued overleaf →

→ **Table 1. continued**

Perceived Issues	Impacts	Cultural Relevance	Management Implications
	Littering and Discards		
Plastic bags.	Sea turtle mortality through becoming trapped or consuming plastic bags.	Affects availability of wild food source (turtle); Potential mortality of totemic /sacred species; A feeling of sadness and worry.	Retail outlets in township shift from plastic to paper bags; Beach clean-ups; Rubbish bins made available.
Discarding fish remains at boat ramps (after filleting).	Discarded fish attract crocodiles.	Discards or waste of any fish are culturally inappropriate; Boat ramps are popular swimming spots for Yolŋu.	Visitor information and education; Fishing guidelines.
Rubbish at beaches including ghost nets / marine debris.	Pollution of the coastal environment; Incidental catch of turtle, shark and dolphins in ghost nets.	Unhealthy Sea Country induces worry and concern; Affects key totemic species.	(Community) clean-up activities, monitoring ghost nets; Media and public awareness; Lobbying regional & (inter)national governments.
Commercial fishers discard sharks after cutting fins.	Declining shark population and damage to breeding populations.	Affects especially the four clans with 'Shark Dreaming' totemic links; Agitation over 'waste' of species. Induces worry and concern.	Lobby to improve shark fishing protocols within fishing industry (at various scales); Enforce Sacred Site Act over Shark Dreaming/sacred sites.
	Access and Recreation		
Swimming at specific sites (at certain times of the year).	Disturbance of species behaviour (e.g. believed that Trevally with roe are disturbed and leave the area).	Affects (presence and populations of) sacred species and availability of wild food source.	Visitor information; Education and signage; Enforcement in recreational zones.
Visitor access to beaches.	Trespassing on sacred sites; Driving over turtle nests or disrupting turtle nesting; Leaving garbage and other waste; Noise pollution.	Desecration of sacred sites; Culturally inappropriate behaviour; Frustration and 'worry' within the Yolŋu community; Possible impacts on key species.	Education and signage; Monitoring and enforcement; Restrict access to certain areas.
Anchoring over sacred sites, coral reefs and sea grass.	Damage to sacred sites, coral reefs and sea grass.	Desecration of sacred sites; Decreasing quality of coral reef habitat.	Register more sacred sites; Map sacred sites at sea; Indicate 'no go zone' on maps; Education and signage.
By-catch: Sea turtles and crocodile become caught in commercial and sometimes recreational fishers' nets.	Decreasing sea turtle and crocodile populations (as well as other less visible species); Decapitated crocodiles have been found floating on the water.	Affects sacred/totemic species; Affects wild food source; Causes agitation amongst clans with Turtle or Crocodile Dreaming.	Urge fishers to use Turtle Exclusion Devices (TED) and to check nets regularly to prevent species (e.g. crocodile) from drowning.
Turtles become caught on (discarded) recreational fishing lines.	(Fatal) injuries to sea turtle	Sacred-totemic species; Affects wild food source and the two clans with Turtle Dreaming.	Educate fishers on safe release procedures; Investigate (and promote) the use of steel hooks.
Increasing number of vessels on waterways.	Increased recreational fishing pressure and illegal catch.	Affects availability of wild food source – reducing hunting 'success'; Increase of impacts on sacred sites.	Encourage adherence to protocols; Limit access and permits; Enforce boat registration and tracking; Increase enforcement patrols.
Difficult to check bag or 'catch' limits.	Potential overfishing or illegal fishing; Pressure on fish stocks.	Feeling of not being in control of activities taking place on Yolŋu estates.	Train indigenous enforcement officers; Increase monitoring capacity.
	Indigenous Yolŋu Harvest		
Increasing and uncontrolled traditional (Yolŋu) sea turtle and dugong hunting.	Contributes to pressure on species populations; Yolŋu may (over) hunt species (previously) considered taboo according to cultural protocols.	Traditional law is not in place – or enforced (particularly for younger Yolŋu); Reduced respect for Yolŋu hunting culture, identity and Dreaming by non-Yolŋu; Current policies often inconsistent with traditional species use.	Monitor and record numbers hunted within community; Participatory education of youth by Yolŋu elders; Reinforce traditional law; Further develop *Both Ways* management approach; Resolve inconsistencies in policies.

modern-day conservation is to be able to effectively transpose such intimate cultural and spiritual relations into ecosystem management (Verschuuren, 2012) – in our case the *Guidelines for Fishers and Boaters*. Coombes et al. (2014) surpass this notion of 'transposing' by reconceptualizing notions of participation, action and representation by doing research with indigenous people.

PERCEPTION OF FISHERIES RELATED ISSUES AND THEIR CULTURAL SIGNIFICANCE

In the second phase of the research, the analysis of issues of importance to Yolŋu focused on the fishing interests and activities of predominantly non-Yolŋu recreational fishers and, to some extent, concerns about commercial fishers (whose vessels usually – but not always – operate further from the coast). Fishing activities were reviewed and grouped based on the issues identified and observed by Yolŋu (e.g. such as vessels trawling or anchoring over sacred sites). Much concern was given to areas where spiritual values are connected to specific places in the coastal zone or seabed such as, for example, Shark Dreaming that covers many square kilometres. Despite many sacred sites having been registered in an atlas that commercial fishers are required to consult, prawn trawlers have in cases been observed operating over them, thus causing worry and giving rise to concern among the Yolŋu (Yolŋu interviewee, pers. comm.).

Other issues raised by Yolŋu concern: fishers accessing sacred outcrops and islands; excessive vessel speed over sea grass areas and sacred sites; improper discard of fish

Table 2: *Guidelines for Fishers and Boaters* (adapted from Dhimurru, 2010)

Sea Grass
Slow down: Reduce speed over sea grass areas or preferably avoid them altogether *Reduce noise:* Be aware of the effect that motor noise has on marine life *Avoid boat strikes*: Keep an eye out for grazing dugong or surfacing turtles
Discards
Be thoughtful: Yolŋu are proud of their tradition of harvesting only what they need and using their catch to the fullest. Remain sensitive to the cultural environment in which marine life is caught and how it is utilized. *Be mindful:* When discarding fish carcasses, please do so well away from the boat ramps.
Possession Limits
Comply: Stick to the bag limits recommended by your local fishing club and beware not to exceed personal possession limits as stipulated by the Northern Territory (NT) Fisheries Act.
Anchoring
Be aware: Do not drop anchor over sea grass or sacred site areas and avoid damage to fragile coral beds. If you are not sure where these are contact Dhimurru Aboriginal Corporation for more information.
Seasonality
Be informed: Seasonal cultural or natural resource management closures may apply to certain areas at times.
Access
Stick to the law: Whether or not you intend to fish, a fishing permit is essential to legalize your access to the intertidal zone and permits you to fish outside designated Dhimurru Recreation Areas. *Be sure:* When you want access beyond the intertidal zone, outside designated recreational Areas. Accessing Aboriginal Land including offshore islands without an appropriate permit is an offence under the Aboriginal Land Rights Act and may be an offence under the NT Aboriginal Sacred Sites Act. *Be prepared:* All permits can be obtained from either the Northern Land Council or Dhimurru Aboriginal Corporation Offices.
Reporting
Use your eyes: Dhimurru Sea Rangers are out patrolling to check access permit compliance and looking after Sea Country. Feel free to record and report any damage to the environment or suspicious and/or unlawful behaviour to them, the Dhimurru Office, Police or the Northern Land Council. *Give a hand:* Recording your catch, e.g. species and size, to your local fishing club helps all of us with 'both ways' management in monitoring our resources. *Turtles:* If you accidently hook a marine turtle, take a picture and report the catch. Remove the hook or remove the line as close to the hook as possible and release the turtle back into the sea.
Enforcement
Be responsible: These Guidelines for Fishers and Boaters are in principle voluntary. However, some of the guidance provided can be enforced under Commonwealth and NT Laws.

Cover of the *Dhimurru Guidelines for Fishers and Boaters*. Source: Dhimurru *Guidelines for Fishers and Boaters* available online: www.dhimurru.com.au/recreational-fishing.html

and by-catch; the catching of too many or (from a Yolŋu perspective) undersized fish; and access to the water for fishers' vessels (Table 2). Other issues pertained to increased pressure on sacred animals like the Giant Trevally or *ŋuykal* (*Caranx ignobilis*), Dugong and various species of sea turtle including the endangered Hawksbill Turtle (*Eretmochelys imbricata*): 'You don't go there, [to] Gayŋada, ŋuykal [Giant Trevally Dreaming, known as Twin Eagles in English] when they got the roe… you know when they have eggs in them, no swimming, no hunting… we do not disturb them, no one goes on the water then.' (Yolŋu interviewee, pers. comm.)

The issues raised in this phase of the research helped with the identification of the main body of the guidelines.

MANAGEMENT IMPLICATIONS AND RESPONSES

The third phase of the research focused on Yolŋu responses to the previously identified management and policy issues through a 'both ways' approach (Table 1, far right column). The issues were identified on the basis of what Yolŋu perceived as important, including the extent to which the issue is understood to affect current, future or intergenerational well-being. For example, the aforementioned concern about the Giant Trevally led to consideration of announcing seasonal closures and banning fishing activities at nearby situated campsites and recreational areas from September to November when Giant Trevally carry roe.

Both Yolŋu and non-Yolŋu interviewees made suggestions for management (Table 1). These were primarily related to: the issuing of fishing permits; imposing speed limits over sea grass and sacred sites; the development of guidelines for recreational fishers; and the education of youth through school programmes and by liaising with amateur fishing clubs and associations. This latter initiative was well received by management: 'We [as Dhimurru staff] are interested in the offer of the [local] Fishing Club to distribute a fishing kit and information package to school kids. We can then provide school talks on how to fish in manner that is respectful of Yolŋu culture and safe. We can distribute the guidance we are developing and improve collaboration with the Fishing Club and the schools directly; the problem is capacity…' (Non-Yolŋu interviewee, pers. comm.)

The most relevant management implications were either translated into the *Guidelines for Fishers and Boaters* or contributed to making better-informed decisions in day-to-day management by Dhimurru's Sea Country Rangers.

GUIDELINES FOR FISHERS AND BOATERS: A 'BOTH WAYS' APPROACH

The primary purpose of the *Guidelines for Fishers and Boaters* is to help alleviate Yolŋu concerns and support their cultural responsibilities surrounding sea country, as it relates to activities carried out by non-Yolŋu fishers and the broader range of stakeholders active within the coastal zone on Yolŋu land. The main concerns and issues identified by Yolŋu as being necessary to be countered through implementing the guidelines have similarly been translated into concepts easily understood by recreational fishers (table 2). Each of these issues were elaborated in clear, polite 'plain-speak' language offering guidance and preventive measures in line with the rules and regulations governing the Dhimurru IPA.

Since their publication in 2010, the *Guidelines for Fishers and Boaters* have been made available through

the IPA permit office, the Dhimurru website[4] and local, specialized shops for fishers. This in itself has resulted in a reasonable distribution of the guidelines. Several informants indicated that more could be done to disseminate and enforce the guidelines more efficiently. They suggested providing the guidelines as a supplement with fishing permits and making them available on related websites and printed materials which fishers regularly access such as fishing magazines, tide and fish charts, or other brochures distributed by recreational fishing and indigenous organizations. Such efforts are part 'both ways' collaboration and provide an avenue for sensitizing non-Aboriginal people about Yolŋu ways of life. Making the *Guidelines for Fishers and Boaters* available was seen as an important step towards changing the fisher and boater behaviour and is consistent with the approach set out in the Dhimurru *Sea Country Plan* (Dhimurru, 2006, p. 4): 'It is still our wish to engage in a positive way and in a spirit of good will with those who share the sea with us. We wish to work toward reconciliation of two management systems to ensure the best possible outcomes for our sea country.'

Guidelines for Fishers and Boaters (Dhimurru, 2010) is deliberately intended to strike a chord of mutual collaboration and appreciation for sea country as a way to engender open-mindedness. They urge fishers to observe, respect and adhere to guidance, tradition and restrictions, which are enforceable by law. This is important as earlier research suggests that fishing in the Northern Territory is generally experienced as 'a lifestyle' where much value is placed on open public access and free use of resources whereby any restrictions are viewed as an impingement on the perceived rights and freedoms of non-Aboriginal fishers (Palmer, 2004). Non-Yolŋu fishers interviewed as part of this research repeatedly used phrases such as 'a matter of principle' when explaining their unwillingness to conform to the implications of the Blue Mud Bay case[5] which legally requires visitors to obtain a fishing permit when active within the Yolŋu-owned intertidal zone. Due to such prevalent perceptions, the Yolŋu (through Dhimurru) decided that illegal fishing activity and land access would not be legally pursued if the offender subsequently obtained a fishing permit, which would then be backdated. Yolŋu hope that this conciliatory approach will help in sensitizing non-indigenous fishers to Yolŋu cultural values, which are central to resolving the problematic issues they identified. In general Dhimurru staff reason that: 'when fishers take an interest in why sea country is healthy, it is hoped that they will also want to know how they can help maintain sea country when they are on the water.' (non-Yolŋu interviewee, pers. comm.).

There also exists a general consensus that the *Guidelines for Fishers and Boaters* will only achieve their purpose when adequate communication and dissemination pathways are followed up by appropriate enforcement. Nevertheless, most Yolŋu were unclear about what type of enforcement efforts would be required. This could in part be explained by Yolŋu's unfamiliarity concerning the potential legal implications of the Blue Mud Bay case.

Several Yolŋu suggested increased compliance checks in the face of rising concerns and feelings of not being in control over activities taking place on their land and sea estates. Currently, indigenous rangers have little or no legal enforcement capacity. However, they are permitted to check fishers' catch, record and report marine wildlife casualties as well as report illegal access and inappropriate behaviour to the Australian Customs and Border Protection Service, local police and/or the Parks and Wildlife Commission (PWCNT). Other interviewees suggested that it would be more effective to increase indigenous enforcement capacity and investigate less labour-intensive methods of checking compliance such as obligatory GPS tracking of fishers and vessels on Aboriginal land and waters as well as improved registration of the catch. Many interviewees expected that enforcement by Dhimurru's sea rangers would help to decrease incidences of inappropriate behaviour and, importantly, also act as an effective vehicle for facilitating cross-cultural understanding between Commonwealth law and Yolŋu law (Rom).

CONCLUSIONS

This research elicited Yolŋu perceptions of sea country activities and management as a basis for formulating practical outcomes that are cognizant of Yolŋu and non-Yolŋu cultural values. The action research process, which led to the development of the *Guidelines for Fishers and Boaters*, also contributed to 'both ways' management by placing emphasis on the importance of improving mutual understanding and cross-cultural learning among researchers, IPA staff and other stakeholders. The 'both ways' approach – the framework for our research – has been valuable in this particular conservation context. Similarly, the *Guidelines for Fishers and Boaters* may serve as an example of a process and product to other indigenous groups both along the Northern Territory coastline and in other parts of the world.

- **Improving cross-cultural learning within the 'both ways' approach**

We highlight the importance of solution-oriented action research in addressing conservation concerns in a cross-cultural context. Cultural values are largely intangible

Fishing vessels may damage sea grass, a primary habitat for the endangered dugong. Its quality is of constant concern to Yolŋu who carry out monitoring activities that feed into a larger database on sea grass research across northern Australia. The activity itself is an example of Dhimurru staff and external researchers working together whilst also sharing the experience and expertise with rangers from neighbouring Indigenous Protected Areas © Bas Verschuuren

and render themselves invisible to most non-indigenous people. Therefore, challenges persist in guiding and sensitizing non-indigenous use of the Australian coastal zone in a cross-cultural context. Our research process enabled us to appreciate the synergies that can be found when doing research and developing guidelines through the 'both ways' approach. That is, making a shift from learning about the natural world to learning from and within the natural world based on a Yolŋu worldview. Berkes has described this 'synergizing' as a process of bringing into dialogue different ontological knowledge systems (Berkes, 2009) whilst others have termed it 'weaving' (Bartlett et al., 2012) or 'co-motion' (Muller, 2014).

In remaining true to the Yolŋu analogy of Ganma (i.e. a place where fresh and salt water meet and mix), we believe that the metaphor of 'brackish water' could be invoked as a new way of understanding the 'both ways' process as being fluid rather than static. In this mixed domain, it is possible to encounter both aspects of indigenous ontologies (e.g. certain spirit-beings that appear as animated currents, rocks and animals) as well as of scientific conceptualizations such as keystone or flagship species. This mixing can enrich the social learning process such that outcomes engage with new audiences, disciplines and sectors with the ultimate aim of being recognized or, further, legitimized by becoming embedded in institutional mindsets and contemporary

policy. In achieving conservation outcomes, social learning is as important as conceptual learning (Lauber, Stedman, Decker, & Knuth, 2011). Mixing indigenous knowledge and land management practices with Western views on conservation management can lead to new understandings of conservation management and a broader recognition of the contribution of Yolŋu ontologies in achieving and maintaining regional and national conservation targets.

However, publication of the *Guidelines for Fishers and Boaters* on its own has so far been unable to bring about a significant change in non-Yolŋu fishers' behaviour, or at least to the extent that it alleviated the Yolŋu's original concerns. Social learning is therefore only effective to the extent to which social actors demonstrate an openness and willingness to learn. In the contemporary northern Australian context, effective broad-scale social learning (and intercultural appreciation) will require more intensively tailored approaches that engage specific stakeholders and target specific behaviours as part of the application of a well-formulated community-based social marketing strategy (McKenzie-Mohr, 2011). However, this may require more resources and capacity than most small research teams have at their immediate disposal.

- **The role of researchers in a 'both ways' approach**

We conclude that applied research in a local and social context must strive for participation and shared problem -solving aimed at guiding well-informed action. This process rests on a shared willingness among researchers, practitioners and stakeholders to be open to the validity of each other's perceptions in order to stimulate mutual learning for developing sustainable options for management problems (Hoffmann et al., 2012; Waltner-Toews et al., 2003; Yunupingu & Muller, 2009). It also places a responsibility on researchers to ensure that results and newfound knowledge are ready to be translated into materials that support implementation (Lauber et al., 2011; McNiff & Whitehead, 2006; Pohl et al., 2010).

The scientific researchers working through the 'both ways' approach on this project experienced that their aim as researchers did not simply restrict itself to the production of knowledge but rather involved knowledge co-production through social learning. This required the researchers to take on different roles also described by Pohl and colleagues (2010) as 'the reflective scientist', 'the intermediary' and 'the facilitator' of a joint learning process (Pohl et al., 2010). Like Coombes and colleagues (2014) suggest, those in the roles of researchers were also invited and challenged to engage across boundaries of difference in new ways.

Whilst conceptualizing and understanding ontological differences may not be easy, it is nevertheless integral to the co-production of knowledge and the social learning process which underpins successful participatory conservation strategies. When subsequently providing a framework for mixing such different cultural views and logics, a key determinant is whether the resultant behaviours of the value system applied are likely to sustain the ecological context upon which they depend. We believe that a 'both-ways' approach helped ensure that the *Guidelines for Fishers and Boaters* adhered to this logic.

ENDNOTES

[1] Although conservationists as a broad term can include activists and laypersons we use the word 'conservationist' more specifically to refer to scientific researchers and practitioners such as conservation biologists and ecologists.

[2] We use inverted commas here because we are aware that this generalization does not do justice to existing epistemological and ontological differences within scientific fields.

[3] The 'both ways' approach was the basis for Dhimurru's working agreement with the Parks and Wildlife Commission of the Northern Territory (PWCNT). Rangers and staff from both Dhimurru and the PWCNT share and practise aspects of traditional and contemporary land management on a daily basis.

[4] See: www.dhimurru.com.au/recreational-fishing.html

[5] The Blue Mud Bay case was decided by the Federal Court of Australia on 23 July 2008 and resulted in the recognition of Aboriginal peoples' legal rights over approximately 80 per cent of the Northern Territory's coastal intertidal zone to the mean lowest watermark. Indigenous people now negotiate access and use of this zone in relation to recreational and commercial fisheries. This offers opportunities to extend Yolŋu values into conservation planning processes as well as economic development of the coastal zone.

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The Nuykal or *Giant Trevally* dreaming where fishing is not allowed at certain times of the year because of the Trevally having the roe. The site and surrounding waters are registered in the AAPA sacred sites atlas that commercial fishers use to avoid sacred places during operations © Bas Verschuuren

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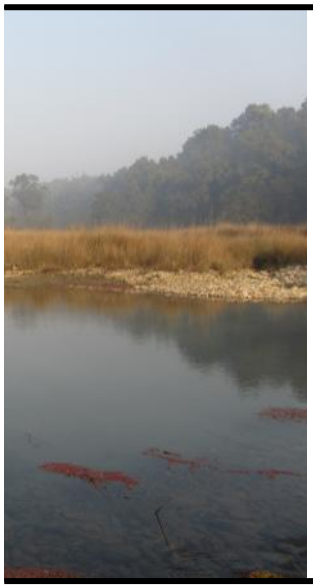
RESUMEN

Este artículo muestra la importancia de las ontologías indígenas en la gestión intercultural o "bidireccional" de la conservación costera del Área Protegida Indígena de Dhimurru en el noreste de Arnhem Land, Australia. En este proyecto de investigación, algunos miembros de la comunidad Yolŋu externaron su preocupación con respecto a las prácticas de pesca y navegación recreativa utilizadas por personas ajenas a la comunidad. Participaron en una discusión sobre temas de interés y la posterior formulación de soluciones para la gestión autóctona. Ello condujo a la elaboración de directrices pertinentes a nivel local para pescadores y navegantes con aplicaciones potencialmente más amplias en otras áreas protegidas indígenas y más allá. Exploramos el enfoque "bidireccional", aprobado por la Asociación Aborigen de Dhimurru, que guía la colaboración entre la comunidad Yolŋu y no Yolŋu. Ilustramos cómo el enfoque facilita ontologías indígenas para crear enfoques de conservación junto con esfuerzos de conservación fundados en la ciencia occidental. También exploramos las disyuntivas y sinergias entre ambos y sostenemos que estas se mezclan y pueden ser compatibles en el marco del enfoque "bidireccional". En base a las enseñanzas extraídas, reflexionamos sobre el proceso de aprendizaje intercultural y el papel de los investigadores en la coproducción intercultural de conocimientos y la formulación de directrices para pescadores y navegantes.

RÉSUMÉ

Cet article démontre l'importance de prendre en compte les ontologies autochtones dans la gestion interculturelle ou bilatérale du littoral dans l'Aire Protégée Autochtone Dhimurru, au nord-est d'Arnhem en Australie. Au cours d'une étude sur le terrain, des individus Yolŋu ont exprimé de l'inquiétude face aux activités de pêche et de navigation en mer des personnes non-Yolŋu. Après avoir engagé des discussions sur ces questions, ils ont proposé des solutions de gestion autochtone. Ceci a mené à la mise en place de directives locales pour les pêcheurs et les plaisanciers qui peuvent potentiellement s'appliquer à d'autres aires protégées autochtones et au-delà. Nous explorons l'approche «bilatérale» adoptée par la Société Autochtone Dhimurru qui définit la collaboration entre Yolŋu et non-Yolŋu. Nous illustrons comment cette approche permet de combiner les ontologies autochtones et les techniques de conservation contemporaines. Nous allons plus loin dans l'analyse des contradictions et des synergies entre ces deux approches pour montrer leur compatibilité dans le cadre d'une solution 'bilatérale'. Les enseignements de cette étude nous permettent de réfléchir sur l'apprentissage inter-culturel et sur le rôle des chercheurs dans la formulation de directives pour les pêcheurs et plaisanciers.



TERRESTRIAL PROTECTED AREAS AND MANAGED REACHES CONSERVE THREATENED FRESHWATER FISH IN UTTARAKHAND, INDIA

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ABSTRACT

Terrestrial protected areas and river reaches managed by local stakeholders can act as management tools for biodiversity conservation. These areas have the potential to safeguard fish species from stressors such as over-fishing, habitat degradation and fragmentation, and pollution. To test this idea, we conducted an evaluation of the potential for managed and unmanaged river reaches, to conserve threatened freshwater fish species. The evaluation involved sampling fish diversity at 62 sites in major rivers in Uttarakhand, India (Kosi, Ramganga and Khoh rivers) both within protected (i.e. sites within Corbett and Rajaji Tiger Reserves and within managed reaches), and unprotected areas (i.e. sites outside tiger reserves and outside managed reaches). In total, 35 fish species were collected from all sites, including two mahseer (*Tor*) species. Protected areas had larger individual fish when compared to individuals collected outside of protected areas. Among all sites, lower levels of habitat degradation were found inside protected areas. Non -protected sites showed higher impacts to water quality (mean threat score: 4.3/5.0), illegal fishing (4.3/5.0), diversion of water flows (4.5/5.0), clearing of riparian vegetation (3.8/5.0), and sand and boulder mining (4.0/5.0) than in protected sites. This study supports the importance of existing terrestrial protected areas and managed sites for conserving threatened fish and preventing harmful activities.

Key words: Freshwater fish diversity, terrestrial protected areas, anthropogenic stressors, Corbett, Rajaji, Ramganga, Kosi, Khoh

INTRODUCTION

Terrestrial protected areas are important for biodiversity conservation, genetic resources maintenance and safeguarding ecosystem functions (Keith, 2000; Kingsford & Nevill, 2005; Mancini et al., 2005; Abell et al., 2007; Roux et al., 2008). For example, the mean body size of fish species was found to be larger in protected than in unprotected areas of Lake Kariba, Zimbabwe (Sanyanga et al., 1995); in the western United States, freshwater preserves have been successfully conserving several fish species, and terrestrial protected areas have also provided conservation benefits to associated species such as the giant freshwater lobster (*Astacopsis gouldi*) in northern Tasmania (Suski & Cooke, 2007), and freshwater mussels in the Mississippi river basin (Ricciardi et al., 1998). Additionally, recent studies have highlighted the importance of terrestrial protected areas for freshwater fish species in South Asia (Abraham & Kelkar, 2012; Sarkar et al., 2013). Freshwater reaches managed by local stakeholders (e.g. community members) have also been shown to provide some benefits to fish species and their associated habitats either through religious beliefs and taboos (Dandekar, 2011), or socio-economic benefits in safeguarding particular fish species (Gupta et al., 2014a).

About 5 per cent of India's geographical area is enclosed within protected areas (Sinha et al., 2009). Legislatively defined terrestrial protected areas perform protective roles for some floral and faunal species (see Post & Pandav, 2013; Rastogi et al., 2013). Further, aquatic reaches associated with temple pools (see Dandekar, 2011), and reaches managed through local community assistance not only safeguard various threatened

An unprotected site outside Rajaji Tiger Reserve © Nishikant Gupta

freshwater fishes but other semi-aquatic and terrestrial species too (see Gupta, 2013). Additionally, river reaches monitored by various angling organizations (i.e., to promote recreational angling of target fish species), are protected by catch-and-release wardens and promote socio-economic opportunities for a range of local stakeholders (see Pinder & Raghavan, 2013; Gupta et al., 2014a; Pinder et al., 2014).

India is home to major river systems (n=7) which contain numerous freshwater fish species (n>900) with high levels of endemism (Pinder & Raghavan, 2013). The fish species here are of importance because they maintain the ecological integrity of freshwater systems (Allen et al., 2010); and also provide a food source for some sections of the society (Gupta et al., 2014a). However, India's increasing population and subsequent urbanization has put pressure on its available water resources (Sarkar & Bain, 2007) and fish species (Lakra et al., 2010) through habitat fragmentation, habitat loss, flow alterations, and introduction of non-native species (Everard & Kataria, 2011).

Indian freshwater fishes have not been afforded the support that is directed towards the conservation of mammals, birds and amphibians (Gupta et al., 2014b). For example, freshwater fish conservation and management policies have suffered from setbacks due to jurisdictional issues and oversights, and implementation of top-down approaches (Raghavan et al., 2011); poor enforcement of existing laws (Raghavan et al., 2013); and community-based conservation initiatives often failing to protect river stretches outside their own jurisdiction (Gupta, 2013). Furthermore, no freshwater fish are afforded mention in the Indian Wildlife (Protection) Act, 1972, the highest legal instrument for wildlife conservation in the country (Raghavan et al., 2013).

Past literature has suggested that protected areas have the potential to protect rivers from negative stressors, and improve fish biodiversity (Keith, 2000; Saunders et al., 2002; Sarkar et al., 2008; Abraham & Kelkar, 2012; Sarkar et al., 2013). In addition, the adequate representation of river systems in protected areas has been suggested to offset various anthropogenic threats (Nel et al., 2009). Some authors have shown high fish densities, and greater sizes of individual fish within protected areas in comparison to sites outside protected areas (Abraham & Kelkar, 2012; Sarkar et al., 2013). In the Indian Himalayan region alone, there are over 100 terrestrial protected areas, (i.e. National Parks and Wildlife Sanctuaries) (Sarkar et al., 2008). Unfortunately, there is poor representation of river ecosystems within these areas and very few studies have been conducted on the role of existing terrestrial protected areas for conserving river ecosystems. Although often criticized for excluding local village communities and their 'rights to forest', the current terrestrial protected areas network could have the potential to provide benefits to river ecosystems. Additionally, community-conservation initiatives for river ecosystems bordering current terrestrial protected areas could see the inclusion of communities within management initiatives, provide socio-economic benefits to local communities, and potentially assist in protecting river ecosystems from harmful stressors (Gupta, 2013). Therefore, it is necessary to examine terrestrial protected areas in terms of their fish diversity and habitat especially if they encompass perennial rivers within their legislatively defined boundaries.

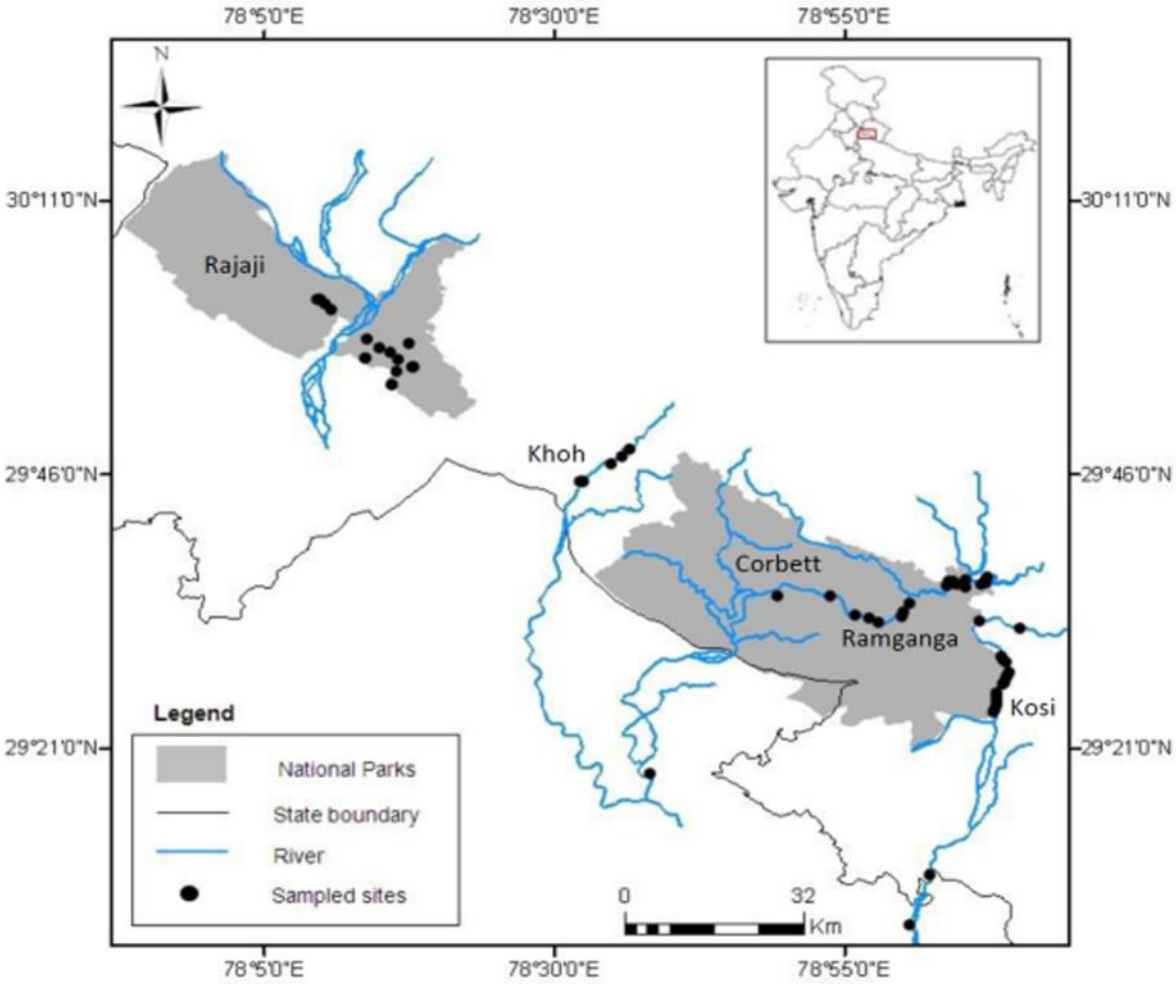

Figure 1: A map of the study area showing the Corbett and Rajaji Tiger Reserves in the north Indian State of Uttarakhand. Also shown are the Kosi, Ramganga and Khoh rivers. The black dots represent the sampled sites (UNPR and PR) (Source: Gupta et al. 2014c)

In view of this rising concern for freshwater fish conservation in India, additional options for their protection need to be investigated to provide vital information and assistance to the ongoing conservation policies of various government agencies. Field studies and documented ecological and socio-economic benefits associated with terrestrial protected areas, temple pools (freshwater reaches safeguarded through religious sentiments and community enforced taboos) and recreational angling pools (prime angling spots on freshwater reaches protected by angling association patrol guards) have been conducted previously by one of the authors (see Gupta et al., 2014a, b, c). We believe that further examining the freshwater bodies and their fish species within terrestrial protected areas and managed reaches, (i.e. temple pools and recreational angling pools under local stakeholder protection) in comparison to unprotected reaches, (i.e. sites outside terrestrial protected areas and outside managed reaches) could offer valuable data for long-term scientific research and assist with freshwater fish conservation.

METHODS

- **Study area**

The Corbett Tiger Reserve is part of the Shivalik mountains in the Bhabar-Terai area of Kumaon and Pauri-Garhwal region of the Indian Himalayas (Joshi et al., 2011). The Rajaji Tiger Reserve is also situated in the Shivalik ranges in the districts of Dehradun, Haridwar and Pauri (Hanna et al., 2001). The Kosi river originates from the Budha Peenath village in the Kausani area of Almora district of Uttarakhand, and has a total length of about 240 km and a catchment area of 3,420 km^2 (Kumar & Bahadur, 2013). The Ramganga river is an important tributary of the Ganges (Roy & Sinha, 2007) and originates from the Shivalik Himalayas at Dudhatoli in the district of Chamoli in Uttarakhand (Alam & Pathak, 2010). The Khoh river is a tributary of the Ramganga, originates from Langur in Dwarikhal and has a catchment basin of over 250 km^2 (Bahuguna, 2013). There are many streams within Rajaji Tiger Reserve which originate from the southern slopes of the Shivaliks and converge with the Ganges river (see Figure 1).

- **Sampling approach**

The north-Indian State of Uttarakhand was chosen as the sampling location due to the presence of terrestrial protected areas with perennial freshwater bodies within their boundaries, i.e. Corbett Tiger Reserve (Ramganga river) and Rajaji Tiger Reserve (streams) at similar elevation. Also, managed reaches, i.e. temple pools (on Kosi, Ramganga and Khoh rivers) and recreational angling pools (on Ramganga and Kosi rivers) were present in close proximity to these terrestrial protected areas. The freshwater fish species and observed anthropogenic threats were recorded at sixty-two sites during December 2011 – January 2013 under two main categories: Category I: 'unprotected areas' which consisted of freshwater reaches outside the terrestrial protected areas (Corbett and Rajaji) and outside the managed reaches (temple pools and recreational angling pools) (*henceforth UNPR*) (see pictures); and Category II: 'protected areas' which consisted of freshwater reaches within the terrestrial protected areas (Corbett and Rajaji) and within the managed reaches (temple pools and recreational angling pools) (*henceforth PR*) (see pictures). Furthermore, data relating to captured fish species and observed anthropogenic stressors were also recorded (at both UNPR and PR reaches) individually for terrestrial protected areas, temple pools and recreational angling pools to document the protection provided by these separate management approaches (at both UNPR and PR reaches).

Throughout the study area ecological factors were recorded such as location of terrestrial protected areas and managed areas, environmental gradient and indicator variables (Abraham & Kelkar, 2012). The river reaches were of roughly the same size, (i.e. width and depth) and found at similar elevations of the Shivalik Himalayan region. An assumption was made that the roughly similar environmental conditions would allow for fair comparisons between resident fish.

Fish sampling was conducted using cast nets, mosquito nets and catch-and-release angling. Each site was sampled twice over the entire field survey. After collection, fish were identified to species using available taxonomic literature (Hamilton, 1822; Talwar & Jhingran, 1991; Badola, 2001; Jayaram, 2010), their numbers counted, measurements such as total body length (mm) recorded using a measuring scale and then the fish were safely released. Species richness (S), Shannon-Weiner diversity index (H), index of fish diversity and evenness (E) were calculated for the fish species recorded (Sarkar et al., 2013). Observations regarding the various threats present at each sampling site (UNPR + PR) were recorded through direct observations. The threats were grouped into six categories (Abraham & Kelkar, 2012): sand and boulder mining; dynamite fishing and use of various poisons; overfishing (i.e. occurrence of fishing by local/regional village communities); domestic and urban waste disposal; clearing of riparian vegetation; and water abstraction. Each of these threats were then allocated a score (0 – 5; 0 = no impact, 5 = most impact) and compared qualitatively between each site.

RESULTS

In total, 4,989 individual fish were collected from all the sampled sites (UNPR + PR), comprising 35 species representing six families and four orders (Table 1). Family Cyprinidae was dominant representing 25 species. Cyprinids belonging to the genus *Barilius* (*B. barila, B. barna, B. bendelisis, B. schacra* and *B. vagra*) had the highest abundance, (n=2,245). Three 'Near Threatened' (*Bagarius bagarius*, *Labeo pangusia* and *Tor tor*), two 'Vulnerable' (*Naziritor chelynoides* and *Schizothorax richardsonii*) and one 'Endangered' (*T. putitora*) fish species were recorded; all known to have a decreasing population trend (see Table 1; IUCN, 2014).

The UNPR on the Kosi (outside temple pools and angling pools) and Khoh (outside temple pools) had almost similar species richness (S) to the PR (within temple pools and angling pools), i.e. Kosi (UNPR, n=16: 16; PR, n=5: 13) and Khoh (UNPR, n=3: 9, PR, n=3: 9). Given the dramatic differences in mean abundances among sites, a qualitative approach was used for species richness between UNPR and PR on the Ramganga and streams (Rajaji), i.e. Ramganga: UNPR (outside terrestrial protected areas, outside temple pools, outside angling pools), n=6: 12; PR (within terrestrial protected areas, within temple pools, within angling pools), n=15: 23; and Rajaji: UNPR (streams outside terrestrial protected areas), n=4: 10; PR (streams within terrestrial protected areas), n=10: 19.

The following results were obtained for the index of fish diversity (mean ± SD): Kosi (UNPR = 3.80±2.51, PR = 3.33±2.08); Ramganga (UNPR = 8.25±2.63, PR = 9.43±6.29); Khoh (UNPR = 9.00±0.00, PR = 9.00±0.00); and Rajaji (UNPR = 5.00±0.82, PR = 5.40±5.04). The Shannon-Wiener diversity index (H) was calculated for UNPR and PR on all the sampled sites and gave the following results (mean ± SD): Kosi (UNPR = 2.46±0.06, PR = 1.03±0.04); Ramganga (UNPR = 1.41±0.17, PR = 1.56±0.16); Khoh (UNPR = 1.03±0.02, PR = 1.09±0.01); and Rajaji (UNPR = 1.36±0.03, PR = 1.62±0.12). The evenness (E) values were as follows: Kosi (UNPR = 0.85, PR = 0.53); Ramganga (UNPR = 0.59, PR = 0.47); Khoh (UNPR = 0.58, PR = 0.47); and Rajaji (UNPR = 0.62, PR = 0.53).

Table 1: Fish species (n=35) recorded during the study period. Also shown are their IUCN Red List status, population trend and use. Source: IUCN, 2014
Key: * = not evaluated

Order	Family	Species	Status (IUCN Red List)	Population trend	Use and trade
Cypriniformes	Nemacheilidae	*Acanthocobitis botia*	Least Concern	Decreasing	Ornamental
		Schistura beavani	Least Concern	Unknown	Ornamental
		Schistura rupecula	Least Concern	Unknown	Ornamental
		Schistura montana	*	*	*
Perciformes	Channidae	*Channa punctata*	Least Concern	Unknown	Food
Cypriniformes	Cobitidae	*Botia lohachata*	*	*	Ornamental
Cypriniformes	Cyprinidae	*Amblypharyngodon mola*	Least Concern	Stable	Food
		Bangana dero	Least Concern	Unknown	Food, game
		Barilius barila	Least Concern	Unknown	Game, ornamental
		Barilius barna	Least Concern	Stable	Food
		Barilius bendelisis	Least Concern	Stable	Ornamental
		Barilius shacra	Least Concern	Unknown	Ornamental
		Barilius vagra	Least Concern	Unknown	Food
		Cabdio morar	Least Concern	Unknown	Food, ornamental
		Chagunius chagunio	*	*	*
		Crossocheilus latius	Least Concern	Unknown	None recorded
		Garra gotyla	Least Concern	Unknown	Food
		Garra lamta	Least Concern	Unknown	Food
		Gibelion catla	Least Concern	Unknown	Food
		Labeo calbasu	Least Concern	Unknown	Food, game
		Labeo dyocheilus	Least Concern	Unknown	Food
		Labeo pangusia	Near Threatened	Decreasing	Food
		Pethia conchonius	Least Concern	Unknown	Ornamental
		Pethia ticto	Least Concern	Unknown	Ornamental
		Naziritor chelynoides	Vulnerable	Decreasing	Food
		Puntius sophore	Least Concern	Unknown	Ornamental
		Raiamas bola	Least Concern	Unknown	Food, game
		Salmostoma acinaces	Least Concern	Unknown	Food
		Schizothorax richardsonii	Vulnerable	Decreasing	Game
		Tor putitora	Endangered	Decreasing	Game, food
		Tor tor	Near Threatened	Decreasing	Food, game
Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Least Concern	Unknown	Food
Siluriformes	Sisoridae	*Bagarius bagarius*	Near Threatened	Decreasing	Food, ornamental, game
		Glyptothorax pectinopterus	Least Concern	Unknown	Food
		Glyptothorax telchitta	Least Concern	Unknown	Food, ornamental

Table 2: Mean total body length (mm ± SD) of threatened fish species (n=6) recorded from terrestrial protected areas and managed reaches (unprotected and protected sites); and current conservation actions in place for these species.
Key: *not recorded; [1,5,6]Near Threatened; [2,3]Vulnerable; [4]Endangered (IUCN, 2014).

Sampled area	Freshwater body	Type of protection	Threatened fish species recorded	Mean total body length (mm±SD)		Conservation action in place
				Unprotected site	Protected site	
Terrestrial protected area (Corbett and Rajaji)	**Ramganga (Corbett), streams (Rajaji)**	**Legislative**	***Labeo pangusia*[1]**	*	**206.50±89.21**	**None**
			Naziritor chelynoides[2]	*	250.05±25.12	None
			Schizothorax richardsonii[3]	*	93.00±12.55	None
			Tor putitora[4]	152.26±49.01	296.40±118.84	Habitat conservation
			Tor tor[5]	*	290.00±56.79	None
			Bagarius bagarius[6]	*	657.00±102.20	None
Temple pools	Kosi, Ramganga, Khoh	Religious sentiments and associated taboos	*Schizothorax richardsonii*	*	104.50±21.25	None
			Tor putitora	125.58±25.69	275.31±109.56	Habitat conservation
Recreational angling pools	Kosi, Ramganga	Local stakeholders	*Naziritor chelynoides*	*	212.55±35.15	None
			Schizothorax richardsonii	*	125.50±15.57	None
			Tor putitora	145.79±58.52	300.58±99.56	Habitat conservation
			Tor tor	*	292.00±78.99	None
			Bagarius bagarius	*	755.00±105.55	None

Further, to assess the conservation effectiveness of sampled terrestrial protected areas and managed reaches (temple pools and recreational angling pools) for freshwater fish conservation, the mean total body length (mm ± SD) of threatened fish species (n=6), (i.e. Near Threatened, Vulnerable, and Endangered (IUCN, 2014)) recorded was compared between UNPR and PR (see Table 2).

Scores (0 = no impact; 5 = most impact) were assigned to the threats (n=6) at all UNPR and PR sites (see Table 3). At UNPR, water abstraction (mean score; 4.5/5.0); dynamite fishing and use of various poisons (4.3/5.0); overfishing (4.3/5.0); and domestic and urban waste (4.3/5.0) were the main threats recorded. These were closely followed by sand and boulder mining (4.0/5.0) and clearing of riparian vegetation (3.8/5.0). Within PR, domestic and urban waste (1.8/5.0) was the main noted threat (see Table 3).

DISCUSSION

Overall, our results show higher species richness and presence of greater numbers of threatened fish species within terrestrial protected areas and managed areas (temple pools and angling pools) (see Table 2). The index of fish diversity (mean ± SD) was comparatively similar within rivers (UNPR+PR), but dissimilar between rivers (Abellan et al., 2007; Sarkar et al., 2013). Similar trends were observed for the Shannon-Weiner diversity index (H) and Evenness (E), and could be due to similar fish diversity, similarity in the relative abundance of fish species, similar geographical distribution, and migratory behaviour of sampled fish species.

Overall, lower threat scores were obtained for sites within terrestrial protected areas and managed reaches in comparison to unprotected sites (see Table 3). The lower threat scores in PR highlights the potential conservation benefits of the studied protected sites (tiger reserves, temple pools and angling associations) for fish species from anthropogenic stressors.

When comparing between the three forms of PR, (i.e. terrestrial protected areas, temple pools and angling pools), terrestrial protected areas recorded six threatened fish species (IUCN, 2014) in comparison to temple pools (n=2) and angling pools (n=5) (see Table 2). Interestingly, of the six recorded threatened species

Table 3: Assigned scores (0 = no impact; 5 = most impact) to rivers and their fish species at unprotected (outside terrestrial protected areas, outside temple pools, outside angling pools) and protected (within terrestrial protected areas, within temple pools, within angling pools) sites according to the observed threats (n=6).

Threats	Sand and boulder mining	Dynamite fishing and use of various poisons	Overfishing	Domestic and urban waste	Clearing of riparian vegetation	Water abstraction
Type of fishes affected	Substrate dwelling	All	Food	All	All	All
Kosi						
Unprotected	5	5	5	4	4	5
Protected	1	1	1	2	3	1
Ramganga						
Unprotected	3	5	5	4	4	4
Protected	0	0	0	1	0	0
Khoh						
Unprotected	4	3	3	5	4	5
Protected	0	1	1	3	1	2
Rajaji						
Unprotected	4	4	4	4	3	4
Protected	0	0	0	1	0	0

(IUCN, 2014), only one (*T. putitora*) was recorded both from the UNPR and PR sites of terrestrial protected areas and managed reaches (see Table 2). This could be attributed to the observed migratory behaviour of this species (Gupta et al., 2014c). Further, terrestrial protected areas scored less for observed anthropogenic threats in comparison to managed reaches (see Table 3). This could be due to the more strictly enforced legislative powers of terrestrial protected areas (N. Gupta, personal observation within the Corbett Tiger Reserve (CTR) and Rajaji Tiger Reserve (RTR)), in comparison to community-driven religious beliefs and associated taboos, or local stakeholder managed species-oriented protective patrolling; and could have influenced the number of threatened species recorded from terrestrial protected areas and managed reaches. The lack of legislative, religious or socio-economic driven protection at UNPR sites could have resulted in increased anthropogenic threats and reduction in fish species richness (see Table 3).

It is also interesting to note the difference in threat scores between the PR (see Table 3). PR on the Ramganga (terrestrial protected areas, temple pools, angling pools) and streams (terrestrial protected areas) were only subjected to domestic and urban waste (mean score: 1.0/5.0). However, PR on the Kosi (temple pools and angling pools) and Khoh (temple pools) were subjected to a minimum of 5 out of 6 observed threats (see Table 3). However, despite these observed benefits there are several ecological and policy oriented concerns and challenges associated with terrestrial protected areas, temple pools and angling pools that need to be addressed (Dudley et al., 2009; Gupta et al., 2014a) before drawing such comparative conclusions (see below). Further, the studied terrestrial protected areas were not set up exclusively to protect the region's freshwater fishes unlike the angling pools, and more extensive research is needed before a comparison can be made.

Despite the examined terrestrial protected areas not encompassing the up- and downstream reaches of the Ramganga (CTR) and the streams (RTR), these terrestrial protected areas do offer some protection to the studied freshwater bodies and their fish species as uncontrolled human access is completely restricted within these areas by enforcement of various legislative measures. Nonetheless, there are ecological and socio-economic issues associated with terrestrial protected areas which cannot be overlooked in the long run. For example, various tourist roads, temporary bridges and upcoming lodges on river banks within protected areas contribute to habitat degradation (Gupta et al., 2014b; see Table 3). Additionally, semi-structured interviews with local community members living alongside protected areas and forest managers have revealed issues and conflicts regarding rights to forest use (N. Gupta, unpublished data).

There are potential hindrances for the managed reaches too. For example, the diminishing dependence on age-old traditional doctrines could mean that religious beliefs and taboos associated with temple pools could have less relevance in the future, especially in the case of communities living along river banks for whom fish is a

Boulder (left) sand mining (right) in unprotected sites © Nishikant Gupta

cheap protein source (Gupta et al., in review). Semi-structured interviews conducted with local priests at the studied temple pools have revealed that illegal fishing practices do occur sporadically at these pools during the night (N. Gupta, unpublished data).

Regardless of the socio-economic benefits of angling pools, recreational angling, in general, has been suggested to negatively affect fish communities, food webs and aquatic ecosystems (see Gupta et al., 2014a). Further, previous study in the region has highlighted monetary grievances among some local community members, and conservation concerns among scientists and forest managers regarding recreational angling activity (see Gupta et al., 2014a). We believe that more field based studies need to be conducted to better understand the long-term ecological benefits of angling pools for target fish species.

Nonetheless, it would be unfair to overlook the fact that the studied terrestrial protected areas and managed reaches were successful in providing some protection to the freshwater bodies and the fish species within their boundaries from anthropogenic stressors. For example, of the 21 recorded food fish species of the region (see Table 1), 13 were documented only from PR (terrestrial protected areas and managed sites). These were *A. mola*, *C. morar*, *C. punctata*, *G. lamta*, *G. catla*, *L. dyocheilus*, *L. pangusia*, *N. chelynoides*, *R. bola*, *T. tor*, *B. bagarius*, *G. pectinopterus* and *G. telchitta*. The remaining fish species (n=8) were found both within UNPR and PR. Among these eight species, the mean length (mm ± SD) of locally preferred food fish species (N. Gupta, personal communication with village members living alongside the sampled rivers; n=5) was significantly higher ($p<0.05$; ANOVA) within PR than UNPR sites. For example, *B. dero* (UNPR: 137.66±32.64, PR: 155.80±20.00; p=0.0028); *B. barna* (UNPR: 56.36±18.48, PR: 63.67±15.56; p=0.0356); *L. calbasu* (UNPR: 142.67±48.79, PR: 185.38±64.81; p=0.0001); *S. acinaces* (UNPR: 56.20±26.68, PR: 73.39±29.03; p=0.0005); and *T. putitora* (UNPR: 152.26±49.02, PR: 296.40±118.84; p=0.0004).

The potential benefits of the studied terrestrial protected areas and managed sites can be further explained by comparing the mean total body length (mm±SD) of the fish species (n=4) recorded from both UNPR and PR. Although these fish species belong to the Least Concern category (see Table 1), and are not as beneficial as game fish in assessing the conservation effectiveness of sampled terrestrial protected areas and managed reaches for freshwater fish conservation. These fish species are *B. barna* (UNPR: 56.36±18.48; PR: 63.67±15.56; p=0.0356), *Crossocheilus latius* (UNPR: 46.50±18.78; PR: 65.19±11.72; p=0.0024), *Puntius sophore* (UNPR: 57.44±23.31; PR: 74.41±17.63; p=0.0097), and *Salmostoma acinaces* (UNPR: 56.20±26.68; PR: 73.39±29.03; p=0.0015).

Further, recreational angling, in particular catch-and-release angling is a rapidly emerging leisure activity in the region (Everard & Kataria, 2011). However, since the angling ban within protected areas in 2012 (see Pinder & Raghavan, 2013 for discussion), angling occurs on river reaches outside CTR (Ramganga river) through the issuing of permits by the Uttarakhand Forest Department. Target species are *T. putitora* and *B. bagarius* which attract both domestic and international anglers to the region and bring social and economic benefits to some local communities (Everard & Kataria, 2011). However, *B. bagarius* was only recorded from

Rajaji Tiger Reserve (left) and temple pools (right) © Nishikant Gupta

terrestrial protected areas (Ramganga river, CTR), a socio-economic concern for the local stakeholders involved in the angling tourism industry here.

Although *T. putitora* was documented from UNPR on the Ramganga river where the angling pools are located (see Gupta et al., 2014a), there are several concerns among local stakeholders regarding the anthropogenic threats faced by this species (see Gupta et al., 2014a, c). UNPR on the Ramganga river are subject to rampant dynamite fishing and use of various poisons (mean score: 5.0/5.0) and overfishing (5.0/5.0) (see Table 3). A decline in this remaining angling target species could influence the viability of the current angling tourism in the region, and negatively affect the available socio-economic returns for local stakeholders.

Based on the data obtained during this study, the inclusion of a freshwater body within legislatively defined zones (protected areas), temple pools or angling pools has the potential to offer some protection to the region's freshwater fish species from observed anthropogenic threats. However, the unprotected river reaches outside protected areas; temple pools and angling pools need to be safeguarded from anthropogenic threats to protect locally important food fish species, and angling target species. In view of the observed threats and their intensity of occurrence within unprotected sites, urgent research also needs to be undertaken to ascertain whether the unprotected sites harbour spawning sites or migratory routes of endemic fish species, especially threatened ones for long-term conservation of fish species, and the protection of associated socio-economic benefits.

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Corbett Tiger Reserve © Nishikant Gupta

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Unprotected sites: domestic and urban waste (left) and outside temple pools (right) © Nishikant Gupta

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RESUMEN

Las áreas terrestres protegidas y los tramos fluviales gestionados por los interesados locales pueden actuar como herramientas de gestión para la conservación de la biodiversidad. Estas áreas pueden proteger las especies de peces contra factores de estrés tales como la sobrepesca, la degradación y fragmentación del hábitat y la contaminación. Para probar este concepto, llevamos a cabo una evaluación sobre el potencial de los tramos fluviales gestionados y no gestionados para conservar las especies amenazadas de peces de agua dulce. La evaluación comprendió el muestreo de una diversidad de peces en 62 sitios en ríos importantes de Uttarakhand, India (los ríos Kosi, Ramganga y Khoh) tanto dentro de áreas protegidas (es decir, sitios dentro de las reservas de tigres Corbett y Rajaji y de tramos gestionados) como no protegidas (es decir, sitios fuera de las reservas de tigres y de tramos gestionados). En total, se recolectaron 35 especies de peces de todos los sitios, incluyendo dos especies de pez carpa (Mahseer). Las áreas protegidas tenían peces más grandes en comparación con los individuos recolectados fuera de las áreas protegidas. Entre todos los sitios, los niveles más bajos de degradación del hábitat se encontraron dentro de las áreas protegidas. Los sitios no protegidos mostraron mayores afectaciones a la calidad del agua (puntuación media de amenaza: 4,3/5,0), pesca ilegal (4,3/5,0), desviación de los cursos de agua (4,5/5,0), despeje de la vegetación ribereña (3.8/5.0), y extracción de arena y piedra (4,0/5,0) que en los sitios protegidos. Este estudio apoya la importancia de la existencia de áreas terrestres protegidas y sitios gestionados para la conservación de peces amenazados y la prevención de actividades perjudiciales.

RÉSUMÉ

Les aires protégées terrestres et les tronçons de rivière gérés par les intervenants locaux peuvent servir d'outils de gestion pour la conservation de la biodiversité. Ces zones ont un rôle potentiel dans la protection des poissons face aux facteurs de stress tels la surpêche, la fragmentation et la dégradation de leur habitat, et la pollution. Pour vérifier cette hypothèse dans les cours de rivière gérés et non-gérés, nous avons effectué une évaluation de leur potentiel pour conserver les espèces menacées de poissons d'eau douce. L'évaluation impliquait un échantillonnage de la diversité des poissons sur 62 sites au long de grands fleuves de l'Uttarakhand en Inde (fleuves Kosi, Ramganga et Khoh), soit au sein d'aires protégés (cours d'eau gérés dans les réserves de tigre du Corbett et Rajaji), soit non protégés (cours d'eau non-gérés, hors des réserves). Au total, 35 espèces ont été prélevées, y compris deux espèces de mahseer (tor). Des poissons de plus grande taille se trouvaient dans les aires protégées par rapport aux spécimens récoltés en dehors des aires protégées. Parmi tous les sites, les niveaux les moins élevés de dégradation de l'habitat ont été trouvés à l'intérieur des aires protégées. Les sites non protégés ont révélé des impacts plus élevés sur la qualité de l'eau (note moyenne : 4.3/5.0), la pêche illégale (4,3/5,0), le détournement des cours d'eau (4.5/5.0), le défrichement de la végétation riveraine (3.8/5.0) et d'extraction de sable et de galets (4.0/5.0). Cette étude confirme l'importance des aires protégées terrestres et des sites gérés pour la conservation de poissons menacés et la prévention des activités nuisibles.