PARKS

The International Journal of Protected Areas and Conservation

Developing capacity for a protected planet

Issue 27.2 November 2021

IUCN WCPA WORLD COMMISSION ON PROTECTED AREAS 1960 - 2020

Convention on Biological Diversity

protected planet

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/
Contribute to developing capacity for a Protected Planet at: www.protectedplanet.net/

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

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 and others;
- 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.

Thanks to: Mariart for layout advice and front cover picture production. Patricia Odio Yglesias and Sarah LaBrasca for abstract translations. Caroline Snow for proofreading. And to all the reviewers who so diligently helped in the production of this issue.

Published by: IUCN, Gland, Switzerland

Citation: IUCN WCPA (2021). *PARKS. The International Journal of Protected Areas and Conservation,* Volume 27.2 Gland, Switzerland: IUCN.

ISSN: ISSN 2411-2119 (Online), ISSN 0960-233X (Print)

DOI: 10.2305/IUCN.CH.2021PARKS-27-2en

Cover photo: Elephants © Marc Hockings

Editing: Marc Hockings, Pamela Wright, Helen Newing, Bas Verschuuren, Olivier Chassot, Jonas Geldmann

Layout by: Marc Hockings, IUCN WCPA

Available from: IUCN (International Union for Conservation of Nature)
Global Programme on Protected Areas
Rue Mauverney 28
1196 Gland
Switzerland
Tel +41 22 999 0000
Fax +41 22 999 0002
parksjournal.com
iucn.org/theme/protected-areas/publications/parks-journal

PARKS: THE INTERNATIONAL JOURNAL OF PROTECTED AREAS AND CONSERVATION

Edited by Marc Hockings, IUCN WCPA Vice-Chair for Science and Management of Protected Areas; Emeritus Professor, University of Queensland.

editor@parksjournal.com
School of Earth and Environmental Sciences, University of Queensland, St Lucia, Queensland 4072, Australia.

CONTENTS

Madhu Rao, Chair IUCN WCPA

Andrew Rhodes Espinoza, Deputy Chair IUCN WCPA

EDITORIAL FROM THE WCPA CHAIR AND DEPUTY CHAIR

Positioning for impact at scale: WCPA priorities for stewardship of nature to 2030 and beyond

Safeguarding natural ecosystems from further degradation and collapse is an existential challenge for humanity. Equitable, well managed and effective networks of protected and conserved areas (PCAs) should form the core of our response to the current biodiversity and climate crises. The World Commission on Protected Areas (WCPA) is uniquely positioned as a provider of technical support to relevant actors to effectively secure natural ecosystems for biodiversity and human well-being.

The core mission of the WCPA is to develop and provide scientific, technical and policy advice and to advocate for global and national systems of marine, freshwater and terrestrial protected areas and other effective area-based conservation measures (OECMs) that result in successful outcomes for the conservation of biodiversity, based on principles of sound design, good management and equitable governance.

The core value of the Commission lies within its themes, specialist groups, and task forces that define its technical strengths and unique contribution to functioning systems of protected and conserved areas. They drive innovation through rigorous technical guidance and practical tools to achieve well-functioning global systems of protection through engagement with diverse constituencies. The strong regional networks of WCPA ensure that this work in developing guidance for PCAs is grounded in an understanding of the diverse circumstances that apply around the world.

We begin the new quadrennium with PCAs facing intense and complex challenges. Economic forces linked to the escalating demand for natural resources are creating enormous pressures on PCAs. Within this context of intensifying threat, our responsibility as a Commission is to ensure that systems of PCAs can not only hold their ground but also expand in spatial scale (quantity) and effectiveness (quality) to protect the ecosystems needed for a healthy planetary future.

Looking into the decade ahead as it unfolds, priorities for the Commission build on its core technical strengths, and positioning within the Union, as a key global knowledge-broker and standard-setter for protected areas.

The IUCN World Conservation Congress 2021 manifesto implored governments to set ambitious targets for protected areas and OECMs, calling for at least 30 per cent of the planet to be protected by 2030. Further, it noted that these targets must be based upon the latest science and reinforce rights – including Free Prior and Informed Consent – as set out in the UN Declaration on the Rights of Indigenous Peoples.

In alignment with the IUCN Programme and the Marseille Manifesto, WCPA will build its work with a foundational emphasis on conservation outcomes. Ensuring that existing and new PCAs are effective in

Tiger, Kanha National park, India © Madhu Rao

achieving biodiversity outcomes – with due respect for and recognition of the rights of people dependent on the area and its resources. Protected and conserved areas are intended to deliver positive benefits for nature, and especially for biodiversity conservation.

This is a fundamental shift, building on good intentions for conservation but moving to demonstrable, sustainable results. The placement of conservation outcomes for PCAs in the front and at the centre of its mission will define the Commission's work in the coming decade.

Achieving effective conservation outcomes requires that protected and conserved areas are equitably governed and effectively managed. WCPA can contribute significantly towards improving effectiveness of area-based conservation measures in many ways, including through supporting the implementation of the IUCN Green List Standard; supporting PCAs to measure, improve and maintain their performance; through to promoting globally consistent criteria that benchmark good governance, sound design and planning, and effective management.

The following are six key priorities of the WCPA as we head into the next quadrennium:

Supporting implementation of Post 2020 Global Biodiversity Framework Target 3 (30x30)

Area-based conservation through the establishment and management of "protected and conserved" areas lies at the heart of the Global Biodiversity Framework being negotiated by the Parties to the Convention on Biological Diversity (CBD). Achieving Target 3 (30 per cent of land and sea in effective, equitable, ecologically representative and well-connected protected and conserved areas by 2030) will require an unprecedented effort to establish, restore and effectively manage a global network of protected and conserved areas (PCAs). WCPA has played an important role in the development of relevant technical guidance including but not restricted to Key Biodiversity Areas, Important Marine Mammal Areas and connectivity. WCPA, with its 3,000 technical experts in 160 countries, has a unique role to play in providing essential technical and scientific support to government agencies, civil society organisations, intergovernmental organisations, NGOs, Indigenous Peoples' organisations and communities and private actors for successful implementation of Target 3.

Protecting and restoring priority ecosystems for biodiversity value, ecosystem services and carbon retention

The WCPA will support and help implement, in priority countries, broad-scale spatial planning to actively identify opportunities for PCAs where there are significant biodiversity values, ecosystem services and carbon retention for protection and restoration. Based on WCPA's work on natural solutions, this will bring capacity for decision-makers and stakeholders on best practices in relation to key science, planning processes and decision-support tools. Improving the protection of the last remaining intact forests and wilderness areas,

along with freshwater, mangrove and peatland ecosystems, for example, can help achieve both biodiversity and climate mitigation goals.

Diversification of governance and management models

Filling gaps in protected and conserved areas coverage will require a wide range of governance and management models through liaising with a range of government and non-government actors. WCPA can promote implementation of OECMs, privately protected areas and urban protected areas by supporting the integration of these measures into national accounting mechanisms.

Strengthening financial capacity for PCAs

Institutions managing PCAs need to have long-term adequate financing and to leverage diverse finance tools to achieve desired biodiversity outcomes and management objectives – the goal of sustainable finance. Historically, area-based conservation remains under-resourced, often overly reliant on a single income source such as donor-funding, tourism or government budgets. The development of new, innovative and resilient sources of finance is critical if area-based conservation mechanisms are to reach their full potential.

WCPA through its newly reorganised Sustainable Finance Specialist Group will enable and empower area-based conservation actors by developing and sharing knowledge, building awareness and capacity, and promoting strategic innovation in sustainable finance solutions.

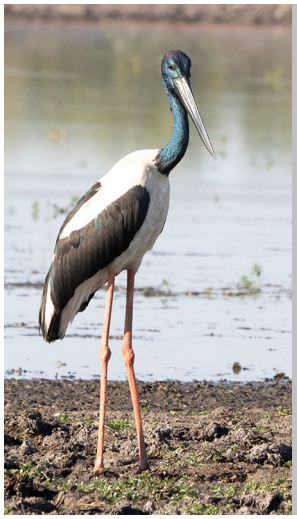
Capacity development and professionalisation

Increased ambition for the global coverage of PCAs has massive implications for human capital. Achieving conservation outcomes for existing and new areas requires a major scaling up of the numbers and diversity of people directly involved in area-based management, extending beyond the 'conventional' management models. Objectives of the Capacity theme will include providing new and existing personnel and stewards with the required recognition, qualifications, skills and resources for effective and equitable management. This will involve both advancing the further professionalisation of 'conventional' protected area personnel (including rangers) and understanding and addressing the capacity needs and contributions of Indigenous and community stewards of existing and future protected areas and OECMs.

Scaling up

Ambitious global commitments for biodiversity (e.g. 30x30) and climate (1.5 degrees) require a radical rethink and shift in approach: in theory WCPA could be providing technical support to a third of the planet's surface. Consequently, an urgent need is to scale up our impact, building on the expert-driven volunteer system of WCPA that has served well until now. This includes but is not limited to guiding the design and management of PCAs as natural solutions to global challenges such as climate change, land degradation, food and water security, health and well-being. We need to purposefully integrate PCAs into the global climate, human health and restoration agendas, always maintaining a focus on the core biodiversity mandate for PCAs. An important priority for WCPA will be to inspire a new generation of conservation leaders and young professionals, across geographies and cultures, to engage with the work of the Commission.

The loss of nature is widely acknowledged as a risk to global societies. Protecting nature is not just an economic imperative, it is essential for human well-being, including prevention of future pandemics within a climate change context. WCPA can contribute impact at scale by building on its core strength as the technical backbone for the global system of protected and conserved areas.



SPEAKING A COMMON LANGUAGE ON WHAT SHOULD COUNT FOR PROTECTING 30 PER CENT BY 2030?

Stephen Woodley[1*], Madhu Rao[1], Kathy MacKinnon[1], Trevor Sandwith[2] and Nigel Dudley[1]

* Corresponding author: Woodleysj@gmail.com

[1]World Commission on Protected Areas, International Union for Conservation of Nature
[2]Centre for Conservation Action, International Union for Conservation of Nature

ABSTRACT

Increases in area-based conservation are essential to halt biodiversity loss and respond to climate change. Parties to the Convention on Biological Diversity are poised to adopt a target of protecting at least 30 per cent of the Earth's lands, seas and freshwater by 2030. This is in the draft Global Biodiversity Framework and supported by over 70 countries who have joined the High Ambition Coalition. The IUCN World Commission on Protected Areas, in partnership with UNEP – World Conservation Monitoring Centre, National Geographic, the Wildlife Conservation Society and Birdlife International has published guidance entitled 'Conserving at least 30% of the planet by 2030: What should count?'. This guidance calls for a focus on quality as an essential part of large area-based conservation targets. Quality includes many elements, including a focus on establishing protected and conserved areas in areas important for biodiversity, how they are designed and ecologically connected, and ensuring management effectiveness and governance equity. But protected and conserved areas must be realised in full partnership with Indigenous and local communities. The 30 per cent minimum target provides a significant opportunity to strengthen security of tenure, land and use rights especially for Indigenous Peoples and support to IPLC-led conservation efforts. Moving to protect at least 30 per cent of the Earth by 2030 is a grand challenge in which we need to speak a common language.

Key words: protected areas; conserved areas; ecological connectivity; Convention on Biological Diversity; conservation equity

As Parties prepare for COP15 of the Convention on Biological Diversity, there is major global momentum towards establishing a more ambitious target of protecting at least 30 per cent of lands, oceans and freshwater by 2030. This milestone towards living in harmony with nature by 2050 is written into the first draft of the Global Biodiversity Framework under the Convention on Biological Diversity (CBD), building on Aichi Target 11. Scientific support (Woodley et al., 2019) for this level of ambition is clear and that 30 per cent is an absolute minimum target. The IUCN World Conservation Congress in Marseille, France adopted a resolution calling for IUCN "to support, at a minimum, a target of effectively and equitably protecting and conserving at least 30% of terrestrial areas and of inland waters and of coastal and marine areas respectively…". This became part of the Marseille Manifesto[i], which "implored governments to set ambitious protected area and other effective area-based conservation measure targets by calling for at least 30% of the planet to be protected by 2030". The 'at least 30 per cent by 2030' target is now IUCN policy.

Over 70 countries have signed onto the High Ambition Coalition[ii], championing a global deal for nature and people, with the central goal of protecting at least 30 per cent of the world's land and ocean by 2030.

A focus on area-based conservation is justified, as the key driver of biodiversity loss is when wildlife habitat is either degraded, often through fragmentation, or destroyed by human activities. Climate change amplifies these pressures. Effective protected and conserved areas are an essential part of solving the global biodiversity crisis, while increasing and protecting carbon stocks in natural ecosystems helps to address the climate crisis.

> Global Biodiversity Framework Draft 1 – Target 3. Ensure that at least 30% globally of land areas and of sea areas, especially areas of particular importance for biodiversity and its contributions to people, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Wabakimi Provincial Park, Ontario, Canada © Alison Woodley

WHAT CAN BE COUNTED TOWARDS THE 30 PER CENT TARGET?

The 'at least 30 per cent' figure should include **only** protected areas and other effective area-based conservation measures (OECMs). Both these types of area-based conservation measures are defined under the CBD and both have extensive CBD and IUCN guidance. Protected and conserved areas represent a wide variety of approaches to ensuring specific biodiversity outcomes. Four governance types are recognised by the IUCN: 1) government; 2) shared, 3) private and 4) Indigenous Peoples and Local Communities. All governance types are important. IUCN's six protected area categories are approaches to management that can be used to meet a wide variety of goals and approaches. This matrix of options for the governance and management of protected and conserved areas is inclusive of the variety of approaches to governance undertaken by a broad constituency of authorities including Indigenous Peoples and local communities.

In implementing the area-based global target of protecting at least 30per cent by 2030, **the focus must be on quality, both for what is conserved and for how it is conserved**. The protected and conserved areas that would constitute the 30 per cent of the planet must deliver positive outcomes for biodiversity. We know that biodiversity outcomes are a function of quality, meaning selecting areas that are important for biodiversity, and ensuring sound ecological design, equitable governance and effective management. Protected and conserved areas must also be socially just and sustainable, not only respecting rights and principles of justice, but engaging the whole of society in their governance and management.

The IUCN World Commission on Protected Areas, in partnership with UNEP – World Conservation Monitoring Centre, National Geographic, the Wildlife Conservation Society and Birdlife International has published guidance entitled 'Conserving at least 30% of the planet by 2030: What should count?' (IUCN-World Commission on Protected Areas, 2021). This guidance, already available in four languages, consolidates and summarises existing IUCN guidance and decisions of the CBD, to enable practitioners to speak a common language on what counts. Halting biodiversity loss is a global ambition, implemented according to national circumstances. However, implementation must follow a set of principles and standards.

First some context. We cannot simply protect 30 per cent of the planet and forget about the rest. The 30x30

target represents high quality, nature-first protection that forms the backbone of halting biodiversity loss. But to live in harmony with nature, we must think about 100 per cent of the planet. The other 70 per cent must focus on well-managed, biodiversity-friendly systems for agriculture, grazing, forestry, fishing, transportation and urban areas. We need a whole-Earth solution. We should not try and pack all our required conservation actions into the 30 per cent that is protected or conserved.

Protecting and conserving at least 30 per cent by 2030 must be addressed in the context of recognising the rights of Indigenous Peoples and Local Communities (IPLCs). It is well established that Indigenous and community-governed territories often effectively retain their biodiversity conservation values (Schuster et al., 2019). It is also clear that protecting at least 30 per cent of the Earth will not occur without the leadership, support and partnership of Indigenous Peoples, local communities, and other governing authorities.

Black-necked Stork, Kakadu National Park, Australia © Marc Hockings

Protected and conserved areas can provide enormous benefits at the local level (Naidoo et al., 2019), but they must be recognised and managed with due regard for human rights (Tauli-Corpuz et al., 2020). This in turn means that there will be many more stakeholders and rightsholders involved in decisions about how, where and what to conserve. Traditional knowledge will be taken into account alongside those of conservation scientists. Conservation works best when it is equitable: based on full participation, shared and transparent decision-making, rights-based approaches, and fair benefit sharing. The 30 per cent minimum target provides a significant opportunity to strengthen security of tenure, land and use rights especially for Indigenous Peoples and support IPLC-led conservation efforts. Protecting at least 30 per cent is not a land or sea grab. It is an opportunity to recognise and support the rights of IPLCs.

A FOCUS ON AREAS IMPORTANT FOR BIODIVERSITY

Biodiversity is not distributed evenly across the globe. Effective conservation requires the identification and protection of areas that are especially important for biodiversity. Countries should focus on protecting and conserving Key Biodiversity Areas (KBAs), defined as "sites contributing significantly to the global persistence of biodiversity". IUCN has developed a Global Standard for the Identification of Key Biodiversity Areas (IUCN, 2016) for countries to use to identify KBAs. The Key Biodiversity Areas Partnership has identified over 16,000 sites globally and countries are called on to identify new sites against the criteria of the Standard. In addition to KBAs, other important sites include Ecologically or Biologically Significant Marine Areas, or EBSAs, Important Marine Mammal Areas, and equivalent national high-priority areas. All these areas can be managed as protected areas or OECMs, depending on the context.

MOVING FROM CONSERVATION ISLANDS TO CONSERVATION NETWORKS

It is clear that we need to move from protecting individual sites to protecting ecological networks. Important sites should be linked into effective ecological networks through systematic conservation planning to optimise biodiversity conservation. With increasing habitat loss and fragmentation, maintaining and conserving ecological connectivity is essential, especially in a world that is impacted by climate change. IUCN has published guidance on ecological corridors and networks (Hilty et al., 2020) and work is underway to report these to the Protected Planet (UNEP-WCMC, IUCN, 2021) database.

EFFECTIVE CONSERVATION

Countries report, through the Protected Planet database, that they currently protect and conserve 16.7 per cent of land and 8 per cent of the global ocean. Unfortunately, many of those protected areas are not well managed or even managed at all, nor do all the areas reported as 'protected areas' meet the definitions of IUCN and the CBD. Conversely, some protected areas – particularly privately protected areas and ICCAs, are not included in government statistics. Many governments are under-investing in conservation, and protected areas are being logged and converted to agriculture rather than being well managed.

Common standards should be applied to both protected and conserved areas so that they are well- designed, well-governed and effectively managed in ways that lead to positive conservation outcomes. The IUCN Green List of Protected and Conserved Areas (Hockings et al., 2019) provides a global standard that applies to land, inland waters, and marine and coastal environments. The Green List criteria can be used to guide authorities and managers of all kinds in seeking to make their protected and conserved areas more effective. It is essential to ensure all protected and conserved areas are effective and to realise that paper parks, degazetting and poorly resourced protected and conserved areas are a major problem for the CBD and for global conservation. There is little point in establishing these places unless they are effective in the long term.

THE CHALLENGE AND OPPORTUNITY OF OTHER EFFECTIVE AREA-BASED CONSERVATION MEASURES

The 'at least 30 per cent' by 2030 target includes other effective area-based conservation measures (OECMs), first referenced by CBD Aichi Target 11 with a definition and criteria adopted by Parties at COP14 (Convention on Biological Diversity, 2018). To date, there have been few OECMs reported to Protected Planet, but many countries are considering OECMs to achieve 30 per cent. This is both a challenge and an opportunity. OECMs should not displace efforts to create additional protected areas or be considered as some lesser form of conservation. Under the CBD decisions, OECMs are meant to complement protected areas and should be equally important for maintaining biodiversity. They must demonstrate that they are delivering effective long -term conservation of important biodiversity. Although OECMs may not be managed primarily for conservation, they should achieve the same level of in-situ, or whole ecosystem, biodiversity conservation as protected areas. Multiple-use production areas (e.g., production forests, plantations and industrial fisheries areas) that are managed with some biodiversity considerations should not be promoted as OECMs. While such areas are important, they should be counted towards additional sustainable use targets and not towards the 30 per cent conservation target. It is critical that we get the recognition, reporting and support of OECMs right. They may be especially useful for assisting Indigenous Peoples and Local Communities to achieve their conservation objectives and provide recognition and support for their work. However, they must not be seen as a lesser path to achieve 30 per cent by 2030. IUCN has provided detailed guidance on OECMs (IUCN -WCPA, 2019) that is consistent with the CBD decision and is developing a range of decision support tools.

THE PATH FORWARD

The 'at least 30 per cent' by 2030 target for area-based conservation will contribute to a range of targets in the Global Biodiversity Framework, as well as other multilateral environmental agreements. In addition to conserving nature, increased area-based conservation provides many additional benefits, contributing to food and water security, healthy communities, livelihoods, and climate change adaptation and mitigation, among others. Well managed protected areas will also reduce the likelihood of the emergence of new zoonotic diseases. The momentum on area-based conservation over the last decade provides encouragement to Parties to the CBD to continue their efforts for more ambitious conservation targets for the Post-2020 Global Biodiversity Framework and strengthens hope for the United Nations' 2030 Agenda for Sustainable Development.

We call on Parties to the CBD, international organisations, development partners, management agencies and civil society to speak a common language when implementing a global goal of protecting at least 30 per cent by 2030. This is an enormous opportunity for conservation, for halting biodiversity loss, and responding to the climate crisis. Well managed protected and conserved areas are an essential part of solving the global biodiversity crisis, while protecting carbon stocks in nature helps to address the climate crisis. Let us focus on quality and equity, and ensure our systems of protected and conserved areas deliver strong conservation outcomes. Nature is in crisis. We must step up and act.

ENDNOTES

[i] IUCN (2021). The Marseille Manifesto. IUCN World Conservation Congress, Marseille, France. https://www.iucncongress2020.org/programme/marseille-manifesto.

[ii] The High Ambition Coalition for Nature and People (2021). https://www.hacfornatureandpeople.org/

ABOUT THE AUTHORS

Stephen Woodley is an ecologist, who has worked in environmental conservation as a consultant, a field biologist, researcher, and first Chief Scientist for Parks Canada. He is Vice Chair for Science and Biodiversity of IUCN's World Commission on Protected Areas, focusing on the role of protected areas as solutions to the current global conservation challenges.

Madhu Rao is the elected Chair of IUCN's World Commission on Protected Areas. She is also Senior Advisor for WCS and serves as Strategic Advisor for the IUCN SSC convened Asian Species Action Partnership. Madhu has engaged with international conservation policy platforms such as CITES and CBD and has published in the peer-reviewed literature on topics related to protected area policy and threatened species conservation to human wildlife conflict, conservation prioritization and governance. Her core strength at the science-policy interface is complemented by practical, field implementation experience across Asia and the ASEAN region with protected area creation, management and policy.

Kathy MacKinnon is the former Chair of IUCN's World Commission on Protected Areas. She has spent a lifetime working on protected and conserved areas, from early fieldwork in Southeast Asia to serving as the Lead Biodiversity Specialist at the World Bank. She cochairs the WCPA Specialist Group on other effective area-based conservation measures (OECMs). Dr. Mackinnon received the MIDORI prize in 2018.

Trevor Sandwith is a South African ecologist and nature conservation strategist who promotes the integration of protected and conserved areas in sustainable economic and social development. He has experience in the governance and management of protected and conserved area systems, and in mainstreaming biodiversity considerations into development policies and planning. At international level, he has specialized in transboundary governance of protected areas and in seeking recognition of ecosystem -based approaches to address climate change. He is Director of IUCN's Centre for Conservation Action.

Nigel Dudley is a consultant ecologist and partner at Equilibrium Research who works across many areas of conservation, planning and management.

REFERENCES

Convention on Biological Diversity (2018). *CBD Decision 14/8: Protected areas and other effective area-based conservation measures.* Conference of the Parties 14th meeting, Sharm El-Sheikh, Egypt, 17–29 November. https://www.cbd.int/doc/decisions/cop-14/cop-14-dec-08-en.pdf.

Hilty, J., Worboys, G.L., Keeley, A., Woodley, S., Lausche, B., Locke, H., Carr, M., Pulsford I., Pittock, J., White, J.W., Theobald, D.M., Levine, J., Reuling, M., Watson, J.E.M., Ament, R. and Tabor, G.M. (2020). *Guidelines for conserving connectivity through ecological networks and corridors.* Best Practice Protected Area Guidelines Series No. 30. Gland, Switzerland: IUCN. http://dx.doi.org/10.2305/IUCN.CH.2020.PAG.30.en

Hockings, M., Hardcastle, J., Woodley, S., Sandwith, T., Wilson, J., Bammert, M., Valenzuela, S., Chataigner, B., Lefebvre, T., Leverington, F., Lopoukhine, N., MacKinnon, K. and Londoño, J.M. (2019). The IUCN Green List of Protected and Conserved Areas: Setting the standard for effective area-based conservation. *PARKS* 25(2): 57–66. https://doi.org/10.2305/IUCN.CH.2019.PARKS-25-2MH.en

IUCN (2016). *A Global Standard for the Identification of Key Biodiversity Areas*, Version 1.0. First edition. Gland, Switzerland: IUCN. ISBN 978-2-8317-1835-4

IUCN-WCPA Task Force on OECMs (2019). *Recognising and reporting other effective area-based conservation measures*. Gland, Switzerland: IUCN. http://dx.doi.org/10.2305/IUCN.CH.2019.PATRS.3.en

IUCN-World Commission on Protected Areas (2021). *Conserving at least 30% of the planet by 2030: What should count?* https://www.iucn.org/commissions/world-commission-protected-areas/resources

Naidoo, R., Gerkey, D., Hole, D., Pfaff, A., Ellis, A.M., Golden, C.D., Herrera, D., Johnson, K., Mulligan, M., Ricketts, H. and Fisher, B. (2019). Evaluating the impacts of protected areas on human well-being across the developing world. *Science Advances* 5(4): eaav3006. https://doi.org/10.1126/sciadv.aav3006

Schuster, R., Germain, R.R., Bennett, J.R., Reo, N.J. and Arcese, P. (2019). Vertebrate biodiversity on Indigenous managed lands in Australia, Brazil, and Canada equals that in protected areas. *Environmental Science and Policy* 101: 1–6. https://doi.org/10.1016/j.envsci.2019.07.002

Tauli-Corpuz, V., Alcorn, J., Molnar, A., Healy, C. and Barrow, E. (2020). Cornered by PAs: Adopting rights-based approaches to enable cost-effective conservation and climate action. *World Development* 130: 104923. https://doi.org/10.1016/j.worlddev.2020.104923

UNEP-WCMC, IUCN (2021). *Protected Planet: The World Database on Protected Areas* (WDPA). https://www.protectedplanet.net/en.

Woodley, S., Locke, H., Laffoley, D., MacKinnon, K., Sandwith, T. and Smart, J. (2019). A review of evidence for area-based conservation targets for the Post-2020 Global Biodiversity Framework. *PARKS* 25(2): 19–30. https://doi.org/10.2305/IUCN.CH.2019.PARKS-25-2SW2.en

RESUMEN

El aumento de la conservación basada en áreas es primordial para detener la pérdida de biodiversidad y hacer frente al cambio climático. Las partes del Convenio sobre la Diversidad Biológica están dispuestas a adoptar el objetivo de proteger al menos el 30% de las tierras, los mares y el agua dulce de la Tierra para 2030. Esto está enmarcado en el borrador del Marco Global de Biodiversidad y es apoyado por más de 70 países que se han unido a la Coalición de Alta Ambición. La Comisión Mundial de Áreas Protegidas de la UICN, en colaboración con el Centro Mundial de Monitoreo de la Conservación del PNUMA, National Geographic, la Sociedad para la Conservación de la Vida Silvestre y Birdlife International, ha publicado las directrices "Conservar al menos el 30% del planeta para 2030: ¿qué se debería considerar?" Estas directrices exigen atención especial a la calidad como elemento esencial de los objetivos de conservación basados en áreas de gran tamaño. La calidad incluye muchos elementos, entre ellos el establecimiento de áreas protegidas y conservadas en zonas importantes para la biodiversidad, la forma en que están diseñadas y conectadas ecológicamente, además de asegurar la eficacia de la gestión y la equidad de la gobernanza. Pero las áreas protegidas y conservadas se deben promover en plena colaboración con las comunidades indígenas y locales. El objetivo mínimo del 30% representa una importante oportunidad para reforzar los derechos de tenencia de la tierra, la seguridad de la tenencia y el acceso a la tierra, especialmente para los pueblos indígenas, y para apoyar los esfuerzos de conservación dirigidos por los pueblos indígenas y las comunidades locales (IPLC, por sus siglas en inglés). El avance hacia la protección de al menos el 30% de la Tierra para 2030 es un gran reto en el que debemos hablar con una sola voz.

RÉSUMÉ

L'augmentation de la conservation par zone est essentielle pour stopper la perte de biodiversité et répondre au changement climatique. Les parties présentes à la Convention sur la diversité biologique sont sur le point d'adopter un objectif de protection englobant au moins 30 pour cent des terres, des mers et de l'eau douce de la Terre d'ici 2030. Cet objectif fait parti du projet initial du cadre mondial de la biodiversité soutenu par plus de 70 pays qui ont rejoint la Coalition de la Haute Ambition. La Commission mondiale des aires protégées de l'UICN, en partenariat avec le Centre mondial de surveillance de la conservation du PNUE, le National Geographic, la Wildlife Conservation Society et Birdlife International, a publié des directives intitulées « Le monde doit protéger 30 % des terres et des océans d'ici 2030. Est-ce réalisable ?». Ces orientations appellent à mettre l'accent sur la qualité en tant qu'élément essentiel des objectifs de conservation par zone à grande échelle. La qualité comprend de nombreux éléments, notamment l'établissement d'aires protégées et conservées dans des zones importantes pour la biodiversité, la manière dont elles sont conçues et écologiquement connectées, et l'efficacité de la gestion et de l'équité de la gouvernance. Mais les aires protégées et conservées doivent être réalisées en partenariat absolu avec les communautés autochtones et locales. L'objectif minimum de 30 % offre une opportunité importante de renforcer les droits à la terre, les droits fonciers et d'utilisation en particulier pour les peuples autochtones, et le soutien aux efforts de conservation menés par les PACL. Protéger au moins 30 % de la terre d'ici 2030 est un grand défi pour lequel nous devons tous parler un langage commun.

NAHUEL HUAPI NATIONAL PARK, ARGENTINA: CONSERVATION EFFECTIVENESS ASSESSMENT THROUGH MONITORING SMALL MAMMAL COMMUNITIES

Maria Daniela Rivarola*, Daniel Simberloff and Christy Leppanen

* Corresponding author: mrivarol@vols.utk.edu

University of Tennessee, Knoxville, TN, United States

ABSTRACT

Protected areas are the cornerstone of conservation strategies, but their effectiveness is increasingly questioned. In Argentina's Nahuel Huapi National Park, we compared small mammals in unprotected areas and areas with three protection levels: (1) human activity forbidden, (2) recreation can be authorised, and (3) authorised tourism and extractive uses. A capture-mark-recapture study on five plots in each type of area included a trapping effort of 41,600 traps/night. In 2015, we trapped seven native rodent species and an endemic marsupial. In 2016, we captured the same species except for one rodent. Species richness did not vary among protection levels. However, greatest abundances were in the highest protection level and lowest abundances in the lowest level. We found scant evidence that the Nahuel Huapi National Park protection system substantially conserves small mammals. However, higher abundances in the highest protection level suggest direct human interaction negatively affects this assemblage.

Key words: capture-recapture, community, conservation

INTRODUCTION

Protected areas (PAs) are a key component of biodiversity conservation (Mascia & Pailler, 2011). Target 11 of the Aichi Biodiversity Targets proposes that they must be effectively and equitably managed (CBD, 2010), yet recent publications increasingly question the success of PAs in conserving biodiversity (Barnes et al., 2017; Barnes et al., 2016; Coad et al., 2019; Coetzee et al., 2014; Geldmann et al., 2018). A study published in 2014 found that species richness and abundance inside some PAs in South America were lower than outside (Coetzee et al., 2014).

Developed countries established PAs more than a century ago; however, the process began later in developing countries. Argentina is an exception. Land that would come to constitute Nahuel Huapi National Park (NHNP) was set aside in 1906; in 1922 the area was declared a National Park with the main goal of avoiding the destructive exploitation of forests and preserve the beautiful natural landscape (APN, 2013), and it constitutes the first PA in Latin America (Rivarola et al., 2021). NHNP is located in northwestern Argentinian Patagonia. Its original 717,261 ha are subdivided into three legal categories (Martin & Chehébar, 2001; Rivarola et al., 2021). Although the main purpose of all categories is to promote conservation and preservation of natural ecosystems and cultural values, the uses and activities vary among levels:

a. Strict Natural Reserve (75,525 ha designated in 1990): IUCN Category Ia, (Margutti & Arosteguy, 2019): In these areas, surrounded by National Park, human activity, apart from scientific research, is prohibited.
b. National Park (491,881 ha): IUCN Category II, (WDPA, 2017): Extractive use and tourist infrastructures are not permitted. Recreational use can be authorised.
c. National Reserve (225,380 ha designated in 1968): IUCN Category VI (WDPA, 2017): Tourist infrastructure is allowed. These are buffer zones between protected and unprotected land. Extractive use may be authorised. Furthermore, approximately 60 per cent consists of private properties, and livestock are common (Rusch, 2002).

We compared the small mammal species richness and abundance in these three management categories. A fourth conservation category, Wildlife Natural Reserve (IUCN Category Ib), was created in 1994 but was not analysed in the present study. NHNP aims to protect an

ecological gradient comprising high Andean forest, Valdivian temperate forest and steppe. The Global 200 World Wildlife Fund conservation science programme identified Valdivian Temperate forest as a 'Critical or Endangered' ecoregion (Olson & Dinerstein, 1998). These temperate forests are isolated from other forest by more than 1,000 km (Pearson, 1983). Unique ecological and evolutionary processes have occurred in these forests, leading to low vertebrate biodiversity, a high degree of endemism (Barnosky et al., 2001), and an unusually high rate of pollination and seed-dispersal by birds (Aizen & Escurra, 1998). While large and medium-sized mammals are poorly represented in NHNP's forests (Barnosky et al., 2001), small mammal diversity equals that found in temperate forest elsewhere (Pearson, 1983). Three possible evolutionary paths have been identified for the resident small mammals: (a) evolved in situ from tropical or subtropical relatives (Huchon & Douzery, 2001), (b) relicts from earliest dispersal events (Martin, 2010), or (c) dispersed through a tropical filter (Leite et al., 2014).

Agricultural economies can conflict with natural area protection (Raffaele et al., 2014). Additionally, tourism constitutes a risk; the number of visitors increases annually in NHNP and generates a service demand and consequent economic–ecosystem conflicts (Martin & Chehébar, 2001; Monjeau et al., 2005). Introduced plants, vertebrates and invertebrates have substantially affected forest in NHNP (Arbetman et al., 2012; Barrios Garcia Moar, 2012; Correa et al., 2012; Franzese & Ghermandi, 2014; Nuñez et al., 2013; Rodriguez-Cabal et al., 2013; Simberloff et al., 2002; Svriz et al., 2013). Also, a combination of natural and anthropogenic factors has increased wildfire severity in Patagonia more widely (Davis et al., 2019; Godoy et al., 2019; Paritsis et al., 2013; Raffaele et al., 2014; Tiribelli et al., 2019; Urretavizcaya & Defossé, 2019).

Many problems in NHNP have been identified through scoring or PA management effectiveness evaluations, but no clear evidence shows to what extent they impact resident small mammals, since most information regarding flora and fauna was limited to inventories (Rusch, 2002). In an ecosystem with low vertebrate diversity like NHNP, small mammals (particularly rodents) affect forest dynamics and constitute the main food of many other species (Raffaele et al., 2014). Nevertheless, because rodents are small and fecund, the general perception is that they occur in high density and require little area, so they can persist in a fragmented landscape, which may not be true for all species (Lidicker, 1989). Small mammal species extinctions and distribution contractions have been reported in northern Patagonia (Teta et al., 2014).

We aimed to assess potential differences in species richness and abundance in NHNP by monitoring its small mammals. We proposed that communities inhabiting the Strict Reserve Areas will be richer and more abundant because they lack human intervention. Increasing contact with human activities and presence along the gradient National Park–National Reserve–unprotected area could be reflected in impoverished small mammal communities.

METHODS

Study site

We conducted our study in 2015 and 2016 in NHNP in the Andean foothills of Argentina (Fig. 1). Average temperatures range from 3°C (July) to 15°C (January). Precipitation is greatest in austral autumn and winter, averaging 1,800 mm annually. The area lies within the southern temperate forest in the sub-Antarctic biogeographic province, with the Patagonian Steppe ecoregion also represented along the eastern, drier fringe (Mermoz & Martin, 1986). Southern Beeches (*Nothofagus dombeyi*, *N. pumilio*, *N. antarctica*) and Chilean Cedar (*Austrocedrus chilensis*) dominate the canopy, and Bamboo (*Chusquea culeou*) and several species of shrubs and smaller trees the understory (Dimitri, 1977). Elevation (from 500 to 3554 m.a.s.l.), water availability and dominant species are inter-related. Differences in biological outcomes measured in different ecological conditions might reflect variation of those conditions rather than the management approach (Barnes et al., 2017). To reduce such variation, we worked entirely in *N. dombeyi*-dominated forest between 500 and 700 m a.s.l.

Sampling method

We implemented a widely used strategy to assess PA effectiveness, comparing communities inside and outside of PAs (Coetzee et al., 2014). We conducted a capture-mark-recapture study to evaluate small mammal communities across three different protection levels and outside of NHNP, establishing 20 plots (60 x 60 m) at least 1 km apart, five each in the Strict Reserve, National Park, National Reserve and outside the NHNP (Fig. 1). NHNP is bounded to the north by Lanin National Park, to the west by Chile, and to the east changes to a different ecoregion (steppe), leaving the southern region as the only comparable non-protected area with forest dominated by *N. dombeyi* and within the elevation range mentioned above. Accessibility to these private lands is restricted by the main road (RP83). Plot selection took into account walking distances to allow early release of trapped animals. In 2015, we also established two extra plots on Isla Victoria (the largest island in Nahuel Huapi Lake) in an area

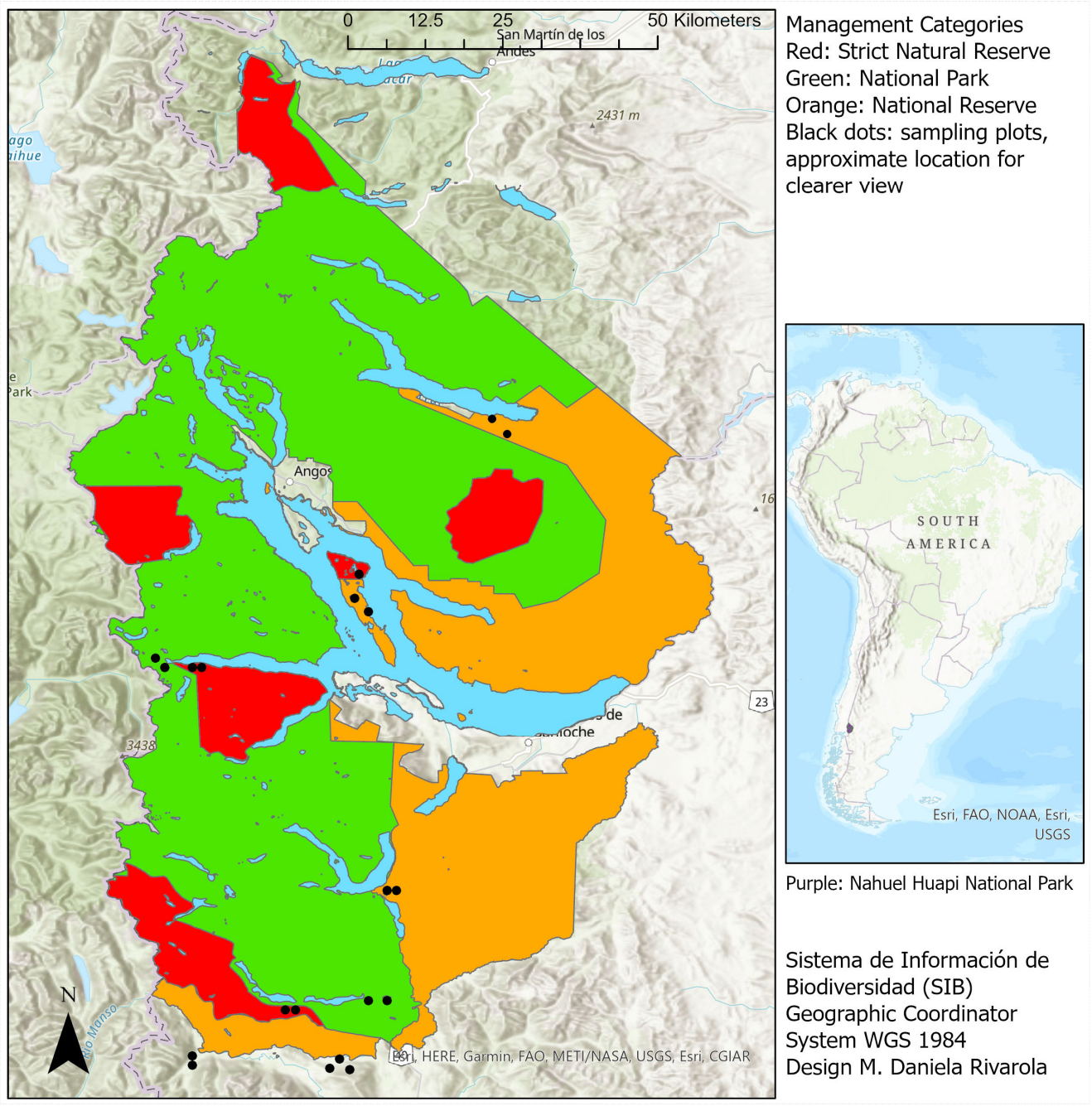


Figure 1. Map of NHNP with protection categories indicated with different colours. Red: Strict Reserve, Green: National Park, Orange: National Reserve. Dots indicate sampling plots (which were at least 1,000 m apart).

where natural forest was replaced by Douglas Fir (*Pseudotsuga menziesii*) plantations approximately 70 years ago. We used a star design for each plot, establishing 25 trap stations 10 m apart, georeferencing the central trap station with a Garmin GPS60. At each station, we activated a Sherman trap (10 x 10 x 29 cm) baited with oats and peanut butter (Pearson & Pearson, 1982) on the ground and a Tomahawk trap (30 x 14 x 14 cm) baited with apple and banana slices (Fonturbel & Jimenez, 2009; Rivarola, 2010) in vegetation 1 m above the ground. We conducted monthly capture sessions during austral summers in 2015 and 2016, activating traps four consecutive nights and checking them at sunrise and at sunset, yielding a total capture effort of 41,600 traps/night. Trap success was calculated as the number of small mammals caught divided by the number of active traps.

We identified each individual captured to species. Before releasing individuals, we marked marsupials with

Passive Integrated Transponders (PIT-Tags, TXP148511B model, Biomark 8.5 mm x 2.12 mm, 134.2 kHz ISO, 0.067g) by subcutaneous implantation on the back and rodents with ear-tags (National Band and Tag Company, style 1005-1). We handled captured animals following UTK-IACUC protocol # 2409-0116 (Institutional Animal Care and Use Committee, University of Tennessee).

To assess sampling area equivalences, we measured vegetation cover and plant species composition in 100 squares (1 x 1 m) per plot both years, and to estimate forest structure we superimposed over each plot a 13 x 13-transect grid, with transects 5 m apart. We defined 169 nodes (one at each transect intersection) where we measured the diameter at breast height (DBH) of the nearest tree (within 1 m radius) or recorded zero for treeless nodes. We estimated tree density by the number of trees over the plot area (3,600 m²). We converted DBH values to obtain basal area per plot (G):

$$G = \frac{\sum g_i}{S_T}$$

where g_i is the stem cross-section area of tree i in m^2 and S_T is the plot area in hectares.

Arthropods are components of small mammal diets in Patagonian temperate forests (Pearson, 1983). We established nine pitfall traps per plot: plastic containers 10 cm in diameter and 15 cm deep half-filled with a water/dishwashing liquid solution. We activated pitfall traps simultaneously with small mammal trapping sessions. We preserved samples in 70 per cent ethanol and recorded abundances as the total number of arthropods per plot.

Data analysis

To compare small mammal diversity between sites under different levels of protection, we used species richness (S), assemblage abundance, and abundance of each species. We used Kruskal-Wallis tests to compare each index across protection levels and conducted post-hoc Tukey's Honest Significance Differences analyses with 95 per cent confidence level when an index varied in response to protection level. To evaluate habitat equivalence between plots, we used ANOVA and Kruskal-Wallis tests to compare vegetation cover, plant species richness, tree basal area, tree density and arthropod abundance. Finally, we analysed these environmental variables with Principal Component Analysis to evaluate clustering of plots within protection levels.

Juvenile *Dromiciops gliroides* feeding on remaining bait after released © María Daniela Rivarola

RESULTS

We had a higher capture effort in 2016 but higher capture success in 2015 (Table 1). We trapped no small mammals in the two plots established in 2015 in areas dominated by Douglas Fir, despite a capture effort of 2,100 traps/night.

In 2015, we trapped seven rodents – Long-haired Mouse *Abrothrix hirta*, Olive Grass Mouse *A. olivacea*, Long-tailed Pygmy Rice Rat *Oligoryzomys longicaudatus*, Long-clawed Mole Mouse *Geouxus valdivianus*, Andean Long-clawed Mouse *Chelemys macronyx*, Chilean Climbing Mouse *Irenomys tarsalis*, Southern Big-eared Mouse *Loxodontomys micropus* – and the endemic marsupial Monito del Monte *Dromiciops gliroides*. In 2016, we captured the same species except for *C. macronyx*. *A. hirta*, *D. gliroides* and *O. longicaudatus* were by far the most abundant across the four levels of protection in both years (Figure 2).

Species richness did not vary among levels of protection in 2015 or 2016 (Table 2). However, assemblage

Table 1. Summary of small mammals captured during 2015 and 2016. Capture effort for two extra plots in area dominated by Douglas Fir during season 2015 not included here.

	Summer 2015	Summer 2016
Capture effort	20,600 trap nights	21,000 trap nights
Number of individuals caught	727	532
Total number of captures	2,102	1,894
Capture success rate	10.20%	9.02%

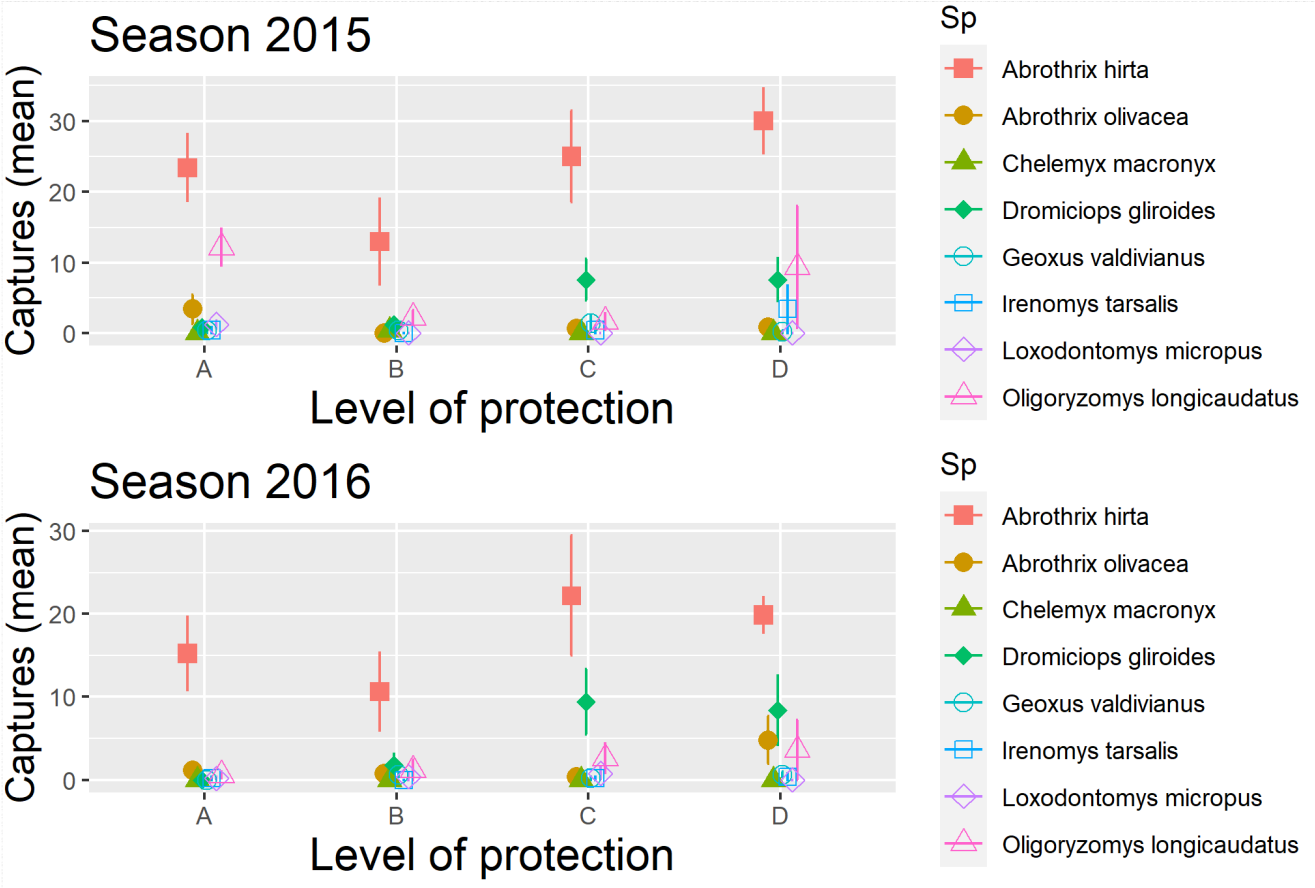


Figure 2. Diversity and average abundance of small mammals caught across different protection levels in NHNP during summer 2015 (top) and 2016 (bottom). (A) outside NHNP, (B) National Reserve, (C) National Park, (D) Strict Reserve

Table 2. Comparison among small mammal communities across different protection levels in the NHNP system and outside. Each variable (column 1) was analysed for each year independently by Kruskal-Wallis Test. Mean ±standard error is indicated in each cell. * indicates statistical significance

		Outside NHNP	National Reserve	National Park	Strict Reserve	KW X^2	df	P-value
Species Richness	2015	3.8 ±0.66	3.0 ±0.74	3.0 ±0.54	3.2 ± 0.37	0.853	3,16	0.8368
	2016	2.2 ±0.49	3.0 ± 0.32	2.8 ±0.66	3.0 ± 0.54	4.1315	3,16	0.2476
Assemblage Abundance	2015	41.8 ±8.45	17.2 ±5.91	36.6 ±7.86	51.4 ± 8.26	7.6316	3,16	0.0542*
	2016	17.0 ±3.99	15.4 ±5.55	35.8 ±7.08	37.6 ± 3.75	9.2491	3,16	0.0261*

abundances were greatest in the highest level of protection and lowest in the lowest level of protection in both years (Table 2; Tukey test [p = 0.0287 for 2015 and p = 0.0399 for 2016]). Finally, abundance by species across the NHNP system and outside PAs differed only for *L. micropus* and *D. gliroides* (Supplementary Online Material, Table 1). *Loxodontomys micropus* was trapped only outside the PA in 2015; this difference did not persist in 2016.

A Kruskal-Wallis test on abundance of *D. gliroides* vs protection level yielded p = 0.0381 in 2016; however, the subsequent Tukey test did not indicate a significant difference between any pairs; thus these results should be interpreted with caution. Nevertheless, *D. gliroides* abundances appeared greater in the National Park and Strict Reserve than in the National Reserve and outside the PA. To evaluate these unequal abundances further, we combined capture numbers from the Strict Reserve

and National Park as 'High protection' and National Reserve and outside NHNP as 'Low–no protection'. Each year saw a difference between these groups (2015, t = 3.2188, df = 9.4882, p = 0.0098; 2016: t = 2.8567, df = 10.16, p = 0.0168).

Most environmental variables showed no differences among treatments, suggesting habitat equivalence. We evaluated forest structure with two variables (tree basal area and tree density). While the former manifested no difference among protection levels (F = 2.162, df = 3, 16, p = 0.1324), the latter showed a marginal difference between the National Reserve and National Park (F = 3.218, df = 3, 16, p = 0.051, Tukey test p = 0.049). Ground vegetation cover and plant richness were analysed separately by year. While vegetation cover did not differ among treatments both years (F = 1.801, df = 3, 16, p = 0.187, and KW chi-squared = 3.549, df = 3, 16, p = 0.314 for 2015 and 2016, respectively), plant species richness was consistently higher in the unprotected area (F = 7.813, df = 3, 16, p = 0.002 for 2015, and KW chi-squared = 13.16, df = 3, 16, p = 0.004 for 2016, Supplementary Online Material, Figure 1).

Finally, arthropod abundance did not vary among levels of protection (chi-squared = 1.1102, DF 3, p = 0.7746 and chi-squared = 5.7657, DF = 3, p = 0.1236, for 2015 and 2016 respectively).

We evaluated clustering of plots within protection levels using PC1, PC2 and PC3, which accounted for over 80 per cent of environmental variation (Supplementary material, Table 2). No clear clustering of plots occurred within protection levels (Figure 3).

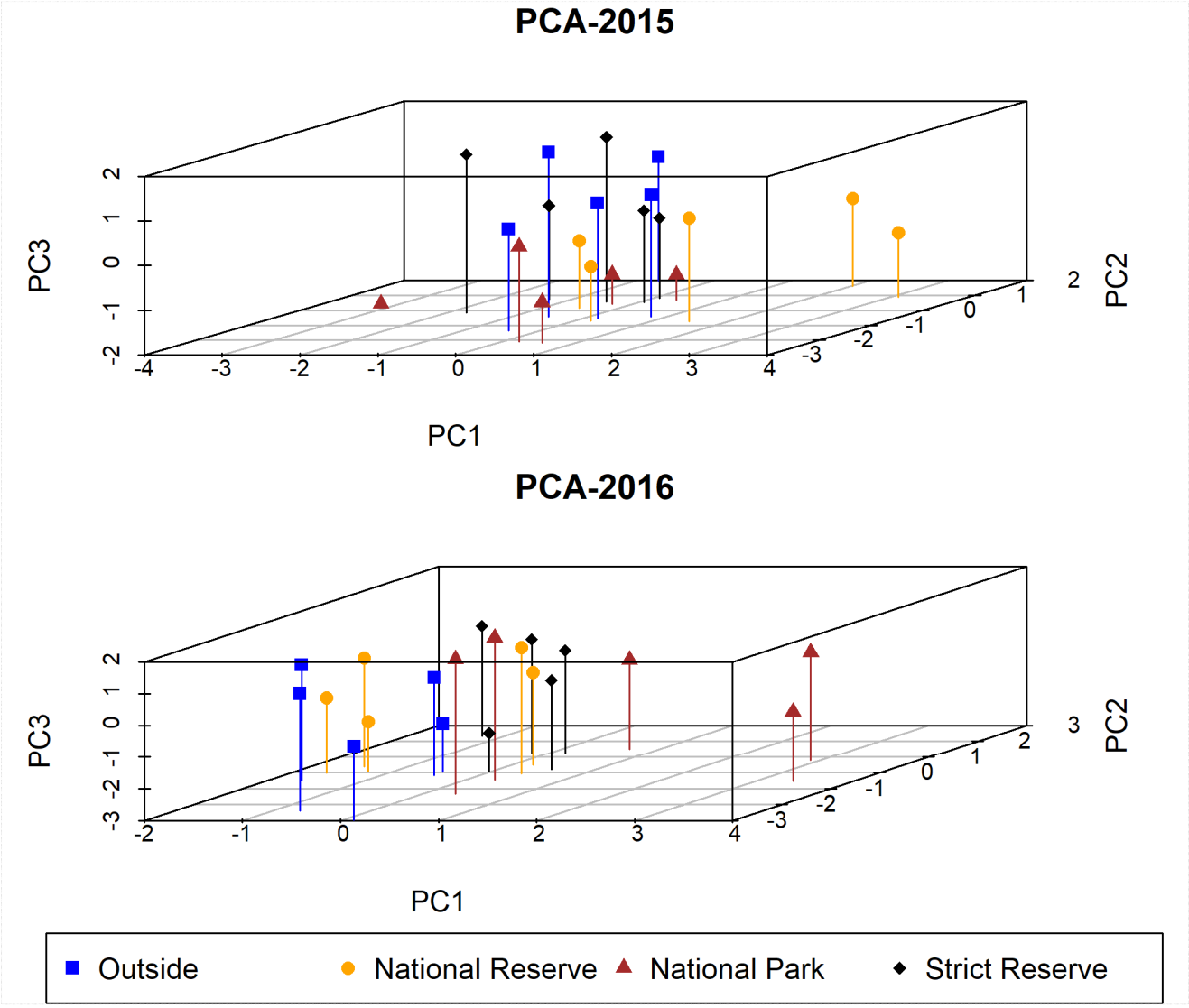


Figure 3. Lack of clustering of plots within protection levels using PC1, PC2 and PC3. Top 2015, bottom 2016.

DISCUSSION

Assessing PA effectiveness by comparing PAs across levels of protection or with unprotected areas is hindered by selection bias – the initially protected site may have been selected as it was especially likely to favour the persistence of target species (Ferraro, 2009; Joppa & Pfaff, 2010). When NHNP was established in 1922, the vicinity of unprotected plots did not differ in evident ways from the area that later became NHNP, and by choosing all plots in a narrow elevational range dominated by *N. dombeyi* and with no apparent anthropogenic impacts, we attempted to minimise the possible influence of factors other than the level of protection. The division in 1968 of NHNP into a National Park largely in the west and National Reserve largely in the east located most private properties that existed before park establishment in the National Reserve, while the sites designated Strict Reserve in 1990 were generally in more pristine areas but "did not necessarily respond to ecological criteria of conservation" (Margutti & Arosteguy, 2019). None of these designations are specifically aimed at small mammal conservation. Again, we aimed to minimise the influence of factors other than protection levels by limitations on plot features, but we cannot rule out a degree of selection bias.

Two PA evaluations have been conducted in Patagonian temperate forest using different methods. A management effectiveness evaluation based on stakeholders and field personnel questionnaires and interviews aimed to assess four key elements: context, planning, inputs and processes. NHNP performance was scored as 'fairly satisfactory' (scoring 51–75 per cent of optimal), with internal disorganisation, reduction in funding, inadequate use of budget and political weakness due to external pressure noted (Rusch, 2002). However, lack of monitoring for most resident species, particularly small mammals, prevents assessment of the effectiveness of current management for these communities. NHNP is part of 4,817,000 ha of North Andean Patagonian Corridor (Chile–Argentina), an area internationally recognised as a biodiversity hotspot (Margutti & Arosteguy, 2019); however, the PAs along the Patagonian Andes in Argentina were created during the 1930–1940s, in response to an international boundary dispute with Chile and preference for protecting forests over other ecosystems (Rivarola et al., 2021). A second evaluation assessed coverage of endemic species. Endemism areas determined using parsimony analyses of endemism based on the known distribution of five unrelated taxa (ferns, trees, reptiles, birds and mammals) concluded that the coverage of this PA corridor (including NHNP) poorly overlapped with the Patagonian hotspot (Rodriguez-Cabal et al., 2008).

Creating a species conservation priority list of Patagonian vertebrates was proposed as an inexpensive, rapid tool to use resources allotted to biodiversity protection efficiently (Christie, 1984a). Detailed monitoring methods such as that presented here could help validate or update such lists. The conservation status of the 32 resident mammal species of NHNP was assessed in 1994 (Úbeda et al., 1994). The study considered two protection levels, National Park (high) and National Reserve (low) and defined 14 variables believed relevant for species survival and conservation, assigning scores to each. However, using variables such as body size, feeding behaviour and reproductive potential yielded low scores for small mammals, which could bias results against this group as suggested for previous studies (Lidicker, 1989). Most species recorded in our study occupy the bottom part of the priority list proposed by Úbeda et al. (1994). *Dromiciops gliroides* was the exception, ranked tenth in this list, declared vulnerable in Argentina (Diaz & Ojeda, 2000), and listed as Near Threatened because its population is declining mainly owing to habitat changes, especially forest conversion to agriculture and habitat fragmentation (IUCN Red List; Martin et al., 2015). It is remarkable that *D. gliroides* was the third and second most abundant species in 2015 and 2016, respectively (Supplementary material, Fig. 2). However, these populations were smaller than those previously reported in Argentina (Rivarola, 2010) and Chile (Fonturbel et al., 2012). The first long-term study tracking population changes in this species demonstrated yearly variation associated with natural events (Balazote Oliver et al., 2017). Importantly, we trapped most individuals in plots with a high protection level (Strict Reserve and National Park). Although the seven rodent species identified in our study had low conservation priority, a comparative study evaluating the potential consequences of European colonisation in the region reported a population contraction for six of these species, with the only exception being the opportunistic *O. longicaudatus* (Teta et al., 2014).

To minimise the effect of landscape variation on species presence/absence and abundance, we restricted our plots to forest dominated by *N. dombeyi*, since it constitutes the species with the broadest distribution and dominance within NHNP, aiming to relate community and population variation to protection levels. The absence of native small mammals in the Douglas Fir plantation agrees with previous studies in northern Patagonia (Lantschner et al., 2011). Pearson

Nahuel Huapi National Park, Lake Huala Hue (front) and Lake Steffen (middle) in National Park category. Lake Martin (back) in Strict Reserve category © María Daniela Rivarola

(1983) described nine species in the most comprehensive small mammal study in northern Patagonian forests. We recorded all but *Aconaemys fuscus*, whose distribution occurs north of NHNP (Roach, 2016). Our analysis yielded scant evidence that the NHNP different protection categories are effectively conserving small mammals. Nevertheless, the different protection categories did not actually differ as much as we expected in terms of anthropogenic impacts and park ranger enforcement. Livestock and wildfires have been identified as the major anthropogenic forces in Patagonian forests (Teta et al., 2014). We found cattle (domestic, semi-wild or wild) in almost every plot, and wildfires are frequent every year across the region. Over the course of this study, we witnessed areas that encompass both National Park and Strict Reserve without a park ranger on duty during the tourist season and with hundreds of daily visitors who move at will into the Strict Reserve, including areas lacking trails and surrounded by rivers and lakes where a ranger lacked the boat required to patrol the area. The park vehicles are outdated and in poor condition, thus are unreliable for patrolling this rough terrain (Monjeau et al., 2005; Rusch, 2002).

Abrothrix hirta exceeded all other species in abundance and distribution (Supplementary Online Material, Figures 2 and 3), in agreement with previous studies (Christie, 1984b; Pearson & Pearson, 1982). Although a typical forest species, *A. hirta* is found in steppe with sufficient ground cover and bushes (Pearson, 1983). This habitat breadth plus its omnivorous feeding behaviour could be associated with its numerical dominance. *Oligoryzomys longicaudatus* has been described as scarce in dense forest (Pearson, 1983). However, it was the second most abundant species trapped during 2015 and the third most abundant species in 2016 (Supplementary Online Material, Figure 2). As abundance and protection level were unrelated, this decline could be due to a natural process. The other rodent species and *D. gliroides* combined accounted for 8.84 per cent of the assemblage abundance in 2015 and 10.17 per cent in 2016. Their low numbers and uneven distribution (Supplementary Online Material, Figures 2 and 3) suggest that conclusions based on these data are preliminary.

Small mammals have been proposed as indicators of habitat disturbance both in unprotected (Olifiers et al., 2005) and PAs (Avenant, 2000; Stephenson, 1993). However, small mammal populations commonly undergo cycles of different length responding to biotic and abiotic factors (Armas et al., 2016; Murua et al., 1986), which suggests that their use to assess landscape

disturbances or management effectiveness requires a multi-year approach (Avenant, 2011, Pearce & Venier, 2005). Lack of this information for the communities in this area renders tenuous our conclusion regarding NHNP effectiveness and highlights the importance of long-term studies and regularly scheduled monitoring programmes. This study is the first attempt to fill this gap. Our data provide evidence on changes in species abundances not only yearly, but also monthly.

The higher assemblage abundance recorded both years inside the Strict Reserve suggests that direct human interaction negatively affects this assemblage, a situation particularly important for *D. gliroides*, an endemic and Near Threatened species and the only living species of the order Microbiotheria. Species inhabiting plots near human settlements might suffer predation by domestic cats. *Dromiciops gliroides* was preyed on by domestic cats in a municipal PA in Bariloche (Di Virgilio et al., 2014). Interestingly, the four plots located in the area of Puerto Blest, where no domestic cats are present, recorded the highest abundances of *D. gliroides*. In general, areas where we found more diversity and abundance were located in zones with more difficult access (accessible only by boat or walking), possibly implying it is not the protection category but primarily the inaccessibility that is preserving these communities, as has happened in forest PAs elsewhere (Struhsaker et al., 2005; Joppa et al., 2008).

In 2019, the National Parks Administration (APN) approved a management plan for NHNP (Margutti & Arosteguy, 2019). Weaknesses and strengths of the current system were identified. A continuous cycle of planning and feedback through an annual operational planning was proposed as the best strategy to achieve the conservation goals of NHNP. Monitoring of species of special value is part of the continuous evaluation process. *Dromiciops gliroides* is included in this list. Our study would provide an important baseline regarding the distribution and relative abundance of the species, since to the best of our knowledge our study provides the most comprehensive dataset mapping the distribution of *D. gliroides* in NHNP.

SUPPLEMENTARY ONLINE MATERIAL

Supplementary tables, figures and species information

ACKNOWLEDGEMENTS

This research was supported by the Nancy Gore Hunger Professorship in Environmental Studies at the University of Tennessee. We are grateful to two anonymous reviewers and Dr Geldmann for their valuable feedback and suggestions. Our special thanks to NHNP rangers and Prefectura Naval Argentina officers for help in the field, and our field assistants: Ludovico Zeller, Isabela Zeller, Emmanuel Imizcoz, Lucila Amione, Flavia Casinelli, Marlene Zaracho, Edgardo Balverdi, Ana Blazina, Thais Efron, Celeste Lado, Florencia Mallou, Laura Barbieri, Sofia Jones, Julieta D'Amario, Carolina Mansilla, Belen Dri, Antonio Navarro, Sabrina Ignacio, Mauro Ricci, Natanael Griffa, Francisco Molina and Pilar Rivarola.

ABOUT THE AUTHORS

María Daniela Rivarola is a PhD candidate in the Department of Ecology and Evolutionary Biology at the University of Tennessee. She conducts research on conservation and ecology of small mammals and on their ecological services. She is interested in national park policies, conservation efforts, and outcomes. ORCID: 0000-0003-4033-418X.

Daniel Simberloff is the Nancy Gore Hunger Professor of Environmental Studies at the University of Tennessee. He has conducted research in several areas of ecology and conservation biology, including refuge design, biological invasions and invasive species impacts, management and policy in national parks in Argentina and the United States.
ORCID: 0000-0002-1424-9291.

Christy Leppanen is a biologist with expertise in the mitigation of harmful effects of biological and chemical contaminants. She performed this research as a research associate professor in the Department of Ecology and Evolutionary Biology at the University of Tennessee and is now a biologist with the U.S. Food and Drug Administration, Center for Tobacco Products (CTP)*. ORCID: 0000-0002-0065-3197. *Although the author is an FDA/CTP employee, this work was not done as part of her official duties. This publication reflects the views of the author and should not be construed to reflect the FDA/CTP's views or policies.

REFERENCES

Aizen, M. and Escurra, C. (1998). High incidence of plant-animal mutualisms in the woody flora of the temperate forest of southern South America: biogeographical origin and present ecological significance. *Ecología Austral* 8:217–236.

APN (2013). Antecedentes históricos de la APN. Carta de donación del Perito Moreno, Proyectos legislativos, Creación de la Comisión Pro Parques Nacionales. Administración de Parques Nacionales. Ministerio de Turismo. Documentos de la Biblioteca Perito Francisco P. Moreno 2, 18 pp.

Arbetman, M.P., Meeus, I., Morales, C.L., Aizen, M.A. and Smagghe, G. (2012). Alien parasite hitchhikes to Patagonia

on invasive bumblebee. *Biological Invasions* 15:489–494, doi:10.1007/s10530-012-0311-0.

Armas, C., Gutiérrez, J.R., Kelt, D.A. and Meserve, P.L. (2016). Twenty-five years of research in the north-central Chilean semiarid zone: The Fray Jorge Long-Term Socio-Ecological Research (LTSER) site and Norte Chico. *Journal of Arid Environments* 126:1–6, doi::10.1016/j.jaridenv.2015.12.008.

Avenant, N. (2000). Small mammal community characteristics as indicators of ecological disturbance in the Willem Pretorius Nature Reserve, Free State, South Africa. *South African Journal of Wildlife Research* (24-month delayed open access) 30:26–33, doi:10.10520/EJC117089.

Avenant, N. (2011). The potential utility of rodents and other small mammals as indicators of ecosystem 'integrity' of South African grasslands. *Wildlife Research* 38:626–639, doi: 10.1071/WR10223.

Balazote Oliver, A., Amico, G.C., Rivarola, M.D. and Morales, J.M. (2017). Population dynamics of *Dromiciops gliroides* (Microbiotheriidae) in an austral temperate forest. *Journal of Mammalogy* 98:1179–1184, doi:10.1093/jmammal/gyx051.

Barnes, M.D., Craigie, I.D., Dudley, N. and Hockings, M. (2017). Understanding local-scale drivers of biodiversity outcomes in terrestrial protected areas. *Annals of the New York Academy of Sciences* 1399:42–60, doi:10.1111/nyas.13154.

Barnes, M.D., Craigie, I.D., Harrison, L.B., Geldamann, J., Collen, B., Whitmee, S., Balmford, A., Burgess, N.D., Brooks, T.M., Hockings, M. and Woodley, S. (2016). Wildlife population trends in protected areas predicted by national socio-economic metrics and body size. *Nature Communications* 7:1 –9, doi:10.1038/ncomms12747.

Barnosky, A.D., Hadly, E.A., Maurer, B.A. and Christie, M.I. (2001). Temperate terrestrial vertebrate faunas in North and South America: Interplay of ecology, evolution, and geography with biodiversity. *Conservation Biology* 15:658–674.

Barrios Garcia Moar, M.N. (2012). Multi-level impacts of introduced wild boar on Patagonian ecosystems. PhD thesis, Ecology and Evolutionary Biology Department, University of Tennessee, Knoxville. Trace: Tennessee Research and Creative Exchange, pp. 151.

CBD (2010). Decision adopted by the CoP to the CBD at its 10th meeting (UNEP/CBD/COP/DEC/X/2). Montreal: Secretariat of the CBD.

Christie, M.I. (1984a). Determinación de prioridades conservacionistas para la fauna de vertebrados Patagónico. Rev. Mus. Arg. Cs. Nat., *Zoologia* 13:535–544.

Christie, M.I. (1984b). *Informe preliminar del Relevamiento de Fauna de los Parques Nacionales Lanin y Nahuel Huapi.* Inventario, A. d. P. N.-P., (Ed.), Vol. III, pp. 72.

Coad, L., Watson, J.E., Geldmann, J., Burgess, N.D., Leverington, F., Hockings, M., Knights, K. and Di Marco, M. (2019). Widespread shortfalls in protected area resourcing undermine efforts to conserve biodiversity. *Frontiers in Ecology and the Environment* 17:259–264, doi:10.1002/fee.2042.

Coetzee, B.W., Gaston, K.J. and Chown, S.L. (2014). Local scale comparisons of biodiversity as a test for global protected area ecological performance: a meta-analysis. *PLoS One* 9:e105824, doi:10.1371/journal.pone.0105824.

Correa, C., Bravo, A.P. and Hendry, A.P. (2012). Reciprocal trophic niche shifts in native and invasive fish: salmonids and galaxiids in Patagonian lakes. *Freshwater Biology* 57:1769–1781, doi:10.1111/j.1365-2427.2012.02837.x.

Davis, K.T., Maxwell, B.D., Caplat, P., Pauchard, A. and Nuñez, M.A. (2019). Simulation model suggest that fire promotes lodgepole pine (*Pinus contorta*) invasion in Patagonia. *Biological Invasions* 21:2287–2300, doi:10.1007/s10530-019-01975-1.

Di Virgilio, A., Amico, G.C. and Morales, J.M. (2014). Behavioral traits of the arboreal marsupial *Dromiciops gliroides* during *Tristerix corymbosus* fruiting season. *Journal of Mammalogy* 95:1189–1198, doi:10.1644/13-MAMM-A-281.

Diaz, G.B. and Ojeda, R.A. (2000). *Libro Rojo de los mamíferos Amenazados de la Argentina*. Mendoza: SAREM.

Dimitri, M.J. (1977). *Pequeña Flora Ilustrada de Los Parques Nacionales Andino Patagonicos. Separata de Anales de Parques Nacionales, Vol. XIII*. Ministerio de Economia de la Nacion. Secretaria de Estado de Agricultura y Ganaderia. Sub -secretaria de Recursos Naturales Renovables y Ecologia. Buenos Aires, Argentina: Servicio Nacional de Parques Nacionales, pp. 1-122.

Ferraro, P.J. (2009). Counterfactual thinking and impact evaluation in environmental policy. In: M. Birnbaum and P. Mickwitz (Eds.), Environmental program and policy evaluation: Addressing methodological challenges. *New Directions for Evaluation* 122:75–84.

Fonturbel, F.E. and Jimenez, J.E. (2009). Underestimation of abundance of the Monito del Monte (*Dromiciops gliroides*) due to a sampling artifact. *Journal of Mammalogy* 90:1357-–1362.

Fonturbel, F.E., Franco, M., Rodriguez-Cabal, M.A., Rivarola, M.D. and Amico, G.C. (2012). Ecological consistency across space: a synthesis of the ecological aspects of *Dromiciops gliroides* in Argentina and Chile. *Naturwissenschaften* 99:873–881, doi:10.1007/s00114-012-0969-2.

Franzese, J. and Ghermandi, L. (2014). Early competition between the exotic herb *Rumex acetosella* and two native tussock grasses with different palatability and water stress tolerance. *Journal of Arid Environments* 106:58–62, doi:10.1016/ j.jaridenv.2014.03.004.

Geldmann, J., Coad, L., Barnes, M.D., Craigie, I.D., Woodley, S., Balmford, A., Brooks, T.M., Hockings, M., Knights, K., Mascia, M.B., McRae, L. and Burgess, N.D. (2018). A global analysis of management capacity and ecological outcomes in terrestrial protected areas. *Conservation Letters* 11:e12434, doi:10.1111/conl.12434.

Godoy, M.M., Martinuzzi, S., Kramer, H.A., Defossé, G.E., Argañaraz, J. and Radeloff, V.C. (2019). Rapid WUI growth in a natural amenity-rich region in central-western Patagonia, Argentina. *International Journal of Wildland Fire* 28:473–484.

Huchon, D. and Douzery, E.J.P. (2001). From the Old World to the New World: A molecular chronicle of the phylogeny and biogeography of Hystricognath rodents. *Molecular Phylogenetics and Evolution* 20:238–251, doi:10.1006/ mpev.2001.0961.

Joppa, L.N., Loarie, S.R. and Pimm, S.L. (2008). On the protection of protected areas. *Proceedings of the National Academy of Sciences* 105:6673–6678.

Joppa, L. and Pfaff, A. (2010). Reassessing the forest impacts of protection. The challenge of nonrandom location and a corrective method. *Annals of the New York Academy of Sciences* 1185:135–149.

Lantschner, M.V., Rusch, V. and Hayes, J.P. (2011). Influences of pine plantations on small mammal assemblages of the Patagonian forest-steppe ecotone. *Mammalia* 75:249–255. doi:10.1515/mamm.2011.031.

Leite, R.N., Kolokotronis, S.O., Almeida, F.C., Werneck, F.P., Rogers, D.S. and Weksler, M. (2014). In the wake of invasion: tracing the historical biogeography of the South American cricetid radiation (Rodentia, Sigmodontinae). *PLoS One* 9:e100687, doi:10.1371/journal.pone.0100687.

Lidicker, W.Z.J. (1989). Rodents: A World Survey of Species of Conservation Concern. *World Conservation Union*.

Margutti, L. and Arosteguy, C. (2019). Plan de Gestión del Parque Nacional Nahuel Huapi. San Carlos de Bariloche, Argentina: Administración de Parques Nacionales, pp. 470. https://www.nahuelhuapi.gov.ar/plangestion.html

Martin, C.E. and Chehébar, C. (2001). The national parks of Argentinian Patagonia — management policies for conservation, public use, rural settlements, and indigenous communities. *Journal of the Royal Society of New Zealand* 31:845–864, doi:10.1080/03014223.2001.9517680.

Martin, G.M. (2010). Geographic distribution and historical occurrence of *Dromiciops gliroides* Thomas (Metatheria: Microbiotheria). *Journal of Mammalogy* 91:1025–1035, doi:10.1644/09-mamm-a-347.1.

Martin, G.M., Flores, D. and Teta, P. (2015). *Dromiciops gliroides*. The IUCN Red List of Threatened Species 2015: e.T6834A22180239. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T6834A22180239.en.

Mascia, M.B. and Pailler, S. (2011). Protected area downgrading, downsizing, and degazettement (PADDD) and its conservation implications. *Conservation Letters* 4:9–20, doi:10.1111/j.1755-263X.2010.00147.x.

Mermoz, M. and Martin, C. (1986). *Mapa de Vegetación del Parque y la Reserva Nacional Nahuel Huapi.* Bariloche, Argentina: Secretaria de Ciencia y Tecnica de la Nacion, pp. 22.

Monjeau, A., Nazar Anchorena, S., Montoni, V., Marquez, J., Alcalde, D., D'Iorio, A., Galván, H., Denholm, C., Di Vincenzo, A. and Gonzalez, F. (2005). *Perfil del Área Protegida Argentina: Parque Nacional Nahuel Huapi*. http://www.parkswatch.org/parkprofile.php?l=eng&country=arg&park=nhnp.

Murua, R., Gonzalez, L.A. and Meserve, P.L. (1986). Population ecology of *Oryzomys longicaudatus philippii* (Rodentia: Cricetidae) in southern Chile. *Journal of Animal Ecology* 55:281–293.

Nuñez, M.A., Hayward, J., Horton, T.R., Amico, G.C., Dimarco, R.D., Barrios-Garcia, M.N. and Simberloff, D. (2013). Exotic mammals disperse exotic fungi that promote invasion by exotic trees. *PLoS One* 8:e66832, doi:10.1371/journal.pone.0066832.

Olifiers, N., Gentile, R. and Fiszon, J.T. (2005). Relation between small-mammal species composition and anthropic variables in the Brazilian Atlantic Forest. *Brazilian Journal of Biology* 65:495–501.

Olson, D.M. and Dinerstein, E. (1998). The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. *Conservation Biology* 12:502–515.

Paritsis, J., Holz, A., Veblen, T.T. and Kitzberger, T. (2013). Habitat distribution modeling reveals vegetation flammability and land use as drivers of wildfire in SW Patagonia. *Ecosphere* 4:53.

Pearce, J. and Venier, L. (2005). Small mammals as bioindicators of sustainable boreal forest management. *Forest Ecology and Management* 208:153–175, doi:10.1016/j.foreco.2004.11.024.

Pearson, O.P. (1983). Characteristics of a mammalian fauna from forests in Patagonia, Southern Argentina. *Journal of Mammalogy* 64:476–492.

Pearson, O.P. and Pearson, A.K. (1982). Ecology and biogeography of the southern rainforest of Argentina. In: M.A. Mares and H.H. Genoways (Eds.), *Mammalian biology in South America*, Vol. 6. Pymatuning Laboratory of Ecology, Pymatuning Symposium Ecology, pp. 129–142.

Raffaele, E., de Torres Curth, M., Morales, C.L. and Kitzberger, T. (2014). Ecología *e Historia Natural de la Patagonia Andina.* Fundación de Historia Natural Felix de Azara, Ciuddad Autonoma de Buenos Aires, Argentina.

Rivarola, M.D. (2010). Interacción entre un muérdago y un marsupial: estructura poblacional y área de acción de *Dromiciops gliroides*, y caracterización de la remoción de frutos de *Tristerix corymbosus*. Vol. Licenciatura. Universidad Nacional del Comahue, Bariloche, Argentina, pp. 110.

Rivarola, M. D., Simberloff, D., and Leppanen, C. (2021). History of Protected Areas in Argentina: A Seesaw of Shifting Priorities and Policies in a Developing Country. *Environment and History,* 27(4):515-548. doi:10.3197/096734019X15740974883825

Roach, N. (2016). *Aconaemys fuscus*. The IUCN Red List of Threatened Species 2016: e.T278A78318793. doi:10.2305/IUCN.UK.2016-2.RLTS.T278A78318793.en.

Rodriguez-Cabal, M.A., Barrios-Garcia, M.N., Amico, G.C., Aizen, M.A. and Sanders, N.J. (2013). Node-by-node disassembly of a mutualistic interaction web driven by species introductions. *PNAS* 110:16503-7, doi:10.1073/pnas.1300131110.

Rodriguez-Cabal, M.A., Nuñez, M.A. and Martínez, A.S. (2008). Quantity versus quality: Endemism and protected areas in the temperate forest of South America. *Austral Ecology* 33:730–736, doi:10.1111/j.1442-9993.2008.01841.x.

Rusch, V. (2002). *Estado de Situación de las Áreas Protegidas de la porción Argentina de la Ecoregion Valdiviana.* Argentina: Fundación Vida Silvestre Argentina, WWF, pp. 98.

Simberloff, D., Relva, M.A. and Nuñez, M.A. (2002). Gringos en el bosque: introduced tree invasion in native *Nothofagus*/*Austrocedrus* forest. *Biological Invasions* 4:35–53.

Stephenson, P.J. (1993). The small mammal fauna of Réserve Spéciale d'Analamazaotra, Madagascar: the effects of human disturbance on endemic species diversity. *Biodiversity & Conservation* 2:603–615, doi:10.1007/BF00051961.

Struhsaker, T.T., Struhsaker, P.J. and Siex, K.S. (2005). Conserving Africa's rain forests: problems in protected areas and possible solutions. *Biological Conservation* 123:45–54.

Svriz, M., Damascos, M.A., Zimmermann, H. and Hensen, I. (2013). The exotic shrub *Rosa rubiginosa* as a nurse plant. Implications for the restoration of disturbed temperate forests in Patagonia, Argentina. *Forest Ecology and Management* 289:234–242, doi:10.1016/j.foreco.2012.09.037.

Teta, P., Formoso, A., Tammone, M., de Tommaso, D.C., Fernández, F.J., Torres, J. and Pardiñas, U.F.J. (2014). Micromamíferos, cambio climático e impacto antrópico: Cuánto han cambiado las comunidades del sur de América

del Sur en los últimos 500 años? *Therya* 5:7–38, doi:10.12933/therya-14-183.

Tiribelli, F., Morales, J.M., Gowda, J.H., Mermoz, M. and Kitzberger, T. (2019). Non-additive effects of alternative stable states on landscape flammability in NW Patagonia: fire history and simulation modelling evidence. *International Journal of Wildland Fire* 28:149–159, doi:https://doi.org/10.1071/WF18073.

Úbeda, C.A., Grigera, D.E. and Reca, A.R. (1994). Conservación de la fauna de tetrápodos. II. Estado de conservación de los mamíferos del Parque y Reserva Nacional Nahuel Huapi. *Mastozoologia Neotropical* 1:29–44.

Urretavizcaya, M.F. and Defossé, G.E. (2019). Restoration of burned and post-fire logged *Austrocedrus chilensis* stands in Patagonia: effects of competition and environmental conditions on seedling survival and growth. *International Journal of Wildland Fire* 28:365–376, doi:https://doi.org/10.1071/WF18154.

WDPA (2017). World Database of Protected Areas – *Protected Planet*. Retrieved 01-10-2017 from https://www.protectedplanet.net/en

RESUMEN

Las áreas protegidas son la piedra angular de las estrategias de conservación, pero su eficacia es cada vez más cuestionada. En el Parque Nacional Nahuel Huapi de Argentina, comparamos pequeños mamíferos en áreas no protegidas y en áreas con tres niveles de protección: (1) actividad humana prohibida, (2) recreación autorizada, y (3) turismo y usos extractivos autorizados. Un estudio basado en la captura, marcaje y recaptura en cinco parcelas de cada tipo de área incluyó un esfuerzo de captura mediante la colocación de 41.600 trampas/noche. En 2015, atrapamos siete especies de roedores autóctonos y un marsupial endémico. En 2016, capturamos las mismas especies salvo un roedor. La abundancia de especies no varió entre los niveles de protección. Sin embargo, las mayores abundancias se dieron en el nivel de protección más alto y la abundancia más baja en el nivel más bajo. Hallamos poca evidencia de que el sistema de protección del Parque Nacional Nahuel Huapi preserva de manera sustancial los pequeños mamíferos. Sin embargo, las mayores abundancias en el nivel de protección más alto sugieren que la interacción humana directa afecta este conjunto de manera negativa.

RÉSUMÉ

Les aires protégées constituent la pierre angulaire des stratégies de conservation, mais leur efficacité est de plus en plus remise en question. Dans le parc national Nahuel Huapi en Argentine, nous avons comparé les petits mammifères dans les zones non-protégées et dans des zones avec trois niveaux de protection : (1) activité humaine interdite, (2) loisirs peuvent être autorisés et (3) tourisme et utilisations extractives autorisés. Une étude de capture-marquage-recapture sur cinq secteurs dans chaque type de zone comprenait le piégeage de 41 600 pièges/nuit. En 2015, nous avons piégé sept espèces de rongeurs indigènes et un marsupial endémique. En 2016, nous avons capturé les mêmes espèces à l'exception d'un rongeur. La richesse des espèces ne variait pas selon les niveaux de protection. Cependant, les abondances les plus élevées se trouvaient dans le niveau de protection le plus élevé et les abondances les plus faibles dans le niveau le plus bas. Nous avons trouvé peu de preuves que le système de protection du parc national Nahuel Huapi préserve substantiellement les petits mammifères. Cependant, des abondances plus élevées dans le niveau de protection le plus élevé suggèrent que l'interaction humaine directe affecte négativement cet assemblage.

TRADITIONAL LANDSCAPES TO BOLSTER THE EFFECTIVE SIZE OF PROTECTED AREAS: AN EXAMPLE OF BASTIMENTOS ISLAND, PANAMA

Ted J. Lawrence[1*], Casey Hart[2], Kate Petty[3] and Shelby Bocks[4]

* Corresponding author: TJL222@cornell.edu

[1]The School for Field Studies, Center for Tropical Island Biodiversity Studies, Isla Colon, Bocas del Toro, Panama
[2]Gonzaga University, Spokane, Washington, USA
[3]University of Denver, Denver, Colorado, USA
[4]University of San Diego, San Diego, California, USA

ABSTRACT

Traditionally managed landscapes can play a vital role in protected area management strategies. However, such landscapes are often poorly inventoried and evaluated. Broader land use and land cover patterns may be known, but important details about site-specific land use and structural ecosystem elements and complexity that support biodiversity are often unknown. We conducted a rapid visual assessment to illustrate the relationship between traditionally managed landscapes and biodiversity conservation around a national park in Bocas del Toro, Panama. Our research question was: how does the presence of structural ecosystem elements vary with the degree of traditional land use? We conducted a rapid visual assessment based on the previously established Landscape Assessment Protocol: a field method for landscape conservation surveying, which to our knowledge is the first application of the protocol to a tropical landscape. Our results show that the presence of structural ecosystem elements was strongly and positively related to the degree of traditional land use, which is likely common across the tropics. Such rapid landscape assessments can help park managers and conservationists engage with local communities to determine and prioritise conservation needs, and to ultimately bolster the effective size of protected areas across broader landscapes.

Key words: conservation, traditional land use, biodiversity, landscape assessment

INTRODUCTION

Protected areas (PAs) are the primary strategy to prevent land use directly impacting remnant natural areas, and in turn, conserve biodiversity (Palomo et al., 2014). However, land use around PAs indirectly affects biodiversity conservation within PA boundaries (Hansen & DeFries, 2007). As a result, PA management strategies increasingly include broader landscapes beyond PA boundaries (Dudley et al., 2010; Naughton-Treves & Holland, 2019). The IUCN identifies six different PA categories that describe governance types and management strategies, ranging from strictly protected areas to broader landscapes that include traditional natural resource management systems (Dudley et al., 2016). In particular, traditional natural resource management systems are represented in IUCN categories V and VI: where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value; conserved ecosystems and habitats, together with associated cultural values and traditional natural resource management systems; and resulted in most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen (Dudley et al., 2013). Many PAs focus on strict exclusionary management (Andrade & Rhodes, 2012). Still, more efforts are needed to include traditionally managed landscapes around PAs into park management strategies (Naughton-Treves & Holland, 2019; Plieninger et al., 2014).

Traditional landscapes are complex social-ecological systems that often comprise Indigenous peoples and local communities in which socio-cultural factors and ecological patterns are intricately bound together in dynamic relationships across many generations (Brown & Kothari, 2011; Fischer et al., 2012; Renes, 2015). Despite the importance of traditionally managed landscapes to PA management (Siebert & Belsky, 2014), they are often poorly inventoried and evaluated (Chazdon et al., 2009; Vlami et al., 2017). Broader land use and land cover patterns may be known, but important details about site-specific land use and structural ecosystem elements and complexity that support biodiversity are often unknown. Some basic structural ecosystem elements include native vegetation, flora and natural assemblages that provide a range of resources for the presence, distribution and abundance of species and the species that utilise these resources (Dale & Beyeler, 2001). Also, areas comprising a variety and combination of structural elements foster ecological complexity, bolstering the range of resources and number of species that utilise the resources (McElhinny et al., 2005). Ultimately, the presence of such structural elements and complexity create an ecological setting that is crucial to supporting biodiversity (Farina, 2000).

Traditional land use supports biodiversity conservation across a landscape through relatively low nutrient inputs, little mechanisation, low output per hectare, and a mix of land uses and land covers (Dorresteijn et al., 2015; Plieninger et al., 2006). In turn, traditional landscapes frequently exhibit extensive ecological gradients with diverse patches, habitats and ecosystems (Fischer et al., 2012; Lawrence et al., 2019b; Ribeiro Palacios et al., 2013). Such ecological gradients often comprise substantial amounts of natural and semi-natural vegetation, diverse structural elements, and heterogeneous land use and land cover (Dorresteijn et al., 2015; Plieninger et al., 2006), which maintain wildlife habitat, habitat connectivity and high levels of biodiversity (Lawrence et al., 2019a). However, many traditional land-use systems have vanished or diminished in past decades, as land uses have shifted towards either extensification and land abandonment or intensification (Plieninger et al., 2006).

Protected area management should heed land use around PAs and measure the attendant impacts, such as land cover change and habitat loss that can influence the interior of PAs (Naughton-Treves & Holland, 2019). Although natural variations exist, land use is a dominant driver of local environmental conditions (Hansen & DeFries, 2007). Such information is readily accessible since the effect of land use on structural elements and complexity can be directly and easily assessed (McElhinny et al., 2005). However, the information is frequently lacking in PA management partly because on-site field assessments are routinely complex, time-consuming and costly procedures as many abiotic and biotic indicators, reflecting the detailed and pluralistic components of ecosystems, are used (Vlami et al., 2019). Thus, more straightforward, rapid and low-cost visual field assessments are also needed that effectively engage local communities to evaluate traditional land use and biodiversity conservation around PAs (Dorresteijn et al., 2015; Siebert & Belsky, 2014).

A variety of indices have been devised to express structural elements and complexity as a single number, acting as a summary variable for a pool of structural attributes and as a means of ranking geographic areas in terms of their potential contribution to biodiversity, and thereby facilitating comparisons between different locations (McElhinny et al., 2005). Importantly, ecological indicators need to capture the structural elements and complexities of ecosystems yet remain simple enough to be easily understood and routinely monitored by all stakeholders, including local community members (Dale & Beyeler, 2001). Such an approach is increasingly used in conservation planning to emphasise retaining representative ecological settings rather than focal species, and as such, provide a coarse indicator of biodiversity (McGarigal et al., 2018).

Our objective in this article is to illustrate the relationship between traditionally managed landscapes and biodiversity conservation around a national park in the Province of Bocas del Toro, Panama using a straightforward, rapid and low-cost visual field assessment. Our research question was: how does the presence of structural ecosystem elements vary with the degree of traditional land use? We conducted a rapid visual assessment based on the Landscape Assessment Protocol: a field method for landscape conservation surveying (Vlami et al., 2019), which to our knowledge, is the first application of the protocol to a tropical landscape. Specifically, we used 1) a metric that evaluates land use on a spectrum from less to more traditional, and 2) metrics that evaluate the presence of flora assemblages, wildlife and wildlife habitat, and natural and semi-natural vegetation as coarse indicators of biodiversity. We also visually assessed the number of vegetation height classes and vegetation density at each level as additional measures to capture potential differences in vertical structure, which are important aspects of ecological complexity and the overall

ecological setting that support biodiversity. Such rapid landscape assessments can help park managers and conservationists engage with local communities to determine and prioritise conservation needs and to ultimately bolster the effective size of PAs across broader landscapes.

METHODS

Landscape assessment site

Bastimentos Island (9°30'N, 82°13'W) in an archipelago of Bocas del Toro, Panama, comprises roughly 6,200 ha and a human population of roughly 2,000 (INEC, 2015). Bastimentos Island National Marine Park (PNMIB) was established in 1988, extends across Bastimentos Island, from the northeast to the southwest side, and comprises 1,630 ha (Figure 1; Guerrón-Montero, 2005). PNMIB is an IUCN Category II national park with the primary objective of protecting functioning ecosystems. Still, it allows human activities to support local economies through educational and recreational tourism (IUCN, 2013). Bastimentos Island primarily comprises a hardwood forest that has been historically used for the construction of local homes, furniture and boats (Valdespino & Santamaria, 1997). Small-scale agriculture existed within PNMIB when it was created (Spalding, 2013). People already living or farming within the park were permitted to continue their activities, but with regulations on expansion and deforestation (Guerrón-Montero, 2005).

Landscapes around PNMIB comprise multiple forms of land use. Ngäbe people live in dispersed settlements around the park and practise slash-and-burn agriculture, livestock grazing and selective timber harvesting (Spalding, 2013). Additionally, some communities operate small-scale ecotourism businesses. Other land uses include corporate and large-scale tourism, and commercial and residential development (Cramer, 2013). However, since the park's creation, an increase in foreign residents, growth in tourism, and commercial and residential development in the archipelago has become a substantial threat to biodiversity conservation across Bastimentos Island (Spalding, 2013). Land use on the island centres around the major settlements, including Old Town at the island's northwestern point; Salt Creek to the southeast of the park; Red Frog Resort to the northeast of the park; and Bahia Honda along the northwest border of the park, as well as smaller settlements within the park's southwest end and elsewhere across the island.

Rapid visual landscape assessment

We conducted a rapid visual assessment involving the metrics of land-use pattern, flora, wildlife and wildlife habitat, and vegetation based on the Landscape Assessment Protocol (LAP): a field method for landscape conservation surveying, which previously proved effective and replicable in extensive field trials with both experts and non-experts (Vlami et al., 2019). The LAP includes multiple ecologically-relevant metrics but designates flora and wildlife and wildlife habitat as coarse indicators of biodiversity. We considered the presence of vegetation as an additional metric used to characterise the general appearance of an ecological setting.

For our study, three field research assistants were trained in conducting landscape assessments in consultation with local people over two months, especially in using the LAP. Research assistants were

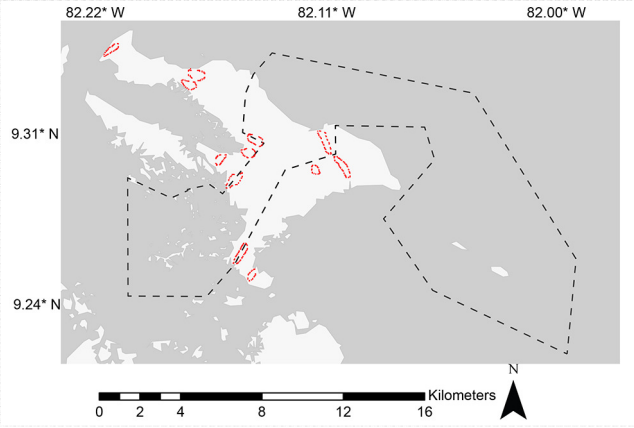


Figure 1. Bastimentos Island National Marine Park. Protected area is represented by dotted black line. Dotted red polygons represent areas where data was collected on Bastimentos Island.

Boundary of Bastimentos Island National Marine Park in Bahia Honda on Bastimentos Island © Ted Lawrence

Salt Creek, a Ngäbe village consisting of about 60 houses located on the southeastern end of Bastimentos Island © Ted Lawrence

also trained over the same period in basic knowledge of local natural history and land use. Further, preliminary field data collection was conducted over several days to customise the protocol to our study site's socio-environmental context; for intercalibration of the protocol among the research assistants; and to address any difficulties that may have arisen in the implementation of our landscape assessment protocol in varying locations. Ultimately, our rapid visual assessment was conducted through transect walks with local informants at 11 field sites. Each field site corresponded to human settlements and/or accessible park boundaries. Local informants guided our field team across each site as we visually identified dominant land uses and collected data approximately every 200 m within different land-use/cover types for a total of 91 data collection points. Figure 1 shows the areas on Bastimentos Island where all data were collected relative to the park boundaries.

At every data collection point, we recorded a score for each of four metrics (land use, flora, wildlife and wildlife habitat, vegetation) within a 25 m radius. The land-use pattern metric measured the degree of traditional land use on a spectrum from modern elements, such as commercial and residential development, to traditional (e.g. original landforms, subsistence-based agriculture and long-standing settlements). The flora metric measured the presence of natural or near-natural floral assemblages. Specifically, we visually assessed the variety and combination of plant communities, including herbaceous and woody plants. The wildlife and wildlife habitat metric measured the presence of native wildlife and habitat distributed horizontally and vertically, which included areas suited for a species to successfully nest, roost, forage and reproduce. Given the challenge of visually assessing all wildlife species in a given area, it is generally accepted that increases in the diversity of resources lead to increases in habitat for a variety of wildlife species (McElhinny et al., 2005). Therefore, the presence of wildlife habitat served as a measure for the potential presence of wildlife species. The vegetation metric measured the presence of natural and semi-natural vegetation to characterise the general appearance of an ecological setting. Each metric was scored on a ranking scale from 0 to 10 for minimal to maximum presence of natural and traditional elements. Table 1 shows descriptions of the minimal, moderate and maximum characteristics that guided our assessments.

The number of vegetation levels (i.e. height classes) and vegetation density within each level were also assessed within a 5 m radius at every data collection point (Aaseng et al., 2011; Ruiz-Jaén & Aide, 2005; Rutten et al., 2015). Vegetation levels were divided into lower-, mid- and upper-level. Lower-level comprised vegetation height below 0.5 m; mid-level comprised vegetation between 0.5–5 m; and upper-level comprised vegetation height above 5m. We visually assessed the vegetation density of each level according to the percent of vegetation (below 25 per cent, between 25–50 per cent, 50–75 per cent and above 75 per cent). The number of vegetation height classes and vegetation density served

Table 1. Summary of minimal, moderate and maximum assessment characteristics

Minimal (0 or 1)	**Summary assessment scale** Moderate (5)	Maximum (9 or 10)
	Traditional land use	
Modern elements and land use dominate. Minimal traditional and cultural features. Evidence of substantially altered landforms or landscapes for modern development.	Mixed modern and traditional land use. Moderate changes to traditional land use practices. Some signs of alteration to landforms or landscapes for modern development.	Traditional and cultural land use dominate. Minimal modern features. Original landforms and cultural landscapes. Most traditional elements and features intact.
	Flora	
Non-native species and manipulated assemblages dominate. Disturbed and more homogeneous plant communities.	Mixed native and non-native species and semi-manipulated assemblages present. Moderately disturbed and somewhat heterogeneous plant communities.	Native species, natural or near-natural assemblages dominate. Undisturbed and more heterogeneous plant communities.
	Wildlife and wildlife habitat	
Apparent lack of wildlife populations (or only over flying and far from location of site assessment). Lack of available resources such as food, water and space arranged to meet the needs of wildlife. Evidence of altered or degraded habitat for wildlife. Habitat manipulated to attract a limited number of specific wildlife species.	Moderate wildlife populations evident but populations appear low. Some available resources such as food, water and space arranged to meet the needs of wildlife. Mixed altered or degraded habitat for wildlife. Moderately habitat-rich landscape.	Abundance of wildlife populations present. Evidence of relatively high wildlife population density. Abundance of available resources such as food, water and space arranged to meet the needs of wildlife. Wildlife habitat-rich landscape. Apparent natural and mostly undisturbed or altered habitats present.
	Vegetation	
Sparse natural vegetation. Apparent lack of native vegetation. Disturbed or highly managed vegetation cover.	Moderate natural vegetation. Moderate amounts of native vegetation. Partially disturbed and managed vegetation cover.	Dense natural vegetation. Abundance of native vegetation. Mostly undisturbed and only slightly managed vegetation cover.

as an additional measure to capture potential differences in the vertical structure of the ecological setting.

Data analysis

We examined the relationship between the presence of structural ecosystem elements and the degree of traditional land use through regression analysis. First, we individually regressed flora, wildlife and wildlife habitat, and vegetation against land-use patterns. Such analysis enabled us to understand the influence that land use had on the individual elements. Next, we averaged the scores of flora, and wildlife and wildlife habitat to create a single composite indicator of the presence of flora and fauna, and regressed it against land-use pattern. The composite indicator enabled us to understand the influence of land use on the integration of the variables as an ecological setting that supports biodiversity.

Additionally, we conducted a One-way Analysis of Variance (ANOVA) with a 5 per cent significance level on the degree of traditional land use associated with each vegetation level and each level's vegetation density, as well as the combined presence of flora and fauna associated with each land-use type. For each ANOVA, we conducted a post-hoc analysis using a pairwise comparison assuming unequal variance. We conducted three pairwise comparisons for the number of vegetation levels and six pairwise comparisons for vegetation density. We analysed the results using the Bonferroni method to correct for multiple comparisons (Townend, 2002). We also conducted pairwise comparisons of the combined presence of flora and fauna across land-use types, including forests, agriculture, human settlements, pastures and commercially developed areas; and small-scale (Indigenous) versus large-scale (commercial) tourism operations.

RESULTS

The presence of structural ecosystem elements was strongly and positively related to the degree of traditional land use across Bastimentos Island (Figure 2). Specifically, there was a strong and positive relationship between the degree of traditional land use, and the presence of flora ($R^2 = 0.84$, $p < 0.001$), wildlife and wildlife habitat ($R^2 = 0.77$, $p < 0.001$) and vegetation ($R^2 = 0.90$, $p < 0.001$). However, wildlife and wildlife habitat contributed little additional information, in terms of regression analysis, when combined with the flora metric to create a composite indicator of the presence of flora and fauna to understand the relationship between the degree of traditional land use and the ecological setting.

The number of vegetation levels showed a significant difference in the degree of traditional land use ($F(3,88) = 16.03$, $p < 0.001$). Areas with mid-level vegetation exhibited an average traditional land use of 6.78, which was significantly different from areas with upper-level vegetation (avg. = 8.64; $p < 0.001$). Mid-level vegetation density was also significantly different in the degree of traditional land use ($F(3,88) = 8.35$, $p < 0.001$). Mid-level vegetation with below 25 per cent density exhibited an average traditional land use of 6.44, which was significantly different from 25–50 per cent (avg. = 8.25; $p < 0.008$), 50–75 per cent (avg. = 8.57; $p < 0.001$) and above 75 per cent (avg. = 8.76; $p < 0.002$).

Finally, there was a statistically significant difference between means ($F(5,85) = 31.78$, $p < 0.001$) in structural ecosystem elements across land-use types (forests, agriculture, human settlements, pastures and commercially developed areas). Post-hoc analysis showed a difference between forests and other land-use types ($p < 0.001$), and commercial developed areas and other land-use types ($p < 0.001$). Additionally, there was a significant difference in the structural ecosystem elements between small-scale Indigenous tourism and large-scale commercial tourism ($p < 0.001$).

DISCUSSION

The ecological setting around PNMIB is linked to the degree of traditional land use, as shown through our use of the LAP and measurement of vegetation structural complexity. While some land uses across Bastimentos Island are extensive, such as cattle grazing, and traditional land uses have likely diminished due to expanded opportunities from markets and influences from commercial development, our analysis showed that

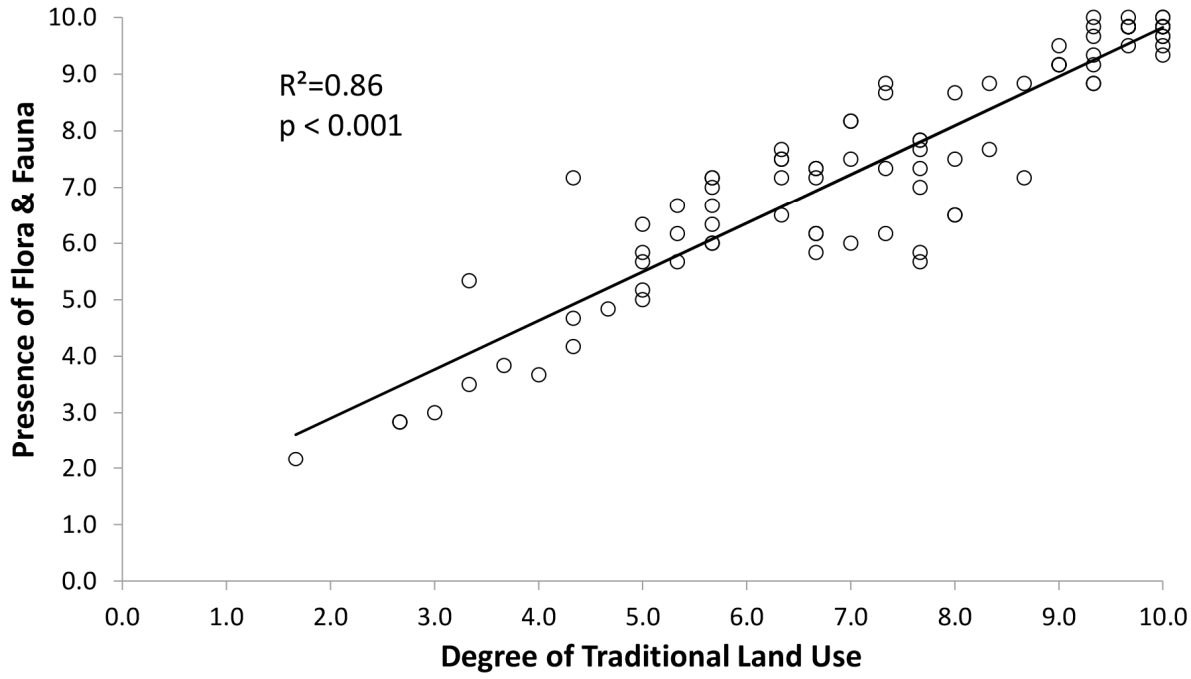


Figure 2. Relationship between the presence of flora and fauna, and the degree of traditional land use across Bastimentos Island. The presence of flora and fauna is a composite indicator that is based on averaging the flora, and wildlife and wildlife habitat metrics, which ranges from minimal (0) to maximum presence. The degree of traditional land use ranges from less (0) to more (10) traditional.

the presence of structural ecosystem elements supporting biodiversity increased as landscapes were traditionally managed. Additionally, as our post-hoc analysis showed, the type of traditional land use (agriculture, pastures, human settlements) had similar structural ecosystem elements, but was significantly different ranging from forest at one end of the land-use spectrum and commercial development at the other end of the spectrum. However, the levels and density of vegetation, as shown in our ANOVA was greater in land uses that were highly traditional compared to diminished traditional land uses. Further, vegetation was consistently denser in highly traditional land uses and immediately became sparse in moderate traditional land uses.

The relationships between the degree of traditional land use and structural ecosystem elements and complexity on Bastimentos Island are likely common across the tropics as traditional landscapes frequently exhibit heterogeneous land use and land cover involving extensive ecological gradients with diverse patches, habitat and ecosystems (Fischer et al., 2012; Lawrence et al., 2019a,b and 2020; Ribeiro Palacios et al., 2013). Such landscape patterns positively influence the presence, distribution and abundance of species assemblages crucial to supporting biodiversity (Farina, 2000). Moreover, protected areas in the tropics, such as PNMIB, are often embedded within and positively influenced by traditional landscapes (Chazdon et al., 2009), which conservationists increasingly recognise (Siebert & Belsky, 2014).

Despite traditional land use around PNMIB exhibiting conservation value, park management has neglected to include traditional natural resource management systems in their PA management strategies (Ban & Frid, 2018). For example, a 'Consulting Assembly' to PNMIB was formed in 1997 that included representatives from eight Ngäbe communities and two non-Indigenous communities. The assembly recommended a sustainable resource use plan with the objectives: 1) to improve the protection, conservation and management of the marine and terrestrial resources of the park and its areas of influence with local communal participation; 2) to promote conservation and sustainable use of resources through environmental education campaigns; 3) to support and promote scientific research and biological education in marine and coastal studies; and 4) to contribute to a better use of the resources in the park and its area of influence with the ideals of conservation of those resources, but this plan was never fully implemented (Guerrón-Montero, 2005). Such an approach would include traditional landscapes around the park as 'areas of influence' to the PA. Still park management disregard this approach. The present-day lack of inclusion is worrying given the growing market forces in Bocas del Toro that can displace traditional land use. This is especially concerning given that our analysis showed a significant difference in structural ecosystem elements between more and less traditional land use, and in particular between small-scale Indigenous tourism and large-scale commercial tourism. We further established these results with the number of vegetation levels, as well as mid-level vegetation density, showing a significant difference in the degree of traditional land use. Many traditional land-use practices across Bastimentos Island are changing due to increased tourism and expatriate in-migration, which are driving landscape change, such as deforestation due to logging and residential projects, as well as the establishment of large-scale tourist lodges and resorts (Spalding, 2013).

PA management strategies, and in particular, PNMIB, need to include traditional natural resource management systems around parks to properly protect biodiversity within PA boundaries (Naughton-Treves & Holland, 2019). This can be at least partially accomplished through the establishment of Indigenous and Community Conserved Areas or Indigenous Protected and Conserved Areas, which create socio-cultural, political and ecological benefits such as improving Indigenous livelihoods, increasing governance and management capacities, and improving species populations and habitat protection (Berkes, 2009; Tran et al., 2020). Additionally, landscape assessments and planning around protected areas are needed to balance conservation and development (Chazdon et al., 2009; DeFries et al., 2010). However, most efforts to include traditional landscapes into PA management strategies focus primarily on socio-economic impacts of PAs, such as poverty reduction and ecosystem services that may benefit nearby communities (Bailey et al., 2015; Martino, 2001; Naughton-Treves et al., 2005; Palomo et al., 2014). Rapid landscape assessments of traditional land use and associated structural ecosystem elements as coarse indicators of biodiversity could be accomplished simultaneously, along with the evaluation of socio-economic impacts. Such an approach can aid managers in understanding baseline conditions, determine and prioritise restoration and conservation needs across broader landscapes, and conduct on-going monitoring to achieve land management goals.

CONCLUSION

We evaluated the relationship between traditional land use and the presence of structural ecosystem elements around a protected area. Traditional landscapes have exceptional conservation value and provide an

important role in supporting protected areas. However, the expansion of market forces into a region can alter the way traditional landscapes function and can displace traditional land use in favour of modern land use (Oldekop et al., 2013). Such a process can decrease the effective size of protected areas (Bailey et al., 2015). The biggest threat to biodiversity within protected areas, as well as traditional livelihoods, is related to modern resource extraction and development (Golden Kroner et al., 2019). Therefore, more attention must be given to include traditional landscapes around PAs in management strategies (Naughton-Treves & Holland, 2019), which can bolster the effective size of PAs across broader landscapes.

ACKNOWLEDGEMENTS

Thank you to MiAmbiente for providing access to Bastimentos Island National Marine Park; communities, residences and field guides for allowing access to their lands; and the School for Field Studies, Center for Tropical Island Biodiversity Studies for providing funding, staff and resources to support this research.

ABOUT THE AUTHORS

Ted Lawrence holds a PhD. in the Science and Management of Natural Resources from Cornell University. He is currently a postdoctoral research fellow with the Geospatial Institute at Saint Louis University. orcid.org/0000-0002-2115-2500

Casey Hart holds a BA in Biology and Environmental Studies from Gonzaga University.

Kate Petty holds a BS in Biological Sciences from the University of Denver.

Shelby Bocks holds a BA in Environmental and Ocean Sciences from the University of San Diego.

REFERENCES

Aaseng, N.E., Almendinger, J.C., Dana, R.P., Hanson, D.S., Lee, M.D., Rowe, E.R. and Wovcha, D.S. (2011). Minnesota's native plant community classification: A statewide classification of terrestrial and wetland vegetation based on numerical analysis of plot data. Biological Report. Retrieved from: https://files.dnr.state.mn.us/eco/mcbs/releve/releve_singlepage.pdf

Andrade, G.S.M. and Rhodes, J.R. (2012). Protected areas and local communities: An inevitable partnership toward successful conservation strategies? *Ecology and Society* 17: 14–31. https://doi.org/10.5751/es-05216-170414

Bailey, K.M., McCleery, R.A., Binford, M.W. and Zweig, C. (2015). Land-cover change within and around protected areas in a biodiversity hotspot. *Journal of Land Use Science* 11: 154–176. https://doi.org/10.1080/1747423x.2015.1086905

Ban, N.C. and Frid, A. (2018). Indigenous peoples' rights and marine protected areas. *Marine Policy* 87: 180–185. https://doi.org/10.1016/j.marpol.2017.10.020

Berkes, F. (2009). Community conserved areas: Policy issues in historic and contemporary context. *Conservation Letters* 2: 20–25. doi:10.1111/j.1755-263x.2008.00040.x

Brown, J. and Kothari, A. (2011). Traditional agricultural landscapes and community conserved areas: an overview. *Management of Environmental Quality: An International Journal* 22: 139–153. doi:10.1108/14777831111113347

Chazdon, R.L., Harvey, C.A., Komar, O., Griffith, D.M., Ferguson, B.G., Martínez-Ramos, M., Morales, H., Nigh, R., Soto-Pinto, L., van Breugel, M. and Philpott, S.M. (2009). Beyond reserves: A research agenda for conserving biodiversity in human-modified tropical landscapes. *Biotropica* 41: 142–153. https://doi.org/10.1111/j.1744-7429.2008.00471.x

Cramer, K.L. (2013). History of human occupation and environmental change in Western and Central Caribbean Panama. *Bulletin of Marine Science* 89: 955–982. https://doi.org/10.5343/bms.2012.1028

Dale, V.H. and Beyeler, S.C. (2001). Challenges in the development and use of ecological indicators. *Ecological Indicators* 1: 3–10. doi:10.1016/s1470-160x(01)00003-6

DeFries, R., Karanth, K. K. and Pareeth, S. (2010). Interactions between protected areas and their surroundings in human-dominated tropical landscapes. *Biological Conservation*, 143: 2870-2880. https://doi.org/10.1016/j.biocon.2010.02.010

Dorresteijn, I., Loos, J., Hanspach, J. and Fischer, J. (2015). Socioecological drivers facilitating biodiversity conservation in traditional farming landscapes. *Ecosystem Health and Sustainability* 1: 1–9. https://doi.org/10.1890/ehs15-0021.1

Dudley, N., Parrish, J.D., Redford, K.H. and Stolton, S. (2010). The revised IUCN protected area management categories: the debate and ways forward. *Oryx* 44: 485–490. https://doi.org/10.1017/s0030605310000566

Dudley, N., Phillips, A., Amend, T., Brown, J. and Stolton, S. (2016). Evidence for biodiversity conservation in protected landscapes. *Land* 5: 38–40. https://doi.org/10.3390/land5040038

Dudley, N., Shadie, P. and Stolton, S. (2013). Guidelines for applying protected area management categories including IUCN WCPA best practice guidance on recognising protected areas and assigning management categories and governance types. *Best Practice Protected Area Guidelines Series* (21). https://portals.iucn.org/library/node/30018

Farina, A. (2000). The cultural landscape as a model for the integration of ecology and economics. *Bioscience* 50: 313–320. https://doi.org/10.1641/0006-3568(2000)050[0313:tclaam]2.3.co;2

Fischer, J., Hartel, T. and Kuemmerle, T. (2012). Conservation policy in traditional farming landscapes. *Conservation Letters* 5: 167–175. https://doi.org/10.1111/j.1755-263x.2012.00227.x

Golden Kroner, R.E., Qin, S., Cook, C.N., Krithivasan, R., Pack, S.M., Bonilla, O.D., Cort-Kansinally, K.A., Coutinho, B., Feng, M., Martínez Garcia, M.I., He, Y., Kennedy, C.J., Lebreton, C., Ledezma, J.C., Lovejoy, T.E., Luther, D.A., Parmanand, Y., Ruíz-Agudelo, C.A., Yerena, E., Zambrano, V.M. and Mascia, M.B. (2019). The uncertain future of protected lands and

waters. *Science* 364: 881–886. https://doi.org/10.1126/science.aau5525

Guerrón-Montero, C. (2005). Marine protected areas in Panama: Grassroots activism and advocacy. *Human Organization* 64: 360–373. https://doi.org/10.17730/humo.64.4.2mx2j6qd0xyg1rqv

Hansen, A.J. and DeFries, R. (2007). Ecological mechanisms linking protected areas to surrounding lands. *Ecological Applications* 17: 974–988. https://doi.org/10.1890/05-1098

INEC (2015). Instituto Nacional de Estadística y Censo*. https://www.inec.gob.pa/*

IUCN (2013). https://portals.iucn.org/library/node/30018

Lawrence, T.J., Morreale, S.J. and Stedman, R.C. (2019a). Distant political-economic forces and global-to-local pathway to impacts on forests of Ejido landscapes across Yucatán, México. *Land Degradation & Development* 30: 2021–2032. https://doi.org/10.1002/ldr.3400

Lawrence, T.J., Stedman, R.C., Morreale, S.J. and Taylor, S.R. (2019b). Rethinking landscape conservation: Linking globalized agriculture to changes to indigenous community-managed landscapes. *Tropical Conservation Science* 12: 1–19. https://doi.org/10.1177/1940082919889503

Lawrence, T.J., Morreale, S.J., Stedman, R.C. and Louis, L.V. (2020). Linking changes in Ejido land tenure to changes in landscape patterns over 30 years across Yucatán, México. *Regional Environmental Change* 20: 1–13. https://doi.org/10.1007/s10113-020-01722-6

Martino, D. (2001). Buffer zones around protected areas: A brief literature review. *Electronic Green Journal* 1(15). https://doi.org/10.5070/g311510434

McElhinny, C., Gibbons, P., Brack, C. and Bauhus, J. (2005). Forest and woodland stand structural complexity: Its definition and measurement. *Forest Ecology and Management* 218: 1–24. doi:10.1016/j.foreco.2005.08.034

McGarigal, K., Compton, B.W., Plunkett, E.B., DeLuca, W.V., Grand, J., Ene, E. and Jackson, S.D. (2018). A landscape index of ecological integrity to inform landscape conservation. *Landscape Ecology* 33: 1029–1048. doi:10.1007/s10980-018-0653-9

Naughton-Treves, L. and Holland, M.B. (2019). Losing ground in protected areas? *Science* 364: 832–833. https://doi.org/10.1126/science.aax6392

Naughton-Treves, L., Holland, M.B. and Brandon, K. (2005). The role of protected areas in conserving biodiversity and sustaining local livelihoods. *Annual Review of Environment and Resources* 30: 219–252. https://doi.org/10.1146/annurev.energy.30.050504.164507

Oldekop, J.A., Holmes, G., Harris, W.E. and Evans, K.L. (2015). A global assessment of the social and conservation outcomes of protected areas. *Conservation Biology* 30: 133–141. https://doi.org/10.1111/cobi.12568

Palomo, I., Montes, C., Martín-López, B., González, J.A., García-Llorente, M., Alcorlo, P. and Mora, M.R.G. (2014). Incorporating the social–ecological approach in protected areas in the Anthropocene. *BioScience* 64: 181–191. https://doi.org/10.1093/biosci/bit033

Plieninger, T., Höchtl, F. and Spek, T. (2006). Traditional land-use and nature conservation in European rural landscapes. *Environmental Science & Policy* 9: 317–321. https://doi.org/10.1016/j.landusepol.2016.04.040

Plieninger, T., van der Horst, D., Schleyer, C. and Bieling, C. (2014). Sustaining ecosystem services in cultural landscapes. *Ecology and Society* 19: 59–64. https://doi.org/10.5751/es-06159-190259

Renes, H. (2015). Historic landscapes without history? A reconsideration of the concept of traditional landscapes. *Rural Landscapes: Society, Environment, History* 2. doi:10.16993/rl.ae

Ribeiro Palacios, M., Huber-Sannwald, E., García Barrios, L., Peña de Paz, F., Carrera Hernández, J. and Galindo Mendoza, M. de G. (2013). Landscape diversity in a rural territory: Emerging land use mosaics coupled to livelihood diversification. *Land Use Policy* 30: 814–824. https://doi.org/10.1016/j.landusepol.2012.06.007

Ruiz-Jaén, M.C. and Aide, T.M. (2005). Vegetation structure, species diversity, and ecosystem processes as measures of restoration success. *Forest Ecology and Management* 218: 159–173. https://doi.org/10.1016/j.foreco.2005.07.008

Rutten, G., Ensslin, A., Hemp, A. and Fischer, M. (2015). Vertical and horizontal vegetation structure across natural and modified habitat types at Mount Kilimanjaro. *PLOS ONE*, 10: 1–15. https://doi.org/10.1371/journal.pone.0138822

Siebert, S.F. and Belsky, J.M. (2014). Historic livelihoods and land uses as ecological disturbances and their role in enhancing biodiversity: An example from Bhutan. *Biological Conservation* 177: 82–89. https://doi.org/10.1016/j.biocon.2014.06.015

Spalding, A.K. (2013). Environmental outcomes of lifestyle migration: Land cover change and land use transitions in the Bocas del Toro Archipelago in Panama. *Journal of Latin American Geography* 12: 179–202. https://doi.org/10.1353/lag.2013.0038

Townend, J. (2002). Practical statistics for environmental and biological scientists. West Sussex: John Wiley & Sons.

Tran, T.C., Ban, N.C. and Bhattacharyya, J. (2020). A review of successes, challenges, and lessons from Indigenous protected and conserved areas. *Biological Conservation* 241: 108271. doi:10.1016/j.biocon.2019.108271

Valdespino, I.A. and Santamaría, D. (eds.) (1997). Evaluación Ecológica Rápida del Parque Nacional Marino Isla Bastimentos y Areas de Influencia: Isla Solarte, Swan Cay, Mimitimbi (Isla Colón), y el Humedal San San-Pond Sak, Provincia de Bocas del Toro. Tomo 1: Recursos Terrestres. Panamá City, Panamá: Asociación Nacional para la Conservación de la Naturaleza (ANCON).

Vlami, V., Kokkoris, I.P., Zogaris, S., Cartalis, C., Kehayias, G. and Dimopoulos, P. (2017). Cultural landscapes and attributes of "culturalness" in protected areas: An exploratory assessment in Greece. *Science of the Total Environment* 595: 229–243. https://doi.org/10.1016/j.scitotenv.2017.03.211

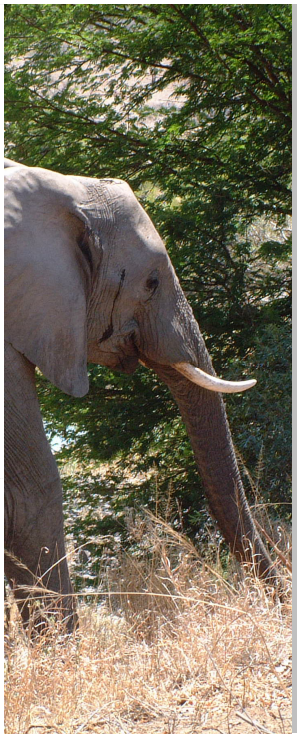
Vlami, V., Zogaris, S., Djuma, H., Kokkoris, I., Kehayias, G. and Dimopoulos, P. (2019). 'A field method for landscape conservation surveying: The Landscape Assessment Protocol (LAP)'. *Sustainability* 11: 1–20. https://doi.org/10.3390/su11072019

RESUMEN

Los paisajes gestionados tradicionalmente pueden desempeñar un papel fundamental en las estrategias de gestión de las áreas protegidas. Sin embargo, estos paisajes suelen ser mal evaluados e inventariados. Es posible que se conozcan los patrones más amplios de uso y cobertura del suelo, pero a menudo se desconocen tanto los detalles importantes sobre el uso de la tierra en un lugar específico como los elementos estructurales y la complejidad del ecosistema en cuestión. Realizamos una evaluación visual rápida para ilustrar la relación entre los paisajes gestionados tradicionalmente y la conservación de la biodiversidad alrededor de un parque nacional en Bocas del Toro, Panamá. La pregunta planteada para nuestra investigación fue: ¿cómo varía la presencia de factores estructurales del ecosistema en función del grado de uso tradicional de la tierra? Llevamos a cabo una evaluación visual rápida basada en el Protocolo de Evaluación del Paisaje previamente establecido: un método de campo para el estudio de la conservación del paisaje que –hasta donde sabemos– constituye la primera aplicación del protocolo a un paisaje tropical. Nuestros resultados muestran que la presencia de factores estructurales del ecosistema estaba fuerte y positivamente relacionada con el grado de uso tradicional de la tierra, lo que probablemente es común en los trópicos. Estas evaluaciones rápidas del paisaje pueden ayudar a los administradores de los parques y a los conservacionistas a colaborar con las comunidades locales para determinar y priorizar las necesidades de conservación y, en última instancia, favorecer el tamaño más eficiente de las áreas protegidas en paisajes más amplios.

RÉSUMÉ

Les sites paysagers gérés traditionnellement jouent un rôle vital dans les stratégies de gestion des aires protégées. Cependant, de tels paysages sont souvent mal inventoriés et évalués. Bien que des modèles larges d'occupation et d'utilisation du sol soit connus, des facteurs importants tels que l'utilisation spécifique de terrains et les composants structurels complexes qui renforcent la conservation de la biodiversité, restent largement méconnus. Nous avons effectué une évaluation visuelle rapide dans le parc national à Bocas del Toro au Panama, afin d'illustrer la corrélation entre les sites paysagers gérés traditionnellement et la conservation de la biodiversité. L'objet de notre recherche consistait à savoir comment la présence de composants structurels de l'écosystème varie avec le degré d'utilisation traditionnelle des terres. Nous avons effectué une évaluation visuelle rapide basée sur un protocole d'évaluation du paysage précédemment établi. Cette enquête sur la préservation du paysage menée sur le terrain, était, à notre connaissance, la première application du protocole à un paysage tropical. Nos résultats montrent que la présence de composants structurels d'un écosystème est fortement et positivement liée au degré d'utilisation traditionnelle des terres, ce qui est probablement courant sous les tropiques. De telles évaluations rapides du paysage peuvent favoriser l'engagement des gestionnaires de parcs et les écologistes auprès des communautés locales afin de déterminer et de hiérarchiser les besoins de conservation et, en fin de compte, aider à accroître la superficie effective des aires protégées dans des paysages plus vastes.



USE OF GEOTRACKER AND KOBOCOLLECT IN MONITORING PATROL EFFORT AND ILLEGAL ACTIVITIES IN OMO FOREST RESERVE, NIGERIA

Tajudeen Okekunle Amusa[1*], Kayode Kaothar Azeez[2] and Emmanuel Abiodun Olabode[3]

* Corresponding author: amusa.to@unilorin.edu.ng

[1]Department of Forest Resources Management, University of Ilorin, Ilorin, Nigeria
[2]Department of Agricultural Extension and Rural Development, University of Ilorin, Ilorin, Nigeria
[3]Nigerian Conservation Foundation, Omo-Oluwa-Shasha Forest Project, Victoria Island, Lagos, Nigeria

ABSTRACT

The study reports the use of GeoTracker and KoBoCollect as law enforcement monitoring tools in the elephant sanctuary of Omo Forest Reserve, southwest Nigeria. Illegal activities in and around the sanctuary were monitored from November 2019 to January 2021 through data collection by rangers while on patrol using the GeoTracker and KoBoCollect system. A total of 267 days of patrol were undertaken during the period. The patrol effort covered 1,081 km (Average = 83 km/month). The mean patrol effort of the rangers was 0.3. About 338 illegal activities that included hunting/gunshots/detection of spent cartridges, setting of wire snare/iron trap, encroachment, logging and farming were recorded. There was a significant difference in the frequencies of encounters of illegal activities across the months. There was also a weak but positive correlation between patrol effort and encounter rate of illegal activities. Spatial distribution of ranger patrols shows that patrols were largely concentrated in the south/mid-eastern part of the sanctuary. The area covered by patrols was relatively small compared to the total area of the sanctuary. The monitoring system provided useful feedback that can help improve the management of the elephant sanctuary.

Key words: anti-poaching patrol, illegal activities, Elephants

INTRODUCTION

The future of many high-value charismatic species and the ecosystems they inhabit across Africa are severely threatened as a result of various anthropogenic activities, including high levels of poaching and habitat destruction (Amusa et al., 2017; Henson et al., 2016). Protected areas have been viewed as the remedy to this malaise (Bruner et al., 2001; Terborgh & van Schaik, 2002), with two major approaches often used: one, being the implementation of a robust exclusionary punitive law enforcement inside core protected areas and the other, being collaborative community-based conservation in areas outside the core protected areas (Nyirenda & Chomba, 2012). The former (law enforcement within and around protected areas) is at the frontline of any site's conservation efforts as its effectiveness is one of the most important factors in providing an operative deterrent to illegal activities in an area (Henson et al., 2016).

Effectiveness of protected areas has been found to be significantly correlated with the level of deterrents to illegal activities (Bruner et al., 2001). Improved law enforcement efforts are associated with a reduction in illegal activities (Jachmann, 2008; Martin, 2010; Leader -Williams et al., 1990). In contrast, poor law enforcement efforts for addressing illegal activities in protected areas have been linked to declines in wildlife populations (Bassett, 2005; Ogutu et al., 2011). Gandiwa et al. (2013) in their study of illegal hunting and law enforcement in northern Gonarezhou National Park and adjacent areas in Zimbabwe reported that the number of illegal hunters arrested declined with increased law enforcement efforts, thereby supporting the hypothesis

that illegal activities would vary with level of law enforcement efforts.

Given the importance of law enforcement to conservation efforts, a number of initiatives have emerged to support management decisions on monitoring and patrol activities in and around protected areas. These range from GIS spatial analysis of illegal activities, use of CyberTracker and SMART as well as deployment of ICT, including the use of tablets and smartphones. All of these have opened up increasing opportunities in the field of forest monitoring, law enforcement and biodiversity conservation. For instance, Mubalama (2010) examined the spatial distribution of wildlife crime incidents in both the Kahuzi-Biega and Virunga National Parks using ArcGIS software with a view to showing how to best direct wildlife crime prevention and mitigation resources. Similarly, the Wildlife Conservation Society (WCS) introduced a CyberTracker-based law enforcement and monitoring system in the Mbe Mountains, Nigeria in 2009, leading to an increase in patrol effort from 343 patrol days/year in 2009 to 830 patrol days/year in 2013 (Imong et al., 2014). It also led to an overall decrease in hunting pressure and a steady increase in great ape observations reflecting the increased patrol effort.

In their study, Bassey et al. (2018) evaluating the use of CyberTracker (cybertracker.org/) and SMART (smartconservationtools.org/) for effective law enforcement monitoring in the Cross River Gorilla Landscape in Nigeria, also reported that total encounter rate of hunting signs per kilometre walked decreased from 2.57 in 2012 to 1.11 in 2017 in Afi Mountain Wildlife Sanctuary. A similar decrease in the total encounter rate of hunting signs was also recorded for the Okwangwo Division of Cross River National Park between 2011 and 2017. In the same vein, Brofeldt et al. (2018) studied community-based monitoring of tropical forest crimes and forest resources using ICT in Prey Lang, Cambodia. The study revealed that local communities with little formal education are able to monitor forest crimes and forest resources cost-effectively using ICT.

In this study, we report on the use of GeoTracker (geo-tracker.org/) and KoBoCollect (www.kobotoolbox.org/) as law enforcement monitoring tools to assess threats, adaptively manage ranger programmes, and improve effectiveness of anti-poaching patrols in the elephant sanctuary of Omo Forest Reserve, southwest Nigeria. GeoTracker alongside KoBoCollect has the capacity to improve the quality of ranger-based patrol data by avoiding errors previously encountered when using GPS units and notebooks only, and also by collecting standardised and comparable data across sites. It also has the potential to reduce the amount of time spent entering data by directly downloading patrol data from input devices to a database for analysis and reporting. In addition to fostering an improved communication between field personnel and managers through faster data analysis and reporting, this initiative can also help in improving the monitoring of ranger performance through the automated tracking function of GeoTracker, thereby increasing transparency and accountability.

MATERIALS AND METHODS

Study area

Omo Forest Reserve (OFR) is located between longitudes 40 19' – 40 40' E and latitudes 60 35' – 70 05' N in the Ijebu East and North Local Government Areas of Ogun State. It was gazetted in 1925 as part of the old Shasha forest reserve of southwestern Nigeria. It covers an area of about 1,305 km^2 forming common boundaries with Osun, Ago-owu and Shasha forest reserves in Osun State and Oluwa forest reserve in Ondo State, all of which also share some common natural endowments (Amusa, 2015). It is a mixed, moist, semi-evergreen rainforest in the Congolian sub-unit of the Guinea-Congolian Centre of Endemism or Phytochorion (Ola-Adams, 2014). The altitude ranges between 15 m and 150 m above sea level, mainly dominated by an undulating topography of up to 15 per cent slope. The rainy season in OFR usually commences in March. The mean annual rainfall in the area ranges from about 1600 to 2000 mm with two annual peaks in June and September, with November and February being the driest months (Isichei, 1995).

The forest reserve is inhabited by people of several ethnic groups, the dominant one being the Yoruba of Ijebu origin. Most parts of the forest are disturbed with a substantial area converted to monoculture plantations of the fast growing exotic *Gmelina arborea* tree. The Nigerian government in 1946 established a 460 ha Strict Nature Reserve (SNR) within the reserve. It was upgraded to a Biosphere Reserve (BR) in 1977 by UNESCO owing to its richness in biological diversity (Obioho, 2005). It is an IUCN category IV reserve. It was, therefore, expected to be a managed nature reserve/wildlife sanctuary with several objectives that are aimed at protecting biodiversity but permitting human use where this is compatible with forest conservation. Nevertheless, the ecological integrity of the reserve is threatened by increasing numbers of migrant farmers and a high rate of logging operations among other anthropogenic activities. In spite of this

situation, OFR still harbours one of the last remaining populations of Elephant, Chimpanzee and White-throated Monkeys in the southwestern part of Nigeria.

Interventions from the government and various conservation agencies (Nigeria Conservation Foundation, Paignton Zoo, UK and Pro-Natura International Nigeria) in order to mitigate threats to the rich biodiversity of the reserve have been implemented. These include establishing a wildlife sanctuary covering an area of about 37,500 ha ≈ 29 per cent of the forest reserve. The wildlife sanctuary is made up of Elephant (30,000 ha ≈ 23 per cent) and Chimpanzee (7,500 ha ≈ 6 per cent) areas or camps. However, the management of the area until recently has been haphazard owing to ineffective institutionalisation and poor law enforcement that has failed to halt most of the anthropogenic activities affecting biodiversity conservation.

Description of the GeoTracker and KoBoCollect system

Elephants in OFR are being protected under the Omo-Oluwa-Shasha Forest Elephant Protection Initiative/ Project. The project has ten rangers actively working in the field with two managers and one rangers' supervisor. The rangers operate in shifts of two teams of five rangers. Patrol activities are carried out by the rangers on foot and motorbikes. The rangers make use of intelligence reports, road blocks, stop and search, ambush and at times joint patrol with the government's Safety Corps in some locations within the project area. Field reporting of daily events and activities are captured in field notebooks, by camera, video recording and recording GPS coordinates of incidence locations. Rangers are empowered to stop and prevent all forms of encroachments into the elephant sanctuary. These encroachments can be in the form of farming, hunting, logging and trespassing.

To improve patrol efforts and activities, we introduced the GeoTracker and KoBoCollect system. Training sessions were conducted on how to use this system. The focus was on field data collection with intensive practical sessions in field testing. The training was tailored to ensure that rangers have the capacity to collect accurate and reliable information and are able to carry out preliminary analysis to provide decision support to meet conservation needs. Prior to the beginning of each training session, various software and databases were installed (GPS Coordinates, GPX Viewer and Google Earth) which are synchronised on different handheld smartphones and laptop computers.

GeoTracker is a database and geographic information system (GIS) that provides online access to environmental data. It is a software application program that was developed around 2013 to record data on GPS points and tracks. The innovation of GeoTracker lies in its ability to record, even when offline. It can be used on a handheld personal digital assistant (PDA), laptop or tablet personal computer and can take data on speed, duration and distance covered. All the data recorded can be geo-referenced and stored in a user-friendly way that allows easy access, display and analysis. It can record very long tracks without problems. Recorded tracks are saved in GPX, KML or KMZ format, so they can be used in certain applications such as OziExplorer or Google Earth. KoBoCollect is data collection app used on mobile devices in the field.

Data collection on illegal activities in the elephant sanctuary and adjoining areas using the GeoTracker and KoBoCollect system

Illegal activities and Elephant sightings in and around the elephant sanctuary of OFR were monitored from November 2019 to January 2021 through data recorded by rangers while on patrol activities using the GeoTracker and KoBoCollect system. Patrol routes were taken as transects with unfixed width. They were used to collect information on indicators of illegal activities and animal observations. During the patrol activities, data were recorded on the numbers of rangers on patrol; the duration of the patrol; the area travelled; the types, quantity and locations of illegal activities encountered; and the numbers of Elephants or their indices encountered.

Given that patrol movements should be unpredictable by nature, the rangers were trained to randomise patrol movements as much as practically feasible, both to optimise the impact of law enforcement, and to enable statistical inference from monitoring data. The patrol routes and the location of all encounters were marked using the GeoTracker and GPS Coordinates on enabled android phones. These were later overlaid on a base map of the project area and subsequent plotting of GPS coordinates. Also, GPX Viewer and Google Earth applications were used to plot and locate the areas covered by the rangers during the patrol activities. The GPS Coordinates application is configured to take pictures with the coordinate imprinted on the picture taken.

For Elephant sightings/indices, the location and signs detected during patrol were recorded. In the case of illegal activities, these were categorised according to

those offences which directly relate to hunting, gunshots, detection of spent cartridges, setting of wire snare/iron trap, encroachment, logging and farming.

Data analysis

Data analyses were conducted using monthly patrol man-days as the measure of effort (Jachmann, 2008). As described by Jachmann (2008), this index has been used in management of protected areas in Ghana due to its ease of interpretation, and the fact that minimum monthly standards for patrols in the country's protected areas are set using effective patrol man-days. One patrol day is designated to be 8 hours in length; the unit "patrol man-days" is then equivalent to the number of staff on patrol, multiplied by the number of days patrolled. In other words, for each patrol, independent of the duration, the number of patrol hours was divided by 8, and multiplied by patrol size (number of staff on patrol), to give the measure of effective patrol man-days, with these summed for the period of the study. An index, referred to as the "kilometric index of abundance" (KIA), based on the number of kilometres walked by patrols (Groupe, 1991), was used to compute encounter rates. This is the number of encounters with illegal activities or with Elephant/elephant indices in a given month divided by the distance in kilometres walked by patrols in that month. Additional data analysis was based on descriptive, parametric and non-parametric statistics, including t-test, Kruskal-Wallis tests and Spearman's rank correlations. All analyses were carried out at $p < 0.05$ in assessing significance. Qualitative and quantitative data were analysed using SPSS 20.0 and MS Excel 2016 and presented in tables and line charts. Spatial presentations were made for relevant data using shapefiles in mapping software directly from the GeoTracker.

RESULTS

Patrol effort

Table 1 and Figure 1 show the patrol effort and spatial distribution of rangers within the period under review (November 2019 – January 2021). A total of 267 days of patrol were undertaken during the period (range = 2–56 man-days/month, average = 20 man-days/month, SD = 14.72, CV = 0.07). Patrols were not made in May and October 2020 owing to severe restrictions in lockdowns occasioned by the COVID-19 pandemic. Generally, permits were obtained for rangers to carry out patrols as part of essential activities exempted from the lockdown. The highest number of days spent on patrol was in September 2020 (56 man-days), while the lowest was in December 2020 due to a new wave of lockdown and its severity in movement restriction for workers. On average, a total of 20 man-days/month was spent on

Forest Elephant © Equilibrium Consultants

Table 1. Rangers' patrol effort in the elephant sanctuary of Omo Forest Reserve

Month	Days spent on patrol	Distance covered (km)	Patrol effort
Nov-19	28	93.30	0.3
Dec-19	24	48.00	0.5
Jan-20	22	73.30	0.3
Feb-20	28	140.00	0.2
Mar-20	9	90.00	0.1
Apr-20	4	40.00	0.1
Jun-20	16	80.00	0.4
Jul-20	30	84.04	0.4
Aug-20	27	179.21	0.2
Sep-20	56	143.69	0.4
Nov-20	18	90.00	0.2
Dec-20	2	4.00	0.5
Jan-21	3	15.00	0.2

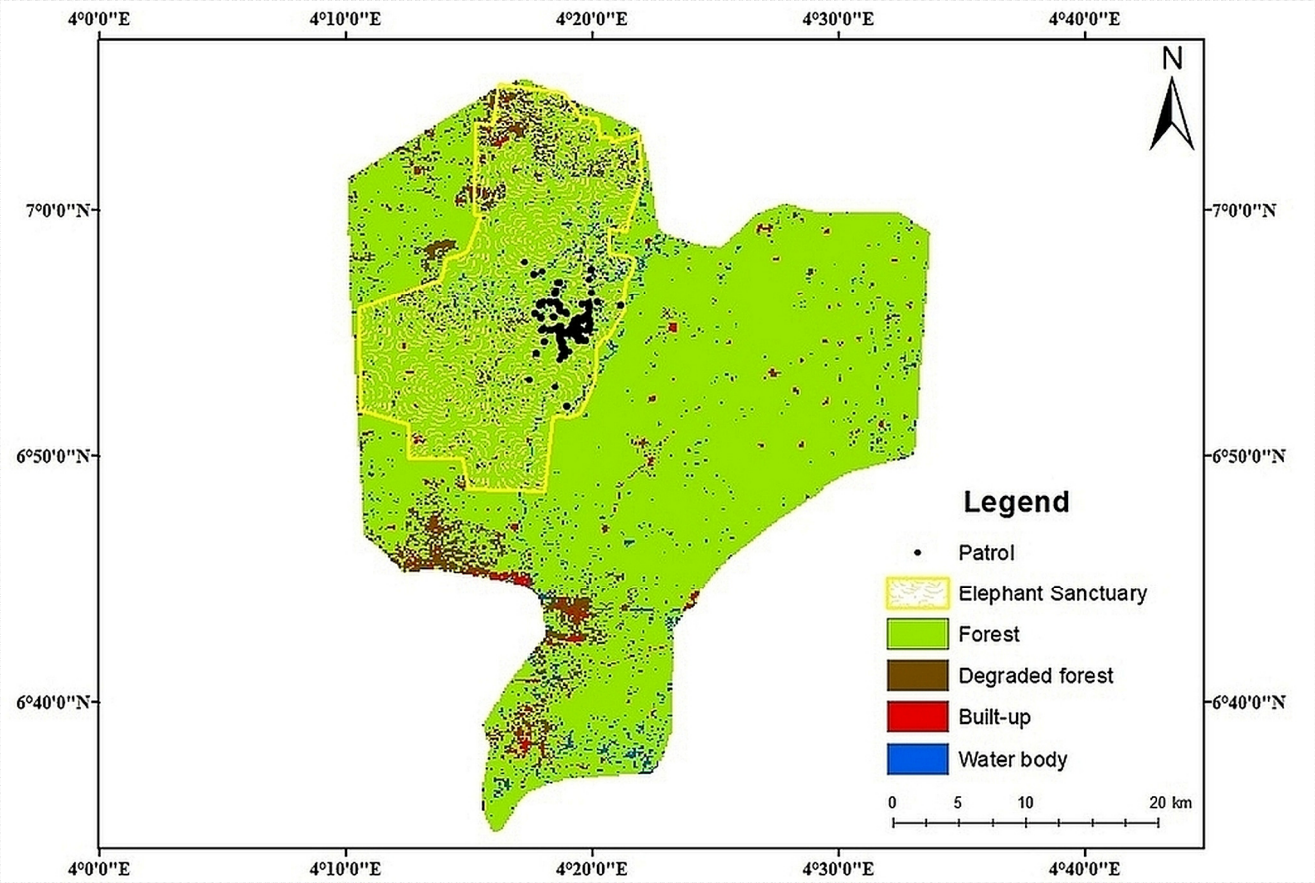


Figure 1. Locations of rangers' patrol effort over the study period

patrol by the rangers. The coefficient of variation (0.07) shows a low disparity across the months. The patrol effort covered a total of 1,081 km during the period under review (range = 4 – 179 km/month, average = 83 km/month, SD = 50.36, CV = 0.61). The maximum distance covered was 179 km/month, while the minimum was 4 km/month. The mean distance covered was 83.12 km/month with little variation across the months. The mean patrol effort of the rangers was 0.3. There is no significant difference in patrol efforts between the dry and rainy season in the study area ($t = 0.60$, $p > 0.05$). Overall, in the period under review, patrol in man-days per month was positively correlated with number of kilometres walked in those months ($rs = 0.72$, $p < 0.05$). Observations on the spatial distribution of ranger patrols show that patrols were largely concentrated in the south/mid-eastern part of the elephant sanctuary with occasional forays into the north -eastern area. The south-western, north-western and larger parts of the central areas of the sanctuary were not covered within the period under review. The area covered by patrols was relatively small compared to the total area of the elephant sanctuary.

Illegal activities encountered

The illegal activities encountered by rangers while on patrol include: hunting, gunshots, detection of spent cartridges, setting of wire snare and iron trap, encroachment, logging and farming activities. These activities were categorised based on prevalence into hunting/gunshots/detection of spent cartridges, setting of wire snare/iron trap, encroachment, logging and farming. A total of 179 hunting/gunshots/detection of spent cartridges were recorded within the period, while 53 setting of wire snare/iron trap were detected. There were four (4) cases of encroachment, eight (8) logging and 94 farming activities respectively. The highest rate of hunting/gunshots/detection of spent cartridges (36) was in August 2020, while the highest rate of setting of wire snare/iron trap (17) was in December 2019. Most of the encroachment (3) and logging activities (3) detected were in March 2020, while the most farming activities (24) detected was in September 2020. In aggregate terms, the highest number of illegal activities (56) of all categories was recorded in December 2019. The highest mean number of illegal activities encountered per kilometre walked was in December 2020 (0.40

encounter/km; Table 2). Kruskal-Wallis One-way Analysis of Variance shows a significant difference in the frequencies of encounters of illegal activities across the months ($H = 25.26$, $p < 0.05$), but not between dry and rainy seasons ($t = -1.185$, $p > 0.05$). There is also a weak but positive correlation between patrol effort and encounter rate of illegal activities ($rs = 0.27$, $p<.001$) in the study area.

Elephant and other animal sightings

Table 3 shows the various observations made on Elephant (*Loxodonta cyclotis*) ranging activities in the study area. These observations were classified as footprints, tracks, feeding site, dung, playing ground, scratching site and call. A total of 115 Elephant footprints were recorded within the period, but no actual sightings were made during the patrols. This was followed by detection of 30 Elephant feeding sites, 28 sites of fresh dung, 18 tracks and playing grounds, nine (9) scratching sites as well as one (1) call. The highest number of Elephant activities recorded was in January 2021 while mean encounter rate was 0.29 signs per kilometre. Meanwhile, several species of key animals other than Elephants were also sighted by rangers while on patrol. A total of 288 sightings involving 19 different species were recorded. The animals encountered include: *Anomalurus beecrofti* (Beecroft's Flying Squirrel), *Atherurus africanus* (Brush-tailed Porcupine)

Table 2. Encounter rate of illegal activities in the elephant sanctuary and adjoining areas across months

Illegal activities	Encounter rate of illegal activities/Km/Month												
	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	Jun 20	Jul 20	Aug 20	Sep 20	Nov 20	Dec 20	Jan 21
Gunshot/Hunting/ Detection of Cartridges	0.03	0.70	0.10	0.12	0.29	0.60	0.00	0.04	0.20	0.08	0.00	1.50	0.93
Wire Snare/Iron Trap	0.00	0.40	0.03	0.00	0.01	0.00	0.00	0.12	0.08	0.05	0.00	0.00	0.07
Encroachment	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Logging	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.01	0.00	0.50	0.00
Farming	0.00	0.13	0.00	0.03	0.09	0.20	0.01	0.27	0.02	0.18	0.06	0.00	0.73
Total	0.03	1.23	0.13	0.15	0.45	0.80	0.01	0.44	0.30	0.32	0.06	2.00	1.80
Average	0.01	0.25	0.03	0.03	0.09	0.16	0.00	0.09	0.06	0.06	0.01	0.40	0.36

Table 3. Observations of Elephants/Elephant activities in the elephant sanctuary and adjoining areas

Elephant activities	Months													
	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	Jun 20	Jul 20	Aug 20	Sep 20	Nov 20	Dec 20	Jan 21	Total
Footprints	4	7	4	17	10	6	-	12	5	9	7	18	16	115
Tracks	-	-	3	1	2	4	-	-	7	-	1	-	-	18
Feeding site	-	-	2	1	1	1	-	4	3	2	5	1	10	30
Dung	-	-	4	-	1	1	-	4	3	5	1	5	4	28
Playing ground	-	-	-	1	-	-	-	1	9	1	2	-	4	18
Scratching site	-	-	-	-	-	-	-	2	3	-	1	-	3	9
Call	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Total	4	7	13	20	14	12		23	30	17	17	24	38	219

Table 4. Observations of other animals/animal activities across months

Animals	Frequency of observations per month													
	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	Jun 20	Jul 20	Aug 20	Sep 20	Nov 20	Dec 20	Jan 21	Total
Anomalurus beecrofti (Squirrel)	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Atherurus africanus (Brush-tailed Porcupine)	-	1	-	2	-	-	-	3	-	2	7	1	5	21
Cephalophus maxwelli (Maxwell's Duiker)	-	3	-	-	1	-	-	-	-	-	-	-	-	4
Cephalophus niger (Black Duiker)	-	-	-	14	7	3	-	6	4	2	5	17	7	65
Cephalophus sylvicultor (Yellow-backed Duiker)	-	-	-	-	-	-	-	-	1	-	-	-	1	2
Cercocebus torquatus (Red-crowned Mangabey)	-	-	-	4	-	-	-	-	-	-	-	-	-	4
Cercopithecus mona (Mona Monkey)	-	-	-	-	-	-	-	-	-	3	-	-	5	8
Chamaeleo africanus (Chameleon)	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Civettictis civetta (African Civet)	2	6	-	-	1	-	-	2	2	1	2	2	4	22
*Cricetomys gambianus (*Gambian Giant-rat)	-	-	-	-	-	-	-	-	1	1	-	-	1	3
Crossarchus obscurus (Cusimanse Mongoose)	1	4	-	-	1	-	-	2	23	4	7	7	7	56
Dendrohyrax dorsalis (Tree Hyrax)	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Epomophorus gambianus (Fruit Bat)	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Manis spp. (Pangolin)	-	-	-	-	-	-	-	2	1	3	-	-	-	6
Naja nigricollis (Cobra)	-	-	-	-	1	-	-	-	-	2	-	-	-	3
Numida meleagris (Helmeted Guineafowl)	-	-	1	2	-	1	-	1	5	-	1	-	4	15
Potamochoerus porcus (Red River Hog)	-	-	1	19	4	-	10	1	8	2	-	1	3	49
Python regius (Rock Python)	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Tragelaphus scriptus (Bushbuck)	-	-	-	6	-	-	-	2	5	-	8	-	4	25
Total	3	15	2	47	15	5	10	20	51	21	30	28	41	288

and *Cephalophus maxwelli* (Maxwell's Duiker) among others (Table 4). *Cephalophus niger* (Black Duiker) was the most frequently encountered animal (65). This was followed by *Crossarchus obscurus* (Cusimanse Mongoose; 56) and *Potamochoerus porcus* (Red River-hog; 49). More animals were encountered in August 2020 (51) than in other months. The mean encounter rate of key animals other than Elephant was also 0.29 signs per kilometre.

DISCUSSION

The work of rangers in protecting flagship species like Elephants and their habitats is not an easy task. Training in new technologies, methods and strategies to achieve better results lightens the load somewhat. The key aspect of this study is the use of GeoTracker and KoBoCollect as law enforcement monitoring tools. Collecting law enforcement and wildlife monitoring data using a notebook and GPS is time consuming and prone to errors (Bassey et al., 2018). In contrast, by using the GeoTracker and KoBoCollect system, we have shown that it is possible for rangers to collect large amounts of geo-referenced data that is downloaded directly from an input device to a desktop computer for analysis and reporting. This has helped to significantly improve ranger motivation and performance in the field.

The study has shown that current patrol efforts in the elephant sanctuary of Omo Forest Reserve may be suboptimal. The mean patrol effort and mean distance covered by rangers as recorded are in contrast with the findings of Wiafe and Amoah (2012) who reported a mean of 381 monthly man-days of patrol effort and average distance covered of 643 km in Kakum Conservation Area, Ghana. The reason for this observation could be attributed to differences in the numbers of rangers carrying out patrols in the areas as well as limitations posed by the COVID-19 pandemic. Further, patrol activities in the study area are currently on a pilot scale and yet to take full shape. This may also explain why the spatial distribution of ranger patrol activities is largely concentrated in certain areas of the elephant sanctuary.

While there is no significant difference in the frequencies of encounters of illegal activities between the dry and rainy seasons in the study area, there is a perceived decline in illegal activities in the landscape even though the decline was not steady over the whole study period. The observation of a significant difference across months suggests that patrol activities may have to be stepped up during certain periods of the year. This is even more important given that farming and hunting are widely practised in the study area with incessant encroachment into the elephant sanctuary. This offers opportunity for scaling up the potential benefits of the GeoTracker system in comparing the detection of illegal activities and patrol efforts in the future.

Meanwhile, observations on Elephant activities and other animals have also shown that the elephant sanctuary is very rich in biodiversity and efforts should be sustained to continuously protect the area. This is underscored by the current conservation status of some of the animals. The Elephants and other animals are generally threatened by habitat loss due to farming and logging in the study area.

CONCLUSION

The monitoring system described in this study has provided useful feedback that can help improve the management of the elephant sanctuary in Omo Forest Reserve, southwest Nigeria. The patrol activities and law enforcement efforts at the elephant sanctuary need to be strengthened and made more effective in reducing all forms of illegal activities in the area. There is a need for more investment in this conservation strategy. The protection activities of the rangers should be intensified across the seasons of the year and into the different parts of the elephant sanctuary. The current size of the ranger force needs to be increased in order to ensure that most areas of the elephant sanctuary are effectively patrolled. The rangers should be motivated, continuously trained and respond to data on the different incidence of illegal activities encountered in order to adapt management strategies for the elephant sanctuary. It is also important and pertinent to provide up-to-date technology such as that used in this study in a sustainable and standardised system to collect patrol information so as to enhance the effectiveness of protection efforts. This should be combined with continuous sensitisation of farmers, hunters and local people in the area.

ACKNOWLEDGEMENTS

We express our sincere gratitude to the Rufford Foundation for providing the financial support to carry out this work through a grant award (RSG 27297-C). We profoundly appreciate the support received from the Nigerian Conservation Foundation towards ensuring the

River Omo in Omo forest reserve, south west of Nigeria © Fela Sanu/Shutterstock.com

success of the project. We also thank all members of the rangers' squad at the elephant sanctuary of Omo Forest Reserve, Nigeria for their cooperation.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

ABOUT THE AUTHORS

Tajudeen Okekunle Amusa (PhD) is a Senior Lecturer in the Department of Forest Resources Management, University of Ilorin, Nigeria. He is also a member of the National-Level IUCN Expert Assessment Group for the Green List (EAGL), Nigeria. He has been working on Elephant conservation in the country for over a decade.

Kayode Kaothar Azeez (PhD) is a trained extension officer with many competencies. He has participated in developmental works such as the Oxford Policy Management/PowerGen project, PATH II BCC Evaluation Survey, FADAMA III Endline Survey Data, and International Food Policy Research Institute (IFPRI) Nutritional Study among others.

Emmanuel Abiodun Olabode works as Education and Research Coordinator on Omo-Shasha-Oluwa Forest Elephant Initiative under the aegis of the Nigerian Conservation Foundation and other partners. He holds a BSc degree in Wildlife Management and a host of certificate courses in tropical ecology and conservation.

REFERENCES

Adebisi, A. (2004). A case study of Garcinia kola nut production-to-consumption system in J4 area of Omo forest reserve, South-west Nigeria. In: T. Sunderland and O. Ndoye (Eds) Forest products, livelihoods and conservation: Case studies on non-timber forest systems, Vol. 2, pp. 115–132. CIFOR. ISBN 979-3361-25-5. DOI: https://www.cifor.org/publications/pdf_files/Books/NTFPAfrica/Chapter7-Chapter13.PDF

Amusa, T.O. (2015). Trade and income generation potentials of African bush pepper (Piper guineense, Schum. & Thonn) in tropical lowland rainforests of southwestern Nigeria. Nature & Faune 29(2): 59–63. ISSN: 2026-5611. DOI: http://www.fao.org/3/i4872e/i4872e.pdf

Amusa, T.O., Omonu, C., Olabode, E. and Newton, N.J. (2017). Population status and distribution of forest elephants (Loxodonta cyclotis Matschie, 1900) in Okomu National Park and Omo Forest Reserve, South-Western Nigeria. Journal of Research in Forestry, Wildlife & Environment 9(2): 23–28. DOI: https://www.ajol.info/index.php/jrfwe/article/view/158950

Bassett, T.J. (2005). Card-carrying hunters, rural poverty, and wildlife decline in northern Côte d'Ivoire. The Geographical Journal 171(1): 24–35. DOI: https://doi.org/https://doi.org/10.1111/j.1475-4959.2005.00147.x

Bassey, E., Mengnjo, C. and Eban, J. (2018). Use of CyberTracker and SMART for effective law enforcement monitoring in the cross river gorilla landscape in Nigeria. Proceedings of 6th NSCB Biodiversity Conference 2018: 322–327. DOI: https://nscbconf2018.files.wordpress.com/2018/05/54_85-nscb-2018.pdf

Brofeldt, S., Argyriou, D., Turreira-García, N., Meilby, H., Danielsen, F. and Theilade, I. (2018). Community-based monitoring of tropical forest crimes and forest resources using information and communication technology – Experiences from Prey Lang, Cambodia. Citizen Science: Theory and Practice 3(2): 4. DOI: https://doi.org/10.5334/cstp.129

Bruner, A.G., Gullison, R.E., Rice, R.E. and Da Fonseca, G.A.B. (2001). Effectiveness of parks in protecting tropical biodiversity. Science 291(5501): 125–128. DOI: https://doi.org/10.1126/science.291.5501.125

Gandiwa, E., Heitkönig, I.M.A., Lokhorst, A.M., Prins, H.H.T. and Leeuwis, C. (2013). Illegal hunting and law enforcement during a period of economic decline in Zimbabwe: A case study of northern Gonarezhou National Park and adjacent areas. Journal for Nature Conservation 21(3): 133–142. DOI: https://doi.org/10.1016/j.jnc.2012.11.009

Groupe, C. (1991). Méthodes de suivi des populations de chevreuils en forêt de plaine: Exemple: L'indice kilométrique (I.K.). Bulletin Mensuel ONC, Supplément 157, Fiche N° 70., pp. 4. Office National de la Chasse, Paris.

Henson, D.W., Malpas, R.C. and D'Udine, F.A.C. (2016). Wildlife law enforcement in Sub-Saharan African protected areas: A review of best practices (Occasional paper of the IUCN Species Survival Commission, No. 58). IUCN. DOI: https://doi.org/10.2305/iucn.ch.2016.ssc-op.58.en

Imong, I., Eban, J. and Celestine, M. (2014). Using technology to save gorillas in the Mbe Mountains. Gorilla Journal 48: 16–17. DOI: https://www.berggorilla.org/en/journal/issues/journal-no-48/

Isichei, A.O. (1995). Omo Biosphere Reserve, current status, utilization of biological resources and sustainable management: Nigeria. DOI: http://www.unesco.org/ulis/cgi-bin/ulis.pl?catno=113912&set=00597FC7AE_1_403&gp=1&lin=1&ll=1

Jachmann, H. (2008). Monitoring law-enforcement performance in nine protected areas in Ghana. Biological Conservation 141 (1): 89–99. DOI: https://doi.org/10.1016/j.biocon.2007.09.012

Leader-Williams, N., Albon, S.D. and Berry, P.S.M. (1990). Illegal exploitation of black rhinoceros and elephant populations: Patterns of decline, law enforcement and patrol effort in Luangwa Valley, Zambia. Journal of Applied Ecology 27(3): 055–1087. DOI: https://www.jstor.org/stable/2404395?origin=crossref

Martin, E. (2010). Effective law enforcement in Ghana reduces elephant poaching and illegal ivory trade. Pachyderm 48: 24–32. DOI: https://pachydermjournal.org/index.php/pachyderm/article/view/233/194

Mubalama, K.L. (2010). Monitoring law enforcement effort and illegal activity in selected protected areas: Implications for management and conservation, Democratic Republic of Congo. Faculty of Science, Department of Geography, January 2010, 347. DOI: https://www.researchgate.net/publication/292435607_Monitoring_law_enforcement_effort_a

nd_illegal_activity_in_selected_protected_areas_implications_for_management_and_conservation_Democratic_Republic_of_Congo

Nyirenda, V.R. and Chomba, C. (2012). Field foot patrol effectiveness in Kafue National Park, Zambia. Journal of Ecology and the Natural Environment 4(6): 163–172. DOI: https://doi.org/10.5897/jene12.010

Obioho, G.I.B. (2005). Ecological ethnobotany and the management of Omo Biosphere Reserve, Nigeria. In: L. Popoola, P. Mfon and P.I. Oni (Eds) Sustainable forest management in Nigeria: Lessons and prospects. Proceedings of the 30th Annual Conference of the Forestry Association of Nigeria, held in Kaduna, Kaduna State: 86–91.

Ogutu, J.O., Owen-Smith, N., Piepho, H.P. and Said, M.Y. (2011). Continuing wildlife population declines and range contraction in the Mara region of Kenya during 1977–2009. Journal of Zoology 285(2): 99–109. DOI: https://doi.org/10.1111/j.1469-7998.2011.00818.x

Ola-Adams, B.A. (2014). Biodiversity Inventory of Omo Biosphere Reserve. DOI: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/GEBR_Biodiversity_Inventory_Report.pdf

Terborgh, J. and van Schaik, C. (2002). Why the world needs parks. In: J. Terborgh, C. van Schaik, L. Davenport and M. Rao (Eds) Making parks work: Strategies for preserving tropical nature. Washington, DC: Island Press.

Wiafe, E.D. and Amoah, M. (2012). The use of field patrol in monitoring of forest primates and illegal hunting activities in Kakum Conservation Area, Ghana. African Primates 7(2): 238–246. DOI: http://journals.sfu.ca/afrprims/index.php/AfricanPrimates/article/viewArticle/64

RESUMEN

El estudio informa sobre el uso de GeoTracker y KoBoCollect como instrumentos de monitoreo para la aplicación de la ley en el santuario de elefantes de la Reserva Forestal Omo, en el suroeste de Nigeria. Las actividades ilegales en el santuario y sus alrededores fueron monitoreadas desde noviembre de 2019 hasta enero de 2021 mediante la recolección de datos durante los patrullajes de los guardaparques utilizando el sistema GeoTracker y KoBoCollect. Durante dicho período se realizó un total de 267 días de patrullaje. Los esfuerzos de patrullaje abarcaron 1.081 km (un promedio de 83 km/mes). El esfuerzo medio de patrullaje de los guardaparques fue de 0,3. Se registraron alrededor de 338 actividades ilícitas que incluían la caza/disparos/detección de cartuchos gastados, colocación de trampas de alambre/hierro, invasión, tala y agricultura. Hubo una diferencia significativa en la frecuencia de los hallazgos de actividades ilícitas en los diferentes meses ($H = 25,26$, $p < 0,05$). También se registró una correlación débil pero positiva entre el esfuerzo de las patrullas y la tasa de hallazgos de actividades ilícitas ($rs = 0,27$, $P < 0,001$). La distribución espacial de los patrullajes muestra que las patrullas se concentraron en gran medida en la parte meridional y centro-oriental del santuario. La zona cubierta por las patrullas era relativamente pequeña en comparación con el área total del santuario. El sistema de monitoreo proporcionó información que podría ser de utilidad para ayudar a mejorar la gestión del santuario de elefantes.

RÉSUMÉ

L'étude examine l'utilisation du GeoTracker et du KoBoCollect en tant qu'outils de surveillance de l'application de la loi dans le sanctuaire des éléphants de la réserve forestière d'Omo, au sud-ouest du Nigeria. Les activités illégales à l'intérieur et autour du sanctuaire ont été surveillées de novembre 2019 à janvier 2021 grâce à la collecte de données à l'aide du système GeoTracker et KoBoCollect lors de patrouilles des rangers. Au total, 267 jours de patrouille ont été effectués au cours de la période. L'effort de patrouille a couvert un total de 1 081 km (en moyenne 83 km/mois), la patrouille moyenne étant de 0,3 km. Environ 338 activités illégales ont été enregistrées dont la chasse, les coups de feu, la détection de cartouches épuisées, la pose de collets métalliques ou de pièges en fer, l'empiètement, l'exploitation forestière et agricole. Le nombre de constats d'activité illégale variait de manière significative au cours des mois ($H = 25.26$, $p < 0.05$). Il y avait aussi une corrélation faible mais positive entre l'effort de patrouille et le taux des constats d'activité illégale (rs 0,27, P \u003c 0,001). La distribution spatiale des patrouilles des rangers montre que ces patrouilles étaient largement concentrées dans la partie sud/centre-est du sanctuaire. La zone couverte par les patrouilles était relativement petite par rapport à la superficie totale du sanctuaire. Ce système de suivi a fourni des informations utiles qui pourront aider à améliorer la gestion du sanctuaire des éléphants.

UNDERSTANDING WASTE MANAGEMENT BEHAVIOUR IN PRIVATE NATURE RESERVES THROUGH THE THEORY OF PLANNED BEHAVIOUR

Claudine Roos[1,2*], Francois Retief[2], Reece Alberts[2], Dirk Cilliers[1,2], William Hodgson[3] and Iain Olivier[3]

* Corresponding author: Claudine.roos@nwu.ac.za

[1]School for Geo- and Spatial Sciences. North-West University, Potchefstroom, South Africa

[2]Research Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa

[3]Sabi Sand Wildtuin, Sabi Sand Pfunanani Trust, Skukuza, South Africa

ABSTRACT

Responsible waste management in protected areas is essential to ensure that these areas remain protected and that negative impacts on visitor experience are reduced. Behaviour plays an important role in establishing and implementing responsible waste management measures. This paper aims to provide insights about the Theory of Planned Behaviour and its application towards understanding waste management behaviour in private nature reserves. The Sabi Sand Wildtuin, a private nature reserve located in the Greater Kruger National Park in South Africa, was selected to explore the research aim. Surveys were used to gather data from the management authority, and the owners or managers of the commercial- and non-commercial properties in the reserve. The responses from forty participants indicated that all three stakeholder groups generally had positive attitudes towards waste management and supported the development of an integrated waste management strategy. The participants also generally expressed their intention to implement responsible waste management practices. The Pearson Chi-Square test highlighted some statistically significant associations between: intrinsic motivation and intent/willingness to participate in certain waste-related interventions; attitude (mostly related to perceiving waste management as a benefit) and support; as well as support and intent.

Key words: attitudes, intent, willingness, support, protected areas, South Africa

INTRODUCTION

Protected areas are increasingly expected to generate tourism revenue and deliver resultant community benefits, placing increased development pressure on already threatened and sensitive environments (Sandbrook et al., 2019). One specific concern with increased development within protected areas is effective waste management (Steg & Vlek, 2009; Sandham et al., 2020). The negative impacts of waste on protected areas are well-known (Przydatek, 2019), affecting conservation efforts, adjacent communities, and visitor experience (Morrison-Saunders et al., 2015; Mateer, 2020). The research by Morrison-Saunders et al. (2015), which focused on understanding expectations for responsible tourism in protected areas, indicated that visitor expectations for waste management included:

- "Effective waste management";
- Consideration of the "waste management hierarchy" and the "circular economy"; and
- Improving "awareness" of visitors around waste management issues and waste management practices.

The need to supplement the income of state-owned (public) conservation areas has been globally recognised, due to a decline in public funding aimed at conservation initiatives, as well as the lack of human resource capacity of public entities to effectively manage existing conservation estates (Kamal et al., 2015). Privately protected areas, such as private nature reserves (PNRs), are considered a key component of protected area strategies (Mitchell et al., 2018; Przydatek, 2019). When compared to protected areas in general, the defining characteristic of PNRs is the reliance on private governance.

In the waste management context, the management frameworks and measures of PNRs may differ from those of state-owned nature reserves. For state-owned protected areas, the management of waste and funding of waste management measures would be the responsibility of government. For PNRs on the other hand, multiple stakeholders may be involved in waste management. The management authority, for instance, may set goals and develop guidelines/best practices and procedures for the management of waste, whereas owners and managers of private land would be responsible for the implementation of these measures (practically and/or financially).

Within the context of waste management in PNRs, responsible waste management practices may, thus, require considerable effort and resources, along with continual commitment and often, changes in behaviour (Gilli et al., 2018). It is, therefore, important to understand the underlying factors influencing behaviour (Ghani et al., 2013; Gilli et al., 2018). In this regard the Theory of Planned Behaviour (TPB) provides an appropriate theoretical framework to better understand waste management behaviour.

The TPB, a psychological theory which was derived from the Theory of Reasoned Action in 1980, aims to predict a person's intention to engage in a specific behaviour (Gilli et al., 2018). The TPB suggests that intentions predict behaviour, and that intentions are a function of subjective norms, attitudes and perceived behavioural control (Nixon & Saphores, 2007). Research findings on waste management behaviour have challenged the traditional thinking around the TPB framework, suggesting the addition of some factors. Cecere et al. (2014) and Gilli et al. (2018) argue that attitude is strongly influenced by intrinsic and extrinsic motivation, while Ghani et al. (2013) and Razali (2020) included situational variables as a factor influencing waste-related behaviour. Chen et al. (2020) have found that support for policies or interventions is a key aspect that can have a positive effect on behavioural intention.

In the light of these findings, this study applies an amended TPB framework (Figure 1) focusing on intrinsic and extrinsic motivation, attitude, subjective norms (reciprocity), intention and support.

Although responsible waste management behaviour in protected areas is imperative from an environmental and social perspective, limited published research is available on waste-related behaviour in protected areas. This paper aims to provide insights about the TPB and its application towards understanding waste management behaviour in PNRs.

METHODS

Given the lack of research on waste management in protected areas in general, and more specifically in PNRs, a South African PNR, the Sabi Sand Wildtuin[i] (SSW) was selected as a case study to explore the research question.

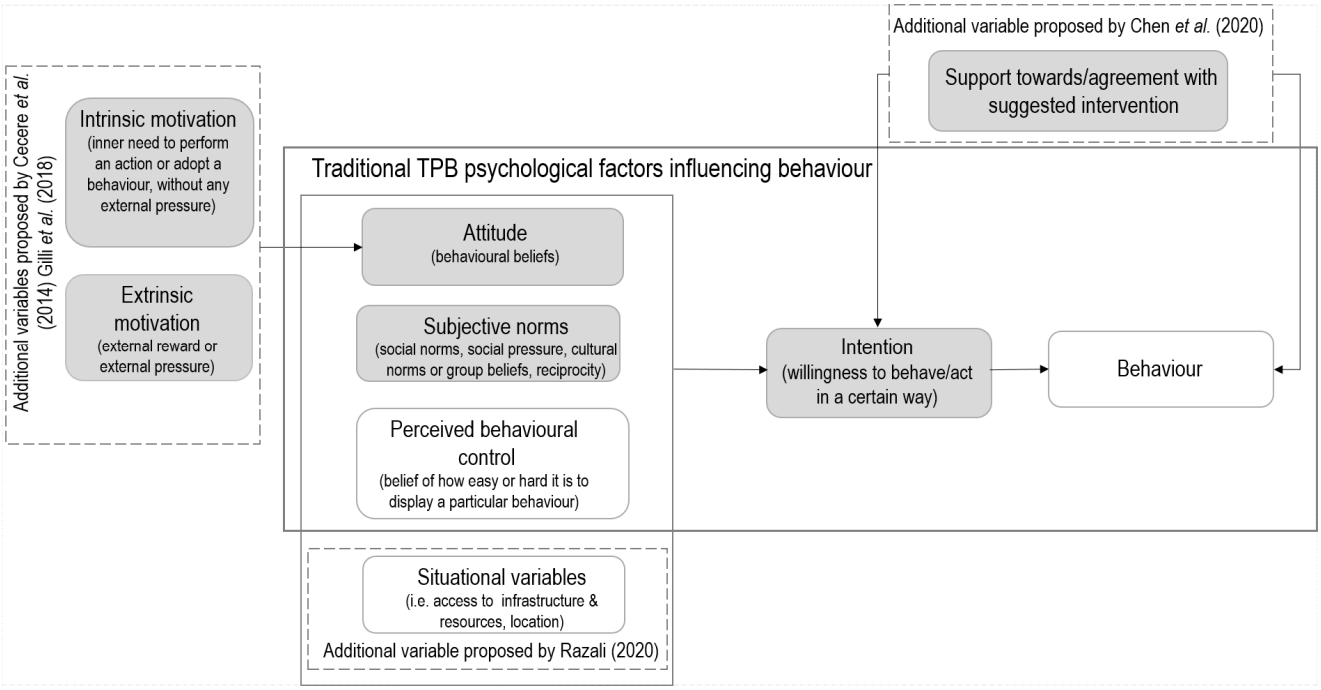


Figure 1. Adapted TPB framework informing this research (adapted from Ghani et al., 2013; Cecere et al., 2014; Gilli et al., 2018; Chen et al., 2020; and Razali, 2020). Variables included in this research are shaded in grey.

Case study design

To apply the TPB towards understanding waste-related behaviour, the case study area would preferably need to meet the following criteria:

- Have existing waste management measures, procedures or practices in place (Chen et al., 2020);
- Provide for pluralistic or divergent views from different stakeholders (Vijayabanu & Amarnath, 2013) in respect of waste-related behaviour; and
- Have an adequate number of individuals willing to participate in the research (Strydom, 2018).

The SSW, located in the Greater Kruger National Park, South Africa (Figure 2) was considered a suitable case study to provide insights about the TPB and its application towards understanding waste management behaviour in PNRs, because:

- The SSW is well-established (since 1948) and has a single management authority in the form of an association that is more than 50 years old and which employs around 300 people;
- A number of stakeholders are involved in the management (of waste) at the SSW, which provides the ideal context to explore waste-related behaviour;
- The SSW is relatively large (consisting of 49,481 hectares of land). The reserve mainly caters for the higher income and international ecotourism markets, and provides for different tourism products, with a range of activities, services, facilities and infrastructure with resultant waste management challenges; and
- Waste management has been identified as a particular priority by SSW. The management of the reserve is in the process of developing an integrated waste management strategy (IWMS). The SSW is the only PNR in South Africa to have initiated the development of an IWMS.

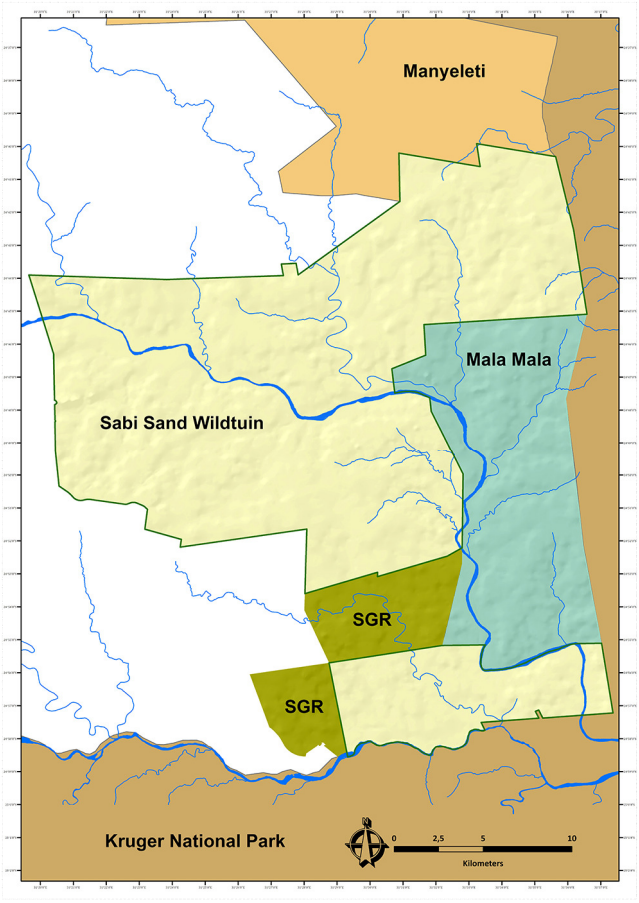


Figure 2. Sabi Sand Wildtuin (SSW) – the PNR selected as a case study for the research

Survey

Three categories of stakeholders were selected for inclusion in the research, namely: the SSW management authority; owners or managers of commercial properties (lodges); and owners of non-commercial properties. Although visitors' behaviour plays an important part in responsible tourism and related waste management, visitors were not included in the scope of this research[ii] and is an interesting area for future research.

Surveys, in the form of structured questionnaires (see Supplementary Online Material Table 1), were used to gather data regarding their responses related to:

- Attitudes and subjective norms towards waste management (A1 to A7);
- Support towards the development and implementation of a coordinated waste management strategy (S1); and
- Intention (or level of willingness) to implement certain (future) waste management practices (I1 to I9).

No pre-designed statements or questions exist to explore waste-related behaviour in PNRs, or any other protected areas. The works of Ghani et al. (2013), Gilli et al. (2018) and Razali et al. (2020) mainly focus on household behaviour towards waste management, and were adapted for the purposes of this research.

Ordinal scales were used to measure the level of agreement, support and intention of respondents relating to these statements. Statements related to intention/willingness were not posed to the management authority, since they have already communicated their commitment and intention as part of their waste management strategy development

process. Reasons for agreement or disagreement with the statements posed were not investigated and form part of future follow-up research.

The survey was administered electronically to 65 potential participants during a response window of 30 days (February to March 2020). Responses were received from a total of 40 participants (62% response rate) that included:

- Eleven (11) members of the Executive Committee of the management authority (100% response rate);
- Representatives from fifteen (15) of the commercial properties (63% response rate from a total of 24 commercial properties); and
- Representatives from fourteen (14) non-commercial properties (47% response rate from a total of 30 non -commercial properties).

The IBM SPSS software package was used to analyse the data (IBM, 2021). The frequency of responses (expressed as percentage per ordinal scale ranking) related to the attitude- (A), support- (S) and intent- (I) statements were calculated per stakeholder category (Supplementary online material – Table 2). The mean ordinal scale ranking was also calculated for each of the statements per stakeholder category. Cross-tabulation (also referred to as contingency tables) was used to determine whether any associations exist between the different TPB factors (i.e. whether associations exist between attitude (A) and support (S); attitude (A) and intent (I); or support (S) and intent (I)). Ordinal scale ratings related to A1, A2, A3, A5, A6[iii], S1 and I1 to I9 were included in the cross-tabulations. Pearson's Chi-Square test (X2), with 2-sided p-values, was used to determine whether associations between TPB factors (individual statements) were statistically significant (if $p<0.05$). The Chi-Square test only assesses associations between categorical variables and cannot provide any inferences about causation (IBM, 2021).

RESULTS AND DISCUSSION

Attitude and subjective norms towards responsible waste management

Responses related to intrinsic motivation, subjective norms and extrinsic motivation are discussed below.

Intrinsic motivation/inner beliefs (Statements A1, A2 and A3)

Intrinsic motivation may be based on factors such as care for other's well-being or altruism, moral norm, and ethical orientation (Gilli et al., 2013). Statements related to beliefs and intrinsic factors (Statements A1 to A3, for detailed wording see Supplementary Online Material Table 2) generally scored well for all three stakeholder categories.

The majority of respondents from the management authority, commercial and non-commercial properties either strongly agreed or agreed that waste management is an essential part of environmental management (A1) and that waste management should form an integral part of the reserve's activities (A2).

The value or benefit of sound waste management practices as a benefit for all properties (A3) was accepted by the management authority and commercial properties, while the majority of respondents from non-commercial properties did not support this view. This may be due to the fact that respondents representing non-commercial properties regard sound waste management practices to be of greater value or benefit to commercial properties (than to themselves) due to indirect benefits accruing to commercial properties, such as marketing and reputation, which would not necessarily be applicable to non-commercial activities.

Subjective norms (reciprocity) (Statement A4)

Reciprocity refers to attitudes towards waste management based on perceived social norms and reputational concerns. Statement A4 required the management authority and commercial properties to reflect on their level of agreement with the statement: "Sound waste management practices are expected by our guests". Existing literature shows that sound waste management is one of the main expectations of visitors to protected areas (Morrison-Saunders et al., 2019; Mateer, 2020).

All of the respondents from the management authority and 80 per cent of the commercial property (lodges) respondents either strongly agreed or agreed that sound waste management practices are expected by the reserve's guests (A4), highlighting the important role that reciprocity may play in waste-related attitudes. It is significant to note that although the majority of respondents agreed that sound waste management practices are expected by their guests (A4), most of these respondents did not believe that waste management considerations should outweigh the convenience and ecotourism experience of their guests (A7).

Extrinsic motivation (Statements A5, A6 and A7)

Extrinsic factors influencing attitudes towards waste management may include factors such as incentives or disincentives, cost, effort, as well as recognition and reward from external sources. For this research, extrinsic considerations focused on the contribution of sound waste management towards the image and brand of the PNR (A5), as well as negative aspects such as cost and effort (A6), and perceived inconvenience caused to guests (A7).

Respondents from the management authority and commercial properties mostly strongly agreed that sound waste management could improve the image of the SSW and marketing of the SSW brand (A5). Respondents from non-commercial properties had diverging opinions, with 38 per cent of respondents feeling neutral or disagreeing with the statement. This may be due to the largely non-commercial nature of their activities, where marketing and the image of the PNR may be less important.

Cost and effort related to the implementation of waste management measures are frequently mentioned as a factor negatively influencing attitudes and participation in waste management practices (Moh & Manaf, 2017). Respondents were asked to indicate their level of agreement with statement A6: "The cost and effort associated with sound waste management do not outweigh the benefit". In this instance, it was the respondents from the non-commercial properties who tended to be more in agreement with this statement, than the more neutral management authority and commercial property respondents. This response may be due to the higher costs and more effort required for waste management for the management authority and commercial properties when compared to the smaller, less complex nature of non-commercial properties and their required waste-related practices.

Lastly, respondents from the management authority and commercial properties were asked to consider whether sound waste management considerations are more important than convenience and the ecotourism experience of their guests (A7). Approximately 55 per cent of the respondents from the management authority and 80 per cent of respondents from commercial properties either strongly disagreed or disagreed with this statement, indicating that the convenience and positive ecotourism experiences of their guests play an important role in waste management considerations. SSW is a world-renowned reserve, which caters for the international market. It is not surprising that positive ecotourism experiences of guests play an important role in their waste management considerations.

Support towards the development of an integrated waste management strategy (IWMS) (Statement S1)

Following Chen et al. (2020), support for policies or interventions is a key aspect that can have a positive effect on behavioural intention. All of the respondents from the management authority and the majority of respondents from commercial properties (87 per cent) indicated that they fully support the development of an IWMS. Responses from the non-commercial property participants also indicated that the majority of participants (76 per cent) fully or partially supported the development of the IWMS. Two respondents (14 per cent) were neutral, and one respondent (7 per cent) indicated that he/she did not support the development of an IWMS. It was found that some of the respondents from non-commercial properties regarded waste management as having limited benefits for them (related to their responses to A3 above), which could explain the reason for the lower level of support from this stakeholder category.

Intention towards implementing waste management practices (Statements I1 to I9)

The majority of commercial and non-commercial property participants reported a relatively strong intention (willingness) to implement the suggested waste management practices (I1 to I9). Statements related to intention/willingness were not posed to the management authority.

Statements I1, I4, I7, I8 and I9 scored relatively highly, with between 47 and 87 per cent of commercial properties indicating that they are willing to implement these measures. Commercial property respondents reacted less enthusiastically to statements I2, I5 and I6, where they indicated willingness "under certain circumstances". Statements I5 and I6, requiring some kind of intervention to or restriction of guests' waste-related activities, may be linked to statement A7, where none of the commercial property respondents agreed with the statement, implying that sound waste management considerations are less important than convenience and ecotourism experience of their guests. This highlights the importance of finding solutions for waste-related issues that are deemed to be acceptable and relatively convenient to guests, or that require limited guest intervention.

Sabi Sand Wildtuin Reserve © Sabi Sand Wildtuin Pfunanani Trust

When comparing mean scores for intent/willingness statements, participants from commercial properties generally reported higher levels of willingness to engage in certain waste management practices than participants from non-commercial properties. The exceptions were statements I5 ("require visitors or occupants to participate in waste separation at source") and I6 ("restrict the disposal of certain waste streams at the PNR"). The more "willing" nature of the non-commercial property respondents (with reference to I5 and I6), may be related to the non-commercial nature of their activities, where the practices suggested in I5 and I6 will not require commercial guest interventions. Owners of non-commercial properties largely use their properties for private purposes. Controlling or influencing the practices of these non-commercial property occupants may be perceived as requiring less effort and impacting less negatively on ecotourism experience, when compared to the more complex guest relationships and interventions required from commercial properties.

The majority of participants from non-commercial properties indicated that they were willing to implement measures related to statements I1, I5, I6 and I7, and were neutral towards statements I3 and I8. They were, however, largely unwilling to: "Allocate human resources towards waste management" (I2) and to "Replace non-recyclable materials, with recyclable materials" (I4).

Associations between attitude and subjective norms, support and intention

Cross-tabulation (also referred to as contingency tables) was used to determine whether any associations exist between the different TPB factors (i.e, whether associations exist between attitude (A) and support (S); attitude (A) and intent (I); or support (S) and intent (I)). Responses to A1, A2, A3, A5, A6, S1 and I1 to I9 were included in the cross-tabulations. Pearson's Chi-Square test (X2), with 2-sided p-values, was used to determine whether associations between TPB factors (individual statements) were statistically significant (if $p<0.05$).

The TPB framework suggests that relationships or associations exist between the different factors (or constructs) influencing behaviour (Ghani et al., 2013; Cecere et al., 2014; Gilli et al., 2018; Chen et al., 2020; Razali, 2020). Table 1 indicates that the associations between the different TPB statements included in this research were generally not statistically significant.

Association (Pearson's Chi Square)		A1	A2	A3	A5	A6	S1
S1	χ^2	0.960	5.886	18.733	45.217	11.759	
	p	0.987	0.751	0.028	0.000	0.465	
I1	χ^2	29.703	32.518	8.815	19.136	8.783	10.705
	p	0.000	0.000	0.455	0.085	0.721	0.297
I2	χ^2	5.053	12.244	17.728	14.048	11.683	10.930
	p	0.537	0.200	0.038	0.298	0.471	0.281
I3	χ^2	8.117	11.406	15.393	9.888	22.871	17.560
	p	0.230	0.249	0.081	0.626	0.029	0.041
I4	χ^2	3.435	7.934	8.621	6.632	9.794	18.874
	p	0.753	0.541	0.473	0.881	0.634	0.026
I5	χ^2	12.287	10.999	7.431	9.729	17.575	12.143
	p	0.056	0.276	0.592	0.640	0.129	0.205
I6	χ^2	4.817	5.522	5.890	7.266	8.770	7.676
	p	0.567	0.787	0.751	0.840	0.722	0.567
I7	χ^2	15.423	17.745	12.295	24.296	12.468	22.111
	p	0.017	0.038	0.197	0.019	0.409	0.009
I8	χ^2	12.625	16.594	15.275	8.882	25.458	5.430
	p	0.049	0.050	0.084	0.713	0.013	0.795
I9	χ^2	11.643	18.926	19.201	14.078	18.150	5.566
	p	0.070	0.026	0.024	0.296	0.111	0.782

Table 1: Associations between different TPB factors indicated by means of Pearson's Chi-Square (X^2) and p-values

Statistically significant associations (which are highlighted in grey), however, exist between:

- A1 and A2 (intrinsic motivation statements), and I1, I7, I8 and I9. This indicated that respondents agreeing with the statements "Waste management is an essential part of sound and sustainable environmental management (A1)" and "Waste management should form an integral part of the reserve's activities (A2)" (i.e. having positive intrinsic motivation) were willing to participate in the interventions suggested in I1 (implement activities outlined in the reserve's IWMS), I7 (acquire waste-related infrastructure), I8 (participate in awareness and education) and I9 (support local community involvement in waste management).
- A3 (intrinsic motivation statement) and A5 (extrinsic motivation), and S1. These were the only attitude statements which showed an association with S1 (supporting the implementation of the IWMS). This means that respondents agreeing with the statements "Sound waste management is for the benefit of all (commercial and non-commercial) properties" (A3) and "Sound waste management can improve the image of the PNR and marketing of the PNR's brand" (A5) were more likely to support the development of an IWMS. Statements A3 and A5 relate to benefits and improving the image/brand of the reserve, as a result of sound waste management. The association between A3 and A5, and S1 may indicate that respondents who regard sound waste management as having some form of benefit, may be more inclined to support the development of the IWMS. The opposite may also be true – that respondents who do not regard sound waste management as having any benefits, would not support the development of the IWMS.
- S1 (support), and I3, I4 and I7. These associations indicated that respondents who were likely to support the development of the IWMS, would also be willing to "avoid the purchasing of non-recyclable materials" (I3), "replace non-recyclables with recyclable materials" (I4) and "acquire waste related infrastructure" (I7). All of these actions relate to the waste management hierarchy where waste should be avoided, minimised, re-used, recycled and recovered; and where disposal should be the last resort. The association between support and these intent/willingness statements may indicate the willingness of respondents (who are supportive of the IWMS development) to implement measures to achieve the waste management hierarchy.

Community-based recycling projects by the Sabi Sand Pfunanani Trust © Sabi Sand Wildtuin Pfunanani Trust

The interrelated nature of the TPB factors discussed above emphasises the potential role that these variables may play to influence behaviour towards responsible waste management, as suggested by the TPB framework.

CONCLUSIONS

The paper aims to provide insights about the Theory of Planned Behaviour (TPB) and its application towards understanding waste management behaviour in private nature reserves (PNRs) using Sabi Sand Wildtuin (SSW) as a case study. In particular, the research evaluated the attitudes, support and intention of different PNR stakeholder categories towards responsible waste management.

The majority of respondents from all three stakeholder categories reported positive attitudes towards waste management, supported the development of an IWMS, and were largely willing to participate in waste management practices. However, non-commercial properties indicated their reluctance towards allocating human resources and avoiding the purchasing of non-recyclable materials, while commercial property respondents were sensitive towards inconveniencing

their guests or influencing the visitors' ecotourism experience. These experiences and expectations in PNRs with a strong commercial/tourism component need to be balanced against the implications of waste management requirements. Both stakeholder categories strongly supported community involvement in waste-related projects, as well as the acquisition of waste separation bins in pursuit of recycling. Differences in stakeholder category attitude/opinion, support and willingness need to be taken into consideration during the implementation of the IWMS, since divergent views may influence buy-in of the different stakeholders, as well as the actual implementation of and compliance to measures stipulated in the IWMS.

The Pearson's Chi-Square test highlighted some statistically significant associations between: intrinsic motivation and intent/willingness to participate in certain waste-related interventions; attitude (mostly related to perceiving waste management as a benefit) and support; as well as support and intent. This emphasises the potential role that these variables play to ultimately influence behaviour towards responsible waste management. The following is, therefore, recommended:

- Since intrinsic factors are more difficult to change, a focus on extrinsic factors are suggested to change attitudes, and ultimately behaviour. Examples may include interventions related to address the cost and effort of waste management, where inexpensive and convenient alternatives need to be considered.
- The role of external incentives and external recognition for sound waste management practices should be optimised. This may include improving brand image, marketing value and international recognition to appeal to eco-conscious tourists.
- Creating awareness amongst the stakeholder categories on the benefits of responsible waste management is an important aspect as it may increase support/buy-in, and change waste-related attitudes and behaviour. This may be achieved through stakeholder communication on legal compliance, local community benefits, financial benefits, as well as environmental benefits.
- The role of education and awareness in waste management behaviour should be taken into consideration. Research by Strydom (2018) on recycling behaviour in South Africa, suggests that the level of education and awareness, as well as the perceived success of existing programmes or practices, have a significant influence on behaviour. Including these aspects in future research may be useful.

In-depth interviews with the stakeholder categories to further understand the reasons behind these results could provide the basis for future research. Furthermore, research into visitors' behaviour in the context of responsible waste management in protected areas is also recommended to gain further insights.

By progressively improving our understanding of waste management behaviour in PNRs, better management and conservation of these protected areas could be achieved.

ENDNOTES

[1]Sabi Sand Wildtuin is the official name of the private nature reserve. Wildtuin is an Afrikaans word that can be translated as "Game Reserve".

[2]Data on visitors' perceptions were not available at the time of the research because of travel restrictions due to the COVID-19 pandemic. Visitors' perceptions on waste management as it relates to the TPB is an area for future research.

[3]Statements A4 and A7 were omitted from the cross-tabulations, since these statements were not posed to all stakeholder groups.

SUPPLEMENTARY ONLINE MATERIAL

Table 1. Survey statements related to attitude, support and intent towards responsible waste management

Table 2. Frequency of responses (expressed as percentage per ordinal scale ranking) and mean ordinal scores per statement for each of the three stakeholder categories

ACKNOWLEDGEMENTS

The authors acknowledge the contributions of the Sabi Sand Wildtuin and Sabi Sand Pfunanani Trust towards this research. The participation of the various stakeholders, namely the SSW management authority, owners/managers of lodges and owners/managers of non-commercial properties are acknowledged and highly appreciated.

ABOUT THE AUTHORS

Claudine Roos is a senior lecturer at the North-West University (NWU), South Africa. She holds a PhD in Environmental Sciences. She is the programme coordinator for the Masters programme in Environmental Management with specialisation in Waste Management. Her research focus is on environmental- and waste management governance, as well as understanding waste-related behaviour.
ORCID: 0000-0002-6290-6129

Francois Retief is a professor in environmental management within the Research Unit for Environmental Science and Management at NWU. He

completed his PhD at the University of Manchester and previously served as Director of the School for Geo and Spatial Sciences at NWU, as well as co-editor of the journal Impact Assessment and Project Appraisal. He is currently developing a Master's programme with specialisation in conservation leadership at NWU. ORCID: 0000-0001-7164-9593

Reece Alberts is senior lecturer at NWU. He holds a PhD in Geography and Environmental Management and has a Master's degree in Environmental Law. Reece does research in environmental impact assessment, nature conservation, environmental law, environmental governance and environmental leadership. His latest publications are aimed at understanding the effectiveness of environmental policy instruments in protected areas. ORCID: 0000-0001-6840-4405

Dirk Cilliers is associate professor at NWU where he obtained his PhD in Geography and Environmental Management. Prof Cilliers is Subject Chair for Geography and Environmental Studies at NWU. His research interests focus on Geographical Information Systems, biogeography, biodiversity and environmental management. ORCID: 0000-0001-9777-0463

William Hodgson is the Sabi Sand Pfunanani Trust Projects Coordinator. Mr. Hodgson is responsible for coordinating the development of the integrated waste management strategy for Sabi Sand Wildtuin. ORCID: 0000-0002-3766-0315

Iain Olivier is the Sabi Sand Wildtuin Reserve Manager. His background is in Conservation Ecology. Iain has 15 years of experience working in protected areas in the field of conservation management with a strong focus on field rangers, monitoring, management of conservation programs, and research. ORCID: 0000-0002-5284-6249

REFERENCES

Cecere, G., Mancinelli, S. and Mazzanti, M. (2014). 'Waste prevention and social preferences: the role of intrinsic and extrinsic motivations'. *Ecological Economics* 107: 163–176. DOI: 10.1016/j.ecolecon.2014.07.007

Chen, F., Chen, H., Liu, S., Li, W., Li, Q. and Long, R. (2020). 'Formation and recurrence mechanism of residents' waste separation behaviour under the intervention of an information interaction'. *Resources, Conservation and Recycling* 162: 105027. DOI: 10.3390/ijerph16101859

Department of Environment, Forestry and Fisheries (DEFF). (2020). *South African Protected Areas Database (SAPAD), Quarter 3, 2020*. Available from: https://egis.environment.gov.za

Ghani, W.A.W.A.K., Rusli, I.F., Biak, D.R.A. and Idris, A. (2013). 'An application of the theory of planned behaviour to study the influencing factors of participation in source separation of food waste'. *Waste Management* 33 (5): 1276–1281. DOI: 10.1016/j.wasman.2012.09.019

Gilli, M., Nicolli, F. and Farinelli, P. (2018). 'Behavioural attitudes towards waste prevention and recycling'. *Ecological Economics* 154: 294–305. DOI: 10.1016/j.ecolecon.2018.08.009

IBM. (2021). IBM SPSS trails. https://www.ibm.com/za-en/analytics/spss-trials. Date of access: October 2021.

Mateer, T., Taff, B.D. and Miller, Z. (2020). *Using visitor observations to predict proper waste disposal: A case study from three US national parks.* DOI: 10.1016/j.crsust.2020.01.001

Mitchell, B.A., Stolton, S., Bezaury-Creel, J., Bingham, H.C., Cumming, T.L., Dudley, N., Fitzsimons, J.A., Malleret-King, D., Redford, K.H. and Solano, P. (2018). *Guidelines for privately protected areas. Best Practice Protected Area Guidelines Series No. 29.* Gland, Switzerland: IUCN. https://mpg.eurosite.org/wp-content/uploads/IUCN-Guidance-on-Management-of-Privately-Owned-PAs.pdf

Moh, Y.C. and Manaf, L.A. (2017). 'Solid waste management transformation and future challenges of source separation and recycling practice in Malaysia'. *Resources, Conservation and Recycling* 116: 1–14. DOI: 10.1016/j.resconrec.2016.09.012

Morrison-Saunders, A., Hughes, M., Pope, J., Douglas, A. and Wessels, J. (2019). 'Understanding visitor expectations for responsible tourism in an iconic national park: differences between local and international visitors'. *Journal of Ecotourism* 18 (3): 284–294. DOI: 10.1080/14724049.2019.1567740

Nguyen, T.T.P., Zhu, D. and Le, N.P. (2015). 'Factors influencing waste separation intention of residential households in a developing country: evidence from Hanoi, Vietnam'. *Habitat International* 48: 169–176. DOI: 10.1016/j.habitatint.2015.03.013

Nixon, H. and Saphores, J.M. (2007). 'Financing electronic waste recycling – Californian households' willingness to pay advanced recycling fees'. *Journal of Environmental Management* 84(4): 547–559. DOI: 10.1016/j.jenvman.2006.07.003.

Przydatek, G. (2019). 'Waste Management in Selected National Parks – A Review'. *Journal of Ecological Engineering* 20 (4): 14–22. DOI: 10.12911/22998993/102609

Razali, F., Daud, D., Weng-Wai, C. and Jiram, W.R.A. (2020). 'Waste separation at source behaviour among Malaysian households: The Theory of Planned Behaviour with moral norm'. *Journal of Cleaner Production* 271: 122025. DOI: 10.1016/j.jclepro.2020.122025

Sandbrook, C., Fisher, J.A., Holmes, G., Luque-Lora, R. and Keane, A. (2019). 'The global conservation movement is diverse but not divided'. *Nature Sustainability* 2: 316–323. DOI: 10.1038/s41893-019-0267-5

Sandham, L.A., Huysamen, C., Retief, F.P., Morrison-Saunders, A., Bond, A.J., Pope, J. and Alberts, R.C. (2020). 'Evaluating Environmental Impact Assessment report quality in South African national parks'. *Koedoe: African Protected Area Conservation and Science* 62(1): a1631. DOI: 10.4102/koedoe.v62i1.1631

Steg, L. and Vlek, C. (2009). 'Encouraging pro-environmental behaviour: An integrative review and research agenda'. *Journal of Environmental Psychology* 29: 309–317. DOI: 10.1016/j.jenvp.2008.10.004

Strydom, W.F. (2018). 'Applying the Theory of Planned Behavior to Recycling Behavior in South Africa'. *Recycling* 43(3): 1–20. DOI: 10.3390/recycling3030043

Tonglet, M., Phillips, P.S. and Read, A.D. (2004). 'Using the Theory of Planned Behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK.' *Resources, Conservation & Recycling* 41 (3): 191–214. DOI: 10.1016/j.resconrec.2003.11.001

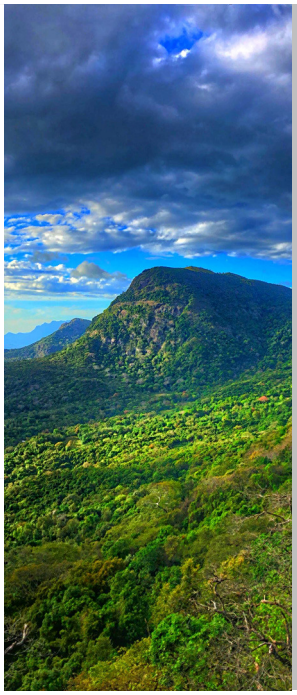
Vijayabanu, U. and Amarnath, N.S. (2013). 'A study on environmental attitude and ecological behaviour.' *Indian Journal of Health & Wellbeing* 4(4): 868–871.

RESUMEN

La gestión responsable de los residuos en las áreas protegidas es fundamental para garantizar que estas áreas permanezcan protegidas y que se reduzcan los impactos negativos en la experiencia de los visitantes. El comportamiento desempeña un papel importante a la hora de establecer y aplicar medidas para la gestión responsable de los residuos. El objetivo de este artículo es proporcionar información sobre la Teoría del comportamiento planificado y su aplicación para comprender el comportamiento de la gestión de residuos en las reservas naturales privadas. Para explorar el objetivo de la investigación se seleccionó la reserva natural privada Sabi Sand Wildtuin, situada en el Gran Parque Nacional Kruger de Sudáfrica. Se utilizaron encuestas para recopilar información del órgano de gestión y de los propietarios o administradores de las propiedades comerciales y no comerciales en la reserva. Las respuestas de cuarenta participantes indicaron que los tres grupos de interesados tenían, en términos generales, actitudes positivas hacia la gestión de residuos y apoyaban el desarrollo de una estrategia para la gestión integrada de los residuos. Los participantes también expresaron su intención de implementar prácticas responsables de gestión de residuos. La correlación de Pearson de chi cuadrado puso de manifiesto algunas asociaciones estadísticamente significativas entre la motivación intrínseca y la intención/ voluntad de participar en determinadas intervenciones relacionadas con los residuos; la actitud (mayormente relacionada con la percepción de la gestión de residuos como un beneficio) y el apoyo; así como la intencionalidad y el apoyo.

RÉSUMÉ

Une gestion responsable des déchets dans les aires protégées est essentielle pour assurer la protection de ces zones et réduire les impacts négatifs sur l'expérience des visiteurs. Le comportement humain joue un rôle important dans l'établissement et la mise en œuvre des mesures de gestion responsable des déchets. Cet article vise à fournir des informations concernant la Théorie du Comportement Planifié et comment son application peut contribuer à mieux comprendre le comportement humain face aux défis de gestion des déchets dans les réserves naturelles privées. Le Sabi Sand Wildtuin, une réserve naturelle privée située dans le parc national du Grand Kruger en Afrique du Sud, a été sélectionné pour servir de support à cette recherche. Des enquêtes ont permis de recueillir des données auprès de l'autorité de gestion ainsi que des propriétaires ou gestionnaires de propriétés commerciales et non commerciales de la réserve. Les réponses de quarante participants ont indiqué que ces trois groupes d'intervenants affichent en général des attitudes positives à l'égard de la gestion des déchets et soutiennent l'élaboration d'une stratégie intégrée de gestion des déchets. Les participants ont aussi généralement exprimé leur intention de mettre en place des pratiques de gestion responsable des déchets. Le test du Chi Carré de Pearson a mis en évidence certaines associations statistiquement significatives : entre la motivation intrinsèque et l'intention/la volonté de participer à certaines interventions liées aux déchets; entre l'attitude (principalement liée à la perception de la gestion des déchets comme un avantage) et le soutien; et entre le soutien et l'intention.



DEFENDERS OF WILDLIFE CONSERVATION IN SRI LANKA: A CAUTIONARY NOTE FOR THE FUTURE OF RANGERS

Supun L. Prakash[1,2], Gamini V. Samarakoon[3], Buddhika D. Madurapperuma[4], Suranjan Karunarathna[5*] and Thilina D. Surasinghe[6]

* Corresponding author: suranjan.karu@gmail.com

[1]Guangxi Key Laboratory for Forest Ecology & Conservation, College of Forestry, Guangxi University, Guangxi, P. R. China
[2]Biodiversity Conservation & Research Circle, Wattala, Sri Lanka
[3]Samarawasa, Liyanegama, Dompe, Sri Lanka
[4]Department of Forestry & Wildland Resources, Humboldt State University, CA, USA
[5]Nature Exploration & Education Team, Moratuwa, Sri Lanka
[6]Department of Biological Sciences, Bridgewater State University, Bridgewater, MA, USA

ABSTRACT

Providing physical protection to wildlife is among the most high-risk professions in the conservation sector as it is directly associated with the prevention of wildlife crimes. In Sri Lanka, the Department of Wildlife Conservation is the primary government agency responsible for the long-term conservation and protection of biological diversity. Since the establishment of the department in October 1949, there have been casualties in the line of duty among field officers of DWC. Here, we examine the nature and the conditions that led to the demise of these field officers whilst on duty. From October 1949 to December 2020, at least 80 have been killed and one reported missing while on duty. The death rate averaged one officer per year. The major cause of death was terrorist attacks followed by encounters with free-ranging Asian Elephants, and confrontations with wildlife criminals. Providing physical protection to the wildlife and prevention of environmental crimes are critical pillars in conservation, therefore preventing untimely death of wildlife officers is paramount. Providing rigorous training for wildlife officers, protective gear, firearms, and other logistic resources and capacity building is imperative to boost the morale and career commitments of Sri Lanka's wildlife officers.

Key words: firearm violence, game guards, poaching, wildlife attacks, wildlife crimes

INTRODUCTION

Biodiversity is vital for both the Earth's life-supporting system and to sustain a multitude of socio-economic benefits to the human society (Wilson, 1992). Nonetheless, increasing human population growth and heightening demands for natural resources have amplified biodiversity erosion worldwide (Cardinale et al., 2012). While protected areas mitigate biodiversity loss, without adequate physical protection, due to poaching, illicit extraction for the pet trade and other purposes (medical, cultural), habitat encroachment and vengeful killing, anthropogenic defaunation can continue even inside protected landscapes, which is particularly notable in tropical biodiversity hotspots of the developing world (Mittermeier et al., 2000; Young et al., 2016).

Wildlife rangers – also known as game/wildlife wardens, forest/game guards, field enforcement officers, environmental police officers – are wildlife professionals tasked with safeguarding the natural, cultural and historical heritage, and protecting the rights and prosperity of current and future generations with respect to natural resources. Bounded by legal and institutional frameworks, rangers oversee the protection of state, communal, Indigenous or private conservation landscapes or seascapes (International Ranger Federation, 2021). They provide a variety of services, including law enforcement, to prevent environmentally harmful activities, maintain a safe and secure environment for humans and wildlife, monitor wildlife and their habitats, manage environmental risks, and empower and engage with local communities, collaborate with key stakeholders of conservation, and assist with tourism, education and public awareness (Warchol & Kapla, 2012; Eliason, 2011). Ranger duties may include working under gruelling field conditions for prolonged time spans despite insufficient logistic support and minimal infrastructure. They are underpaid, undertrained and frequently encounter

Victoria, Randenigala, Rantambe Sanctuary; a wildlife rich area in the intermediate zone of Sri Lanka © Ranga Wijerathna

poachers as well as wildlife, resulting in considerable safety concerns (Belecky et al., 2019; Singh et al., 2020). In developing nations, anthropogenic pressures on wildlife are disproportionately high, which heightens the demands on wildlife rangers (Warchol & Kapla, 2012). Likewise, the socio-economic and political challenges characteristic of developing nations also plague the ground-deployed conservation professions (Eliason, 2011).

Sri Lanka is a small island (65,610 km2) in the Indian Ocean between 5°55' – 9°51' N and 79°41' – 81°54' E and recognised as a global Biodiversity Hotspot (Myers et al., 2000). Sri Lanka has a long legacy in wildlife conservation, even predating the European colonial era. Currently, Sri Lanka's biodiversity receives satisfactory legislative protection (De Zoysa, 2001). There are 660 protected areas which protect nearly a third (19,897 km2) of Sri Lanka's land area (UNEP & WCMC, 2021). The establishment of the Department of Wildlife Conservation (DWC) in October 1949 was a milestone in conservation and management of Sri Lankan biodiversity (Ministry of Land and Land Development, 2014). Since its inception, the field officers of the DWC (hereafter, "field officers") deployed in remote wilderness have encountered exigent and risky circumstances, sometimes resulting in deaths while on duty (DWC, 2017). In this study, we analysed the circumstances that led to field officers' deaths to identify causes and trends in mortality. Our study will help identify proactive interventions to minimise risk associated with field officers and improve their career standards.

METHODS

We accessed data on field officer mortality from numerous archives of the DWC from October 1949 to December 2020 and informally interviewed retired and active field officers (21 in total) to validate the archive data and fill in missing information. The DWC does not maintain a single database on officer deaths. Therefore, we examined multiple sources and unpublished reports (incidental reports, personnel files) produced by the DWC to amalgamate data on casualties. Through these interviews, we clarified the circumstances of the field-officer casualties, particularly with respect to the cause and location of deaths when that information was not available from the archives. We tabulated the name and designation of the officer involved, along with the date, cause and location of death, and other information on the circumstances of death to illustrate causes, patterns and trends in mortality. To approximate locations of fatalities, we used the DIVA-GIS gazetteer portal (https://www.diva-gis.org/gdata) and Google maps. The tabulated data were georeferenced as shapefiles using ArcMap version 10.8.1 (ESRI, Redlands, CA) and

spatially superimposed on data layers for protected areas, bioclimatic regions, and administrative provinces/districts of Sri Lanka to determine geospatial patterns of these casualties.

RESULTS AND DISCUSSION

We identified 80 fatalities among field officers, all males, in the period 1949–2020, plus one officer remains missing. This approximates a net loss of one officer per year (mean 1.32 yr-1). The number of fatalities differed among administrative districts and provinces, bioclimatic zones, as well as between inside and outside protected areas (Figure 1). Nearly two-thirds of the fatalities occurred inside protected areas (59 deaths) while only a third (22 deaths) occurred outside protected areas. Most casualties within protected areas (58 cases) happened in national parks while only one case was reported from sanctuaries. Less than a fifth (18 deaths) of all casualties were reported within the intermediate zone (annual average precipitation: 1,750 to 2,500 mm) while casualties within the dry zone (annual average precipitation: <1,750 mm) were nearly four time greater (63 deaths). Terrorist attacks were the leading cause of death (36 incidents, 44.4 per cent of all deaths), followed by Asian Elephant attacks (*Elephas maximus*) and encounters with wildlife criminals (Figure 2). The North-central (Anuradapura and Polonnaruwa districts) and Eastern administrative provinces (Ampara district) suffered a substantially greater proportion of mortality (57 deaths) than the rest of the country (Figure 1).

Throughout the 72-year period, fatal incidents were limited to only 32 years (Figure 2, Supplementary Online Material). The greatest number of casualties was reported when 24 officers were massacred by terrorists at the headquarters of the Wilpattu National Park (NP) on the 14 May 1985. In the same year, another officer died in a misfire while on foot patrol in Ruhuna National Park. The Liberation Tigers of Tamil Eelam (LTTE) were solely responsible for the terrorist attack.

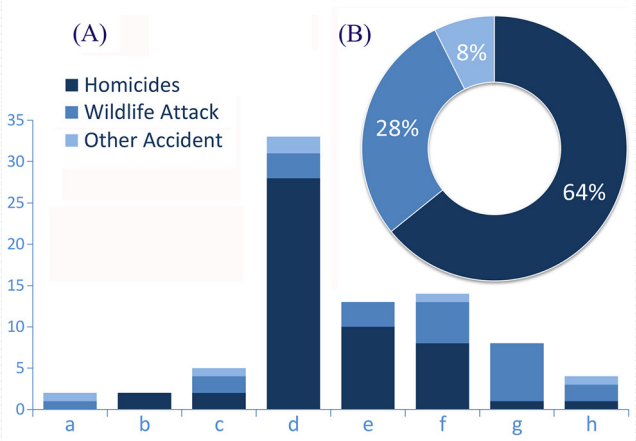


Figure 2. Number of deaths of field officers in DWC, (A) by decade (a) 1950-1959, b) 1960-1969, c) 1970-1979, d) 1980-1989, e) 1990-1999, f) 2000-2009, g) 2010-2019, and h) 2020, (B) by cause of death (Homicides – terrorist attacks, poaching, rebel attacks; Wildlife Attack – attacked by wild animals such as Elephants; Other Accident – misfire, motor accident, missing, and drowning).

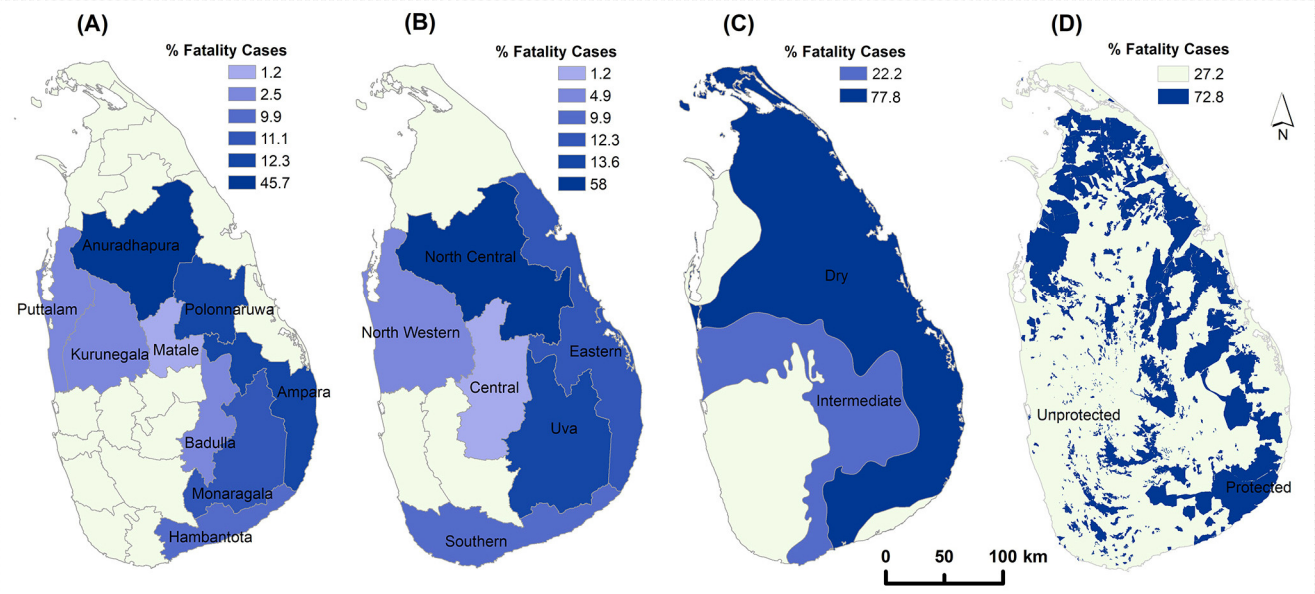


Figure 1. Geographic locations of fatalities among the field officers of the Department of Wildlife Conservation from July 1957 to December 2020 (percentage fatality cases with respect to (A) administrative districts, (B) administrative provinces, (C) bioclimatic zones, (D) inside and outside protected areas).

An anti-government militant organisation, the LTTE operated mostly across the north and eastern parts of Sri Lanka where most of the extensive protected areas exist. If deaths due to terrorist attack in 1985 are left out of calculations, the death rate would drop to 0.77 officers per year, both poaching and Asian Elephant attacks would outnumber terrorist attack as the leading causes of death, and 1985 would rank among years with lowest fatalities. The geographic location of the Wilpattu NP (North-central Sri Lanka) where LTTE operations were concentrated and its greater area (largest NP in Sri Lanka, 1,317 km2) could have contributed to the severity of these attacks. After the 1985 massacre incident, fatalities due to terrorist attacks were also reported in 1988, 1989, 2006 and 2007. However, terrorist operations have ceased in all parts of the county since 2009 and field officers have resumed their duties as usual since then.

The second leading cause of death was Asian Elephant attacks which resulted in 20 deaths (24.7 per cent of fatalities). Most casualties from Elephants, 13 officers (65 per cent) occurred outside the protected areas, while only seven fatalities originated within protected areas. Deaths resulting from Elephant attacks have increased in recent decades (Figure 2), which highlights that human–Elephant conflict (HEC) is a serious wildlife management issue. It is the leading cause of Elephant deaths in Sri Lanka; Elephant raids have also resulted in substantial property damage, deaths and severe injuries among local communities (Prakash et al., 2020). Elephants range across 59.9 per cent of Sri Lanka's land area and human settlements cover 69.4 per cent of the Elephant range (Fernando et al., 2021), intensifying the HEC over time in this shared landscape. The DWC is the prime state agency responsible for both Elephant conservation and the management of HEC, which requires officers to care for injured Elephants, translocate problematic Elephants, and conduct Elephant drives, predisposing them to Elephant attacks. Elephants aside, deaths resulting from attacks by other wildlife remain minimal (Sloth Bear (*Melursus ursinus*): 1 case, Wild Buffalo (*Bubalus arnee*): 1 case and Marsh Crocodile (*Crocodylus palustris*): 1 case).

The third leading cause of death was attack by wildlife criminals while patrolling. Fifteen field officers (18.5 per cent) have been killed in this way where gunfire, physical assaults and stabbing have claimed 10, 3 and 2 lives, respectively. Most perpetrators were poachers (13; 86.6 per cent), while illegal gem miners killed one field officer, and another is unknown. In general, rangers worldwide have identified wildlife criminals as a serious threat to their lives (WWF, 2018). Although historically less prevalent, our analyses indicated a minor yet steady increase in field-officer deaths due to encounters with wildlife criminals (Figure 2). The officer deaths due to accidents were less frequent (misfiring firearms: 2 cases, vehicular accident: 2 cases and drowning: 1 case). Officers killed on duty belong to 10 designations in the DWC hierarchy. The majority were wildlife guards (34 guards, 42 per cent of casualties), followed by 11 wildlife ranger assistants and 10 wildlife rangers (Table 1). The highest-ranked officer killed on duty was a regional assistant director. Other deceased officers included support staff (bungalow keepers, assistant bungalow keepers, drivers, wildlife field assistants, volunteer guides and casual labourers) that aid in conservation and tourism management.

One Wildlife Ranger employed at the Wilpattu NP was murdered and another Wildlife Guard affiliated with the Udawalawa NP was reported missing during an insurrection of a radicalised youth movement which attempted to overthrow the government through armed violence in 1987–1989 in Sri Lanka. The second JVP insurrection (1986-1990) of having caused the deaths and disappearances between 40,000 and 60,000 people (Gunaratna, 1990). Many of these victims were not killed in open conflict, rather were kidnapped by the rebels, government armed forces, police or militias from their homes or workplaces and remain missing since then (Watkins, 2005). The two aforementioned DWC officers are likely victims of this political turmoil.

CONCLUSION

While terrorism no longer threatens Sri Lanka field officers, Asian Elephant attacks and wildlife criminals are emerging as major causes of death. The existing approved cadre of the DWC is limited to 1,200 while

Table 1. Designations of the officers killed on duty from July 1957 to December 2020

Designation	Deaths
Regional Assistant Director	1
Wildlife Rangers	10
Wildlife Ranger Assistants	11
Wildlife Guards	34
Bungalow Keepers	2
Assistant Bungalow Keepers	1
Drivers	6
Wildlife Field Assistants	3
Volunteer Guides	2
Casual Labourers	11
Total	**81**

only ~750 officers are currently employed in field duties. The maximum efficiency of the field staff can only be achieved by creating a secure working environment, increasing the total cadre, and filling the existing vacancies to enhance their collective capacity. We recommend a comprehensive, island-wide assessment to quantify additional labour inputs as the present cadre is evidently insufficient to manage intricate issues of wildlife conservation and management. Science-based formal education should also be imparted to officer training. For example, resolving HEC might require officers trained in megafauna conservation, wildlife behaviour, and human dimensions.

Given the risk exposure, presently available remunerations for field officers should be revised to include a better medical insurance and financial support in case of long-term injury on duty. The infrastructure in field offices should also be reinforced with 4WD vehicles, modern firearms, other equipment, technological applications (wildlife tracking systems, cyber infrastructure for information sharing), training facilities, and standard living quarters. Risks encountered by field officers will change both with time and across geographies. Casualties among field officers, other serious injuries they suffer, and novel threats they encounter (such as emerging zoonotic infections) should be documented and explored in order to plan corrective actions.

SUPPLEMENTARY ONLINE MATERIAL

Appendix 1

ACKNOWLEDGEMENTS

We would like to extend our sincere gratitude to Sumith Pilapitiya (former DG, DWC) for his valuable guidance, assistance by the DWC field staff (Upali Kumarathunga, Dushan Manuranga Jayaweera, Srinath Dissanayake, Laurence Benjamin, Chaminda Aththanayaka) for data validation and Ranga Wijerathna for photographs. Finally, we would like to thank two anonymous reviewers and the editor for constructive comments that helped to improve the manuscript.

ABOUT THE AUTHORS

S.L. Prakash is a conservationist and a freelance journalist in Sri Lanka and reading his Ph.D. in ecology at the Guangxi University, China. He has been recognized as one of ten 2020-United Nations Climate Change: Learn Champions in the World by the United Nations Institute for Training and Research.

G.V. Samarakoon joined DWC in 1981 as a Wildlife Ranger, served as the Assistant Director in the Eastern and Western Wildlife administrative regions and National Wildlife Training Center, and then as the Deputy Director (Law Enforcement), before he retired after 37 years of service (Diploma – Wildlife Institute of India).

B.D. Madurapperuma is a Lecturer/Research Associate at the Department of Forestry & Wildland Resources at Humboldt State University, and teaches GIS, Remote Sensing and Forestry classes and conducts multidisciplinary research in Geospatial Science and Forestry. He earned his Ph.D. in Environmental Science and Conservation (North Dakota State University).

S. Karunarathna is a research scientist working on herpetofaunal taxonomy and ecology. He worked as an ecologist in the IUCN Sri Lanka country office (2004 to 2009), and he is also a member of several specialist groups of IUCN/SSC, and an expert committee member of IUCN National Red List programmes.

T.D. Surasinghe is an Associate Professor (PhD Wildlife Biology) in the Department of Biological Sciences at Bridgewater State University, MA. His expertise includes conservation biology, landscape ecology, and community organisations along urban–rural gradients.

REFERENCES

Belecky, M., Singh, R. and Moreto, W. (2019*). Life on the frontline 2019: A global survey of the working conditions of rangers*. World Wildlife Fund. Available at: https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/k36blpy2c_wwf_rangers_survey_report_2019.pdf?_ga=2.242504514.1118184259.1634325544-725446898.1634325544

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P., Narwani, A., Mace, G.M., Tilman, D. and Wardle, D.A. (2012). Biodiversity loss and its impact on humanity. *Nature* 486: 59–67. https://doi.org/10.1038/nature11148

De Zoysa, M. (2001). A review of forest policy trends in Sri Lanka. *Policy Trend Report* 2001: 57–68.

DWC (2017). Department of Wildlife Conservation History. Available from: <http://www.dwc.gov.lk/?page_id=42>

Eliason, S.L. (2011). Policing natural resources: Issues in a conservation law enforcement agency. *Professional Issues in Criminal Justice* 6, 43–58. https://doi=10.1.1.689.2576

Fernando, P., De Silva, M.C.R., Jayasinghe, L., Janaka, H. and Pastorini, J. (2021). First countrywide survey of the endangered Asian elephant: towards better conservation and management in Sri Lanka. *Oryx* 55(1): 46–55. https://doi.org/10.1017/S0030605318001254

Gunaratna, R. (1990). Sri Lanka, a Lost Revolution?: The Inside Story of the JVP. Institute of Fundamental Studies, Sri Lanka.

International Ranger Federation (2021). *Ranger Code of Conduct*. Version 1.0. . Victoria, Australia: International Ranger Federation.

Ministry of Land and Land Development (2014). *National Policy on Protection and Conservation of Water Sources, their Catchments and Reservations in Sri Lanka*. Battaramulla, Sri Lanka: Land Secretariat.

Mittermeier, M.N., Myers, N. and Mittermeier, G.G. (2000). *Hotspots: Earth's biologically richest and most endangered terrestrial ecoregions.* Mexico City: CEMEX. https://doi.org/10.1644/1545-1542(2002)083<0630:>2.0.CO;2

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A.B. and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature* 403, 853–858. https://doi.org/10.1038/35002501

Prakash, T.G.S.L., Wijeratne, A.W. and Fernando, P. (2020). Human-elephant conflict in Sri Lanka: Patterns and extent. *Gajah* 51(1): 16–25.

Singh, R., Gan, M., Barlow, C., Long, B., Mcvey, D., De Kock, R., Gajardo, O.B., Avino, F. S. and Belecky, M. (2020). What do rangers feel? Perceptions from Asia, Africa and Latin America. *PARKS* 26(1): 63–76. https://doi.org/10.2305/IUCN.CH.2020.PARKS-26-1RS.en

UNEP and WCMC (2021). Protected Area Profile for Sri Lanka from the World Database of Protected Areas. Available at: www.protectedplanet.net.

Warchol, G. and Kapla, D. (2012). Policing the wilderness: A descriptive study of wildlife conservation officers in South Africa. *International Journal of Comparative and Applied Criminal Justice* 36, 83–101. http://dx.doi.org/10.1080/01924036.2012.669911

Watkins, D.J. (2005). The state, conflict and the individual: The effect of the Janatha Vimukthi Peramuna (JVP) insurrections in Sri Lanka on the mental welfare of a population. *Medicine, Conflict and Survival* 21(3): 216–229. https://doi.org/10.1080/13623690500166044

Wilson, E.O. (1992). *The diversity of life.* New York, NY, USA and London, UK: WW Norton & Company. https://doi.org/10.1644/1545-1542(2002)083<0630:>2.0.CO;2

WWF (2018). *Life on the frontline 2018, a global survey of the working conditions of rangers.* World Wildlife Fund.

Young, H.S., Mccauley, D.J., Galetti, M. and Dirzo, R. (2016). Patterns, causes, and consequences of anthropocene defaunation. *Annual Review of Ecology, Evolution, and Systematics* 47(1): 333–358. https://doi.org/10.1146/annurev-ecolsys-112414-054142

RESUMEN

La protección física de la fauna silvestre es una de las profesiones de mayor riesgo en el sector de la conservación, habida cuenta de que está directamente relacionada con la prevención de los delitos contra la fauna silvestre. En Sri Lanka, el Departamento de Conservación de la Vida Silvestre (DWC, por sus siglas en inglés) es el principal organismo gubernamental responsable de la conservación y protección a largo plazo de la biodiversidad. Desde la creación del departamento en octubre de 1949, se han producido bajas en el cumplimiento del deber entre los funcionarios de campo del DWC. En este artículo examinamos la naturaleza y las condiciones que condujeron al fallecimiento de estos oficiales de campo en el cumplimiento de sus funciones. Desde octubre de 1949 hasta diciembre de 2020, al menos 80 han sido asesinados y uno ha sido reportado como desaparecido en el ejercicio de sus funciones. La tasa media de mortalidad fue de un oficial por año. La principal causa de muerte fueron los atentados terroristas, seguidos de los encuentros con elefantes asiáticos en libertad y los enfrentamientos con autores de delitos contra la fauna silvestre. La protección física de la fauna silvestre y la prevención de los delitos contra el medio ambiente son pilares fundamentales de la conservación, por lo que es primordial evitar la muerte prematura de los oficiales responsables de la preservación de la fauna silvestre. La capacitación rigurosa de dichos funcionarios, la provisión de equipos de protección, armas de fuego y otros recursos logísticos y de desarrollo de capacidades es imperativo para aumentar la moral y los compromisos profesionales de los oficiales responsables de la fauna silvestre de Sri Lanka

RÉSUMÉ

La protection physique de la faune est l'une des professions les plus risquées du secteur de la conservation car elle est directement associée à la prévention des délits liés aux espèces sauvages. Au Sri Lanka, le ministère de la conservation de la nature est le principal organisme gouvernemental responsable de la conservation et de la protection à long terme de la diversité biologique. Depuis sa création en octobre 1949, le département a subi plusieurs pertes parmi ses agents de terrain dans l'exercice de leurs fonctions. Nous examinons la nature et les conditions qui ont conduit au décès de ces agents. D'octobre 1949 à décembre 2020, au moins 80 agents ont été tués et un a été porté disparu alors qu'il était en service. Le taux de mortalité était en moyenne d'un agent par an. La principale cause de décès était des attaques terroristes, puis des rencontres avec des éléphants d'Asie en liberté et des confrontations avec des criminels qui s'attaquent aux espèces sauvages. La protection physique de la faune et la prévention des crimes contre l'environnement sont des piliers essentiels de la conservation. Il est donc primordial de prévenir la mort prématurée des agents de terrain. Pour cela il s'avère impératif de fournir une formation rigoureuse aux agents ainsi que des équipements de protection, des armes à feu et d'autres ressources logistiques y compris le renforcement des ressources, afin de stimuler le moral et l'engagement professionnel des agents de terrain du Sri Lanka.

SHORT COMMUNICATION: RECOMMENDATIONS FOR STANDARDISING REPORTING OF SITE-BASED ECONOMIC BENEFITS FROM PROTECTED AND CONSERVED AREAS

Sue Stolton[1*], Candice Stevens[2], Hannah L. Timmins[3] and Nigel Dudley[1]

* Corresponding author: sue@equilibriumresearch.com

[1]Equilibrium Research, UK and IUCN World Commission on Protected Areas
[2]Wilderness Foundation Africa and Sustainable Landscape Finance Coalition, South Africa
[3]Hannah L. Timmins, Bambang Consultants, Nairobi, Kenya

ABSTRACT

A new report from the Convention on Biological Diversity details 36 case studies highlighting tangible benefits which contribute to local livelihoods and conservation management costs from individual conservation areas worldwide. The study focuses on direct economic gains linked to biodiversity which do not undermine the area's conservation objectives. One unexpected finding from the research was the lack of standards for reporting the economic benefits and the wide range of reporting approaches encountered. This short communication provides a background discussion to the issue and makes recommendations relating to eight reporting procedures which could help provide clarity on the amount and distribution of site-based economic benefits. These could also aid attempts to compare, aggregate or help further understand the importance of these benefits from conservation initiatives. The paper is a contribution to ensuring equity of costs and benefits of conservation, the financial sustainability for conservation areas and for allowing successful initiatives to be undertaken at scale and into the long term.

Key words: benefit-sharing, resource-use, conservation finance, landscape finance

INTRODUCTION

A newly published study from the Convention of Biological Diversity (CBD) (Stolton et al., 2021) details 36 case studies from around the world highlighting tangible economic benefits from individual conservation areas (primarily from protected areas although equally relevant for other effective area-based conservation measures – OECMs). Many studies of total economic value rely heavily on theoretical or assumed values, for example over 90 per cent of the provisioning value of tropical forests being the presumed medicinal value of species growing there (De Groot et al., 2012). Conversely, the CBD case studies focus on direct economic benefits which contribute to local livelihoods and conservation management costs.

Linking conservation with a strategy for increasing local economic and social development can be a major incentive, along with other innovative finance mechanisms, for increased conservation and good management. Being able to report on these economic benefits effectively is a critical element of such incentives. However, the CBD study found a lack of consistent reporting on the assorted variables around economic return (e.g., type of income, period of income, relative importance of income). This note introduces the issue of local, tangible economic benefits from conservation areas which can contribute to both local livelihoods and conservation management costs followed by a brief discussion and recommendations for future reporting of such benefits, looking at both the amount and distribution of benefits, from site-specific initiatives. It aims to begin a conversation which will hopefully lead to more standardised reporting in the future, and thus allow collation of results at national, regional, global, biome or benefit level and allow more replicability of innovation.

BACKGROUND

There is an increasing literature on the global value of ecosystem services (Costanza et al., 1997; Kubiszewski et al., 2017; Dasgupta, 2021) and detailed studies on particular biomes, species, sites, countries and services. These studies have stimulated a rapid expansion of the

evaluation of natural capital. One early result was the establishment of The Economics of Ecosystems and Biodiversity (TEEB) initiative (ten Brink, 2011), which continues and has been applied at national and regional scales (Kettunen, et al., 2013). More recently, Natural Capital Valuation (NCV) has become popular (UFZ & WWF, 2020).

Although undoubtedly changing perceptions globally on the accounting of values and potential benefits of conservation, these large-scale analyses have failed to stimulate changes in approaches to land and water management on the scale needed to significantly slow the loss of biodiversity and ecosystem services. Moreover, the biodiversity finance gap continues to widen (OECD, 2020; Dasgupta, 2021).

There is, therefore, the need for a different kind of benefit assessment and valuation: not one that looks at the huge but still hard-to-realize values of all ecosystem services, but rather at the values that can either make money, or at least save identifiable amounts of money in the immediate term. Such benefits can support both local communities and conservation management and are referred to here as tangible economic benefits.

Demand for these kinds of assessment and valuation come from six different angles:

1. To build a stronger constituency for conservation and sustainable development by highlighting the economic value of biodiversity and other ecosystem services.
2. To justify the establishment and management costs of conservation areas by showcasing the returns from such investments compared with the returns from conversion to other uses.
3. To encourage investment of more public and private funds into conservation.
4. To contribute to conservation management costs.
5. To publicize existing economic benefits to communities living in or close to conservation areas, and to identify potential benefits that could be realized in the future.
6. To aid successful initiatives to be undertaken at scale and into the long term.

In particular, emerging debates about the implications of biodiversity conservation on local communities have led to important changes in perspective. Conservation organizations increasingly emphasise the need to stimulate flows of economic revenues from protected areas and OECMs to people living in or near these areas, who otherwise shoulder a disproportionate amount of the costs of conservation (Holden, et al., 2014; Howe et al., 2020). At their best, these initiatives provide forceful arguments for investment in conservation areas. They have helped to develop and progress markets for ecosystem services (such as clean water and carbon storage) which have resulted in some conservation gains and/or have eased the conservation funding gap. In a few cases, they have been the initial impetus behind conservation initiatives. At their worst, they have raised expectations of unrealized benefits, set back the achievement of an area's conservation objectives and started a trend to link conservation too closely to market forces or the rigidly utilitarian 'pay-to-stay' concept.

Any economic activities in protected areas in particular need to be established within a framework of safeguards, policies and standards to ensure they do not undermine conservation objectives or the rights of Indigenous peoples, local and other communities. Standards to ensure that benefits are equitably distributed are also important (Dudley et al., 2016); plenty of money-making schemes support a privileged minority rather than raising overall living standards. It is also important to ensure that any increase in income is not used as a pretext to decrease government support. Incentives to local managers and others supporting conservation areas for raising levels of income must include assurances that it will not lead to reductions of base financing for conservation or other aligned sustainable development initiatives.

While it is possible to combine conservation and economic development, and help ensure support for conservation, achieving a successful and sustainable balance is difficult. Some much-publicized opportunities have been slow to develop, including the carbon market which is still waiting for final agreement after more than a decade (Taskforce on Scaling Voluntary Carbon Markets, 2021). Some initiatives have been highly successful while others have either failed outright or faltered after a period, because resources have been over-exploited or social and economic conditions in communities have changed over time (Stolton et al., 2021). Other successful enterprises remain pilot concepts without achieving scale or are so specific to a particular place that they are impossible to replicate. Thus, moving from individual projects to mainstream application is often challenging (Mills et al., 2019).

Finally, it should be stressed that protected areas will rarely be capable of fully generating their own finances and will need support from governments, as well as private donors. Not all protected areas can, or should, supply economic returns with traditional profit yields. Many were set up because natural resources had declined due to mismanagement or over-exploitation,

Wool production in Península Valdés, Argentina © Ricardo Baldi, Cenpat-Conicet

others because the area is important for a range of vital benefits including biodiversity, cultural and ecosystem services. These benefits should not be assessed only by their ability to generate financial returns. Furthermore, as the current pandemic demonstrates, economic strategies such as tourism are subject to fluctuations and downturns, so that emergency funding streams will sometimes be required. Indeed, any over reliance on just one income generating activity is risky as is relying on one source of funding: fiscal or donation. Diversified income and funding streams are critical for the future resilience and sustainability of these areas.

RECOMMENDATIONS FOR REPORTING PROCEDURES FOR AMOUNT AND DISTRIBUTION OF SITE-BASED ECONOMIC BENEFITS

Economic benefits from conservation areas are far from guaranteed. Each context is unique and requires a tailor -made approach requiring analysis, planning, adaptive management and effective reporting. The recipients of this often varied income stream will also differ and could be for whole communities, specific sectors within communities, or focused more on providing conservation funding.

Although all contacts approached regarding the CBD case studies (Stolton et al., 2021) were happy to provide information on economic benefits, it soon became clear that it would be impossible to develop a standardised template or format for financial information, making attempts to compare, aggregate or really understand the importance of these benefits a challenge. For some initiatives there was also issues around competition and the disclosure of financial information.

Learning from this, we suggest below eight reporting areas and allied recommendations to help provide clarity on reporting of site-based economic benefits which support conservation initiatives. Planning the breadth of monitoring and reporting at the onset of initiatives would be a very useful exercise which these suggestions could also contribute to. Importantly, it is also clear that reporting financial success does not necessarily equate to project success, as, for example, social cohesion, publicity or conservation management may all be as important indicators of success as financial sustainability.

1. Gross or net

Gross is the total income before taxes and other deductions; net the income after deductions and taxes. When collecting data for the CBD case studies the researchers assumed that most of the reporting provided was for net income, but this was rarely made clear.

We recommend that reporting of economic benefits is consistently for net income.

Furthermore, clarity is needed about the calculations that determine gross to net income. Understanding the following seven points related to calculating net income assists both reporting and clarity when attracting further investment or incentives, and in reducing costs to be more resource efficient:

a. General expenses;
b. Extraordinary expenses (e.g., one-off expenses such as equipment);
c. Conservation related expenses;
d. Staffing (e.g., all employment related expenses);
e. Risk costs (including losses and related loss, administrative time);
f. Transaction costs (e.g., cost of bringing a good or service to market); and
g. Available tax deductions and incentives (tax efficiency is often overlooked as a tool to increase net income).

2. Return on investment

Another form of expressing economic benefits is through the return on investment; the money made or lost on an investment over a specified time. This can be presented as the ratio between net profit (over a certain

period) and cost of investment (resulting from an investment of some resources at a point in time). Some case studies reported significant, multi-year income but never achieved an overall profitable economic return, even if they supplied important local socio-economic benefits. This type of information is vital in understanding the viability of projects and potential for replicability.

We recommend that reporting includes return on investment after a specified period of years (e.g., 10 years).

3. Annual reporting

Most income was reported on a yearly basis (financial or tax year). The period became more confused for activities which are only carried out for short periods (e.g., seasonal fisheries or produce harvested). In some cases, even the year being reported was not clear.

We recommend reporting is consistently for annual income with the reporting period clearly defined (e.g., tax year, calendar year), even if the period of activity is for less than a whole year.

4. Income trends

Benefits from protected areas tend to be highly variable, due to conservation management, harvest fluctuations or demand. A close look at income trends forces entities and projects to evaluate income sources and take stock of any vulnerabilities. Many projects prefer to report on income trends over several years. This makes sense and should be encouraged if the timeframe reported is made clear and with annual reporting also carried out, as noted above.

We recommend reporting income trends with a clear indication of the time-period reported.

5. Sustainable resource use trends

Understanding economic benefits, and the conservation impact of these benefits, is much easier if the rate of resource use is provided. This varies widely from entry fees from tourists, tourist bed-nights, harvest of wild resources, agricultural products or fisheries, outputs of manufactured products (e.g., numbers of baskets, soaps, foodstuffs). As noted, this can be subject to conservation measures and seasonal fluctuations. Details of monitoring methods used to provide harvest trends and the format of measurements (e.g., kg, kg per km2, number of products) can help understand the economic benefits (and effectiveness of management) and should ideally be linked to monitoring plans for all elements of protected area management.

We recommend providing clarity of resource use in terms of annual resource use, trends and details of the method for monitoring and measuring resource use.

6. Distribution of benefits

Reports on benefit-sharing vary widely. Sometimes benefits are reported as per person, sometimes per household or even per village. The per household/village measure is particularly difficult to compare, as household numbers or village sizes can vary dramatically.

Similarly, the link between area and benefits needs to be clarified. Reporting benefits per hectare (ha) can be a good standard; but clarity is needed as to whether the whole area provides benefits as can be the case for tourism, or specific areas such as a watershed or where sustainable harvests take place.

We recommend splitting reporting between direct beneficiaries (e.g., the person receiving the income such as the handicraft maker or fisher) and associated beneficiaries (e.g., households with associated reporting of average household size).

We recommend standardising and providing clarity on any per ha measures used including the area being reported as well as the proportion of the protected area this represents.

7. Contribution of benefits to livelihoods

To understand the contribution of economic benefits to livelihoods it is important to know the socio-economic context. Some case studies reported the percentage of annual income the resource provides, which is useful, others provide little in terms of the relative importance of the economic benefit. Monetary values alone can mean very little given the disparities between income worldwide (e.g., average adjusted net national income per capita according to World Bank data ranges from over US$64,000 per year in Switzerland to under US$250 per year in Malawi).[1] Providing contextual information is thus important, as is using standardised data sources such as those provide by the World Bank.

We recommend that reporting includes information on the relative importance of benefits using internationally agreed data sources, ideally through indication of the percentage of annual income for direct and associated beneficiaries.

8. Contribution of benefits to conservation

Given the context of economic benefits from protected areas, many case studies also reported on the contribution of the incomes received being fed back into

protected area management (the same could be done for OECMs). In some cases, this contribution is a significant proportion of management costs. A clear way of indicating this contribution is by fully costing the protected area's management and reporting the percentage contributed by the economic benefit. This can show the management finance gap as well as the contribution of any economic benefits to effective management.[2] If management costs are not ring-fenced, then there needs to be a way to report on their benefit for the area as a whole. In addition, co-benefits can be added to the contribution to conservation beyond just the monetary assistance for management, such as business growth, additional employment, ecological infrastructure investment, etc.

We recommend reporting on the relative importance of benefits for covering conservation management costs, ideally through an indication of the percentage of annual income for protected area management as a whole, or for specific management activities.

CONCLUSIONS

We hope this short paper will help enhance the overall monitoring and reporting of conservation finance for and from protected areas and OECMs. Reporting the success of conservation initiatives will become increasingly important as the calls for more areas to come under conservation management increase. It is hoped that many more protected areas and OECMs will report on their methods and innovations to produce economic benefits where applicable to the area's conservation objectives, using initiatives such as IUCN's Panorama.[3]

We welcome comments on the above recommendations and how to further standardise this type of reporting.

Cocoa farmers getting ready for export, Gola, Sierra Leone © Bjorn Hogarth

ENDNOTES

[1] data.worldbank.org/indicator/NY.ADJ.NNTY.PC.CD
[2] See for example the BIOFIN approach www.biofin.org/sites/default/files/content/publications/workbook_2018/
[3] panorama.solutions/en

ABOUT THE AUTHORS

Sue Stolton is a partner in Equilibrium Research and a WCPA member; interests include management effectiveness and the wider values and benefits of protected and conserved areas.

Candice Stevens is Head of Innovative Finance, WFA and Chairs Africa's Sustainable Landscape Finance Coalition. She is Co-Chair of the IUCN WCPA Specialist Group on Sustainable Finance.

Hannah Timmins worked in landscape and tiger conservation in Indonesia for five years before moving to East Africa where she now specialises in protected areas, connectivity and forest conservation.

Nigel Dudley is an ecologist working in the fields of protected and conserved areas, restoration and landscape approaches to conservation.

REFERENCES

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V.O., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Natur*e 387: 253-260. doi: 10.1038/387253a0

Dasgupta, P. 2021. *The Economics of Biodiversity: The Dasgupta Review*. HM Treasury, London. https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review

De Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F. et al. 2012. Global estimates of the values of ecosystems and their services in monetary units. *Ecosystem Services* **1**: 50-61. doi: 10.1016/j.ecoser.2012.07.005

Dudley, N., Burlando, C., Cooney, R., Jones, S. and Kehaulani Watson, T. 2016. Draft principles for justice and equity in access to and distribution of benefits from ecosystem services in protected areas. In: Burlando, C., Te Pareake Mead, A., Marker Noshirwani, M., Seagle, C. and Kehaulani Watson, T. From Solutions to Resolutions: A New Social Compact for Just and Effective Conservation of Biodiversity, *Policy Matters* **20**: 41-54. https://portals.iucn.org/library/sites/library/files/documents/Policy%20Matters-Issue%2020.pdf

Holden, E., Linnerud, K. and Banister, D. 2014. Sustainable Development: *Our Common Future* Revisited. *Global*

Environmental Change, **26**, 130-139. doi: 10.1016/j.gloenvcha.2014.04.006

Howe, C., Corbera, E., Vira, B., Brockington, D. and Adams, W. 2020. Distinct positions underpin ecosystem services for poverty alleviation. *Oryx* **54**(3), 375-382. doi: 10.1017/S0030605318000261

Kettunen, M., Vihervaara, P., Kinnunen, S., D'Amato, D., Badura, T., Argimon, M. and ten Brink, P. 2013. *Socio-economic importance of ecosystem services in the Nordic Countries – Synthesis in the context of The Economics of Ecosystems and Biodiversity (TEEB)*. Nordic Council of Ministers, Copenhagen. Doi: 10.6027/TN2012-559

Kubiszewski, I., Costanza, R., Anderson, S. and Sutton, P. 2017. The future value of ecosystem services: Global scenarios and national implications. *Ecosystem Services* **26**: 289-301. doi: 10.1016/j.ecoser.2017.05.004

Mills, M., Bode, M., Mascia, M.B., Weeks, R., Gelcich, S., Dudley, N., Govan, H., Archibald, C.L., Romero-de-Diego, C., Holden, M., Biggs, D., Glew, L., Naidoo, R. and Possingham, H.P. 2019. How conservation initiatives go to scale. *Nature Sustainability* **2**: 935-940. doi:10.1038/s41893-019-0384-1

OECD. 2020. *A Comprehensive Overview of Global Biodiversity Finance*. Organisation for Economic Cooperation and Development (OECD). https://www.oecd.org/environment/resources/biodiversity/report-a-comprehensive-overview-of-global-biodiversity-finance.pdf

Stolton, S., Timmins, H. and Dudley, N. 2021. *Making Money Local: Can Protected Areas Deliver Both Economic Benefits and Conservation Objectives?*, Technical Series 97, Secretariat of the Convention on Biological Diversity, Montreal. https://www.cbd.int/doc/publications/cbd-ts-97-en.pdf

ten Brink, P (ed.) 2011. *The Economics of Ecosystems and Biodiversity in National and International Policy Making*. TEEB and Earthscan, London. https://www.researchgate.net/publication/236219248_The_Economics_of_Ecosystems_and_Biodiversity_in_National_and_International_Policy_Making

Taskforce on Scaling Voluntary Carbon Markets. 2021. *Phase II Report*. https://www.iif.com/Portals/1/Files/TSVCM_Phase_2_Report.pdf

UFZ and WWF. 2020. *Natural Capital in international environmental cooperation: Concepts and applications*. Report by UFZ – Helmholtz Centre for Environmental Research, Leipzig; WWF Germany, Berlin. doi:10.13140/RG.2.2.29668.60801

RESUMEN

Un nuevo informe del Convenio sobre la Diversidad Biológica enumera 36 estudios de casos en los que se destacan los beneficios tangibles que contribuyen a los medios de vida locales y a los costos de gestión en materia de conservación de las distintas áreas de conservación en todo el mundo. El estudio se centra en las ventajas económicas directas vinculadas a la biodiversidad que no socavan los objetivos de conservación del área. Un hallazgo inesperado de la investigación fue la falta de normas para informar sobre los beneficios económicos y la amplia gama de planteamientos con respecto a los procedimientos de información. Esta breve comunicación ofrece un análisis de las cuestiones de fondo y formula recomendaciones relativas a ocho procedimientos de presentación de informes que podrían contribuir a aclarar la cantidad y distribución de los beneficios económicos basados en las áreas. También podrían contribuir a los intentos de comparar, agregar o ayudar a lograr una mejor comprensión sobre la importancia de los beneficios derivados de las iniciativas de conservación. El documento es una contribución para garantizar tanto la equidad de los costos y beneficios de la conservación, como la sostenibilidad financiera de las áreas de conservación, y propiciar el emprendimiento de iniciativas exitosas en gran escala y a largo plazo.

RÉSUMÉ

Un nouveau rapport de la Convention sur la diversité biologique compte 36 études de cas mettant en évidence des avantages tangibles qui contribuent aux moyens de subsistance locaux et aux coûts de gestion de la conservation au sein de diverses aires de conservation à travers le monde. L'étude se concentre sur les gains économiques directs liés à la biodiversité qui ne remettent pas en cause les objectifs de conservation de la région. Un constat inattendu de cette étude a été l'absence de normes pour rendre compte des avantages économiques, ainsi que le large éventail des méthodologies de reporting utilisées. Cette courte communication présente le contexte général de la situation et formule des recommandations relatives à huit procédures de reporting qui pourraient aider à clarifier le montant et la répartition des avantages économiques relatifs aux sites. Ces recommandations pourront également faciliter les tentatives de comparaison et d'agrégation des initiatives de conservation, et aider à mieux prendre conscience de leur importance. Le document vise à contribuer à maintenir l'équité coûts-bénéfices de la conservation et la viabilité financière des aires de conservation, et à favoriser la mise en œuvre et la réussite d'initiatives aux échelles appropriées et à long terme.

SHORT COMMUNICATION: DENMARK'S MARINE PROTECTED AREAS ASSESSED ACCORDING TO IUCN'S INTERNATIONAL DEFINITION

Bo Normander[1*], Jan Woollhead[2], Anette Petersen[3] and Ann-Katrine Garn[4]

* Corresponding author: bo@naturtanken.com

[1]NaturTanken, Søborg, Denmark
[2]Parks'nTrails, Sorø, Denmark
[3]GEON – Geology and Nature, Skovlunde, Denmark
[4]IUCN Conservation Planning Specialist Group Europe, Conservation, Copenhagen Zoo, Frederiksberg, Denmark

ABSTRACT

A team of IUCN Commission Members has reviewed Denmark's marine protected areas (MPAs) to assess whether they meet the IUCN international definition for protected areas. Of 332 assessed MPAs, 198 areas were found to fulfil the definition and were assigned an IUCN Management Category, covering 138 'IV Habitat/Species Management' areas, 54 'V Protected Landscape/Seascape' areas, and just a few areas in the remaining management categories. Bottom trawling was found to be a main factor for MPAs not fulfilling IUCN criteria. For Danish waters as a whole, the project estimated that 4.8 per cent fulfil the IUCN definition for protected areas, implying that Denmark is only halfway to meeting Aichi Biodiversity Target 11 to protect at least 10 per cent of coastal and marine areas by 2020.

Key words: marine ecology, fishery, management categories, governance types, Aichi Biodiversity Targets, Sustainable Development Goals

INTRODUCTION

The sea around Denmark amounts to 105,000 km2, which is more than twice the total land area. It contains a high variety of marine areas with great natural value, which is reflected in a large number of protected sites including Natura 2000 and Ramsar wetland protection sites.

According to Aichi Biodiversity Target 11 under the Convention on Biological Diversity, at least 10 per cent of the world's coastal and marine areas should be protected by 2020 (CBD, 2011). More recently, the European Commission in its Biodiversity Strategy for 2030, has adopted targets of 30 per cent nature protection, of which 10 per cent should be strictly protected (European Commission, 2020). However, many interests must be taken into account at sea, including those of fisheries, extraction and dredging industries, the shipping sector and offshore energy farms. These interests are not always compatible with effective marine protection.

In Denmark, nature protection at sea is achieved primarily through the designation of Natura 2000 sites, which also include within them all designations that Denmark has committed to under international conventions such as the Ramsar Convention on Wetlands of International Importance, the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, and the HELCOM Convention on the Protection of the Marine Environment of the Baltic Sea Area (Woollhead et al., 2020). In addition, several marine areas are designated as conservation areas and game reserves through national legislative means.

Currently, the Danish authorities are in the process of preparing Denmark's first maritime spatial plan as part of the implementation of EU Directive 2014/89/EU establishing a framework for maritime spatial planning (Danish Maritime Authority, 2021). In parallel with this, work is underway to review nature protection at sea, including the identification of new protected areas. In this respect, it is highly relevant to assess the current state of marine protection and to examine how Denmark is performing according to international standards and to the targets set by the UN and EU.

The IUCN has developed guidelines for applying management categories to protected areas that are widely used by experts, governments and NGOs around the world (Dudley, 2008; Dudley et al., 2013). In 2018, these guidelines were used for the first time in Denmark in a large desktop study that revealed that 378 of 1,720 Danish conservation areas, mainly terrestrial, fulfilled the IUCN definition for protected areas (Garn et al., 2019; Woollhead & Petersen, 2018).

From October 2019 to September 2020, a team of Danish IUCN Commission members reviewed Denmark's marine protected areas (MPAs) to assess whether they meet the IUCN international definition for protected areas. The team included members of the World Commission on Protected Areas (WCPA), the Commission on Ecosystem Management (CEM) and the Species Survival Commission (SSC).

The project was designed as a desktop study. The Danish Environmental Portal (Danmarks Miljøportal, 2021), along with relevant governmental and institutional websites, and international websites on marine protection, were used to obtain information about geographic distribution, regulation, management, nature quality, fishery statistics, extractive industries and other industries for all MPAs in Denmark. This provided the information base that was subsequently used in this analysis.

Each MPA was assessed according to the IUCN guidelines for applying management categories for protected areas (Dudley, 2008; Dudley et al., 2013), supplemented with the newly published IUCN guidelines for applying management categories to MPAs (Day et al., 2019). At the start of the project, an assessment sheet was prepared, based on these IUCN guidelines, and both test assessments and full assessments were carried out as described by Garn et al. (2019). If all examined criteria were fulfilled, the MPA was regarded as meeting the IUCN definition for protected areas and therefore could be assigned an IUCN Management Category.

In addition, all MPAs were assigned an IUCN Governance Type on the basis of who holds authority, responsibility and can be held accountable for key decisions for the protected area (Borrini-Feyerabend et al., 2013). The IUCN defines four broad governance types – Governance by government, Shared governance, Private governance, and Governance by Indigenous peoples and local communities. The main types are accompanied by a defined set of sub-types.

Specialist knowledge from both external experts and project team members on marine ecology, underwater geology, archaeology (e.g., shipwrecks and ancient settlements) and ecosystem services provided supplementary assessments of selected MPAs. In complex questions, supplementary advice was obtained from an international expert (Nigel Dudley; personal communication). For each assessment a quality check was carried out by another team member than the one who did the initial assessment, ensuring that at least one member of WCPA was included in every assessment. Assessments and quality checks were distributed evenly among project team members.

All 332 MPAs that were identified in Danish waters were assessed. The MPAs cover 13 different types of protection, including conservation areas, game reserves, Natura 2000 sites, National Parks, as well as designations through international conventions and organisations such as UNESCO, OSPAR, HELCOM and Ramsar. An in-depth project review and method of assessments can be found in the project's final report (Woollhead et al., 2020).

The main conclusion from the project is that 198 of the 332 MPAs fulfil the IUCN definition for protected areas and could be assigned an IUCN Management Category (Table 1). This corresponds to 59.6 per cent of the areas. The MPAs are widely distributed and cover all Danish waters (Figure 1).

Table 1. Danish MPAs assigned with an IUCN Management Category for protected areas

IUCN Management Category	Number of sites	%
Ia Strict Nature Reserve	3	0.9%
Ib Wilderness Area	0	0%
II National Park	1	0.3%
III Natural Monument	1	0.3%
IV Habitat/Species Management Area	138	41.6%
V Protected Landscape/Seascape	54	16.3%
VI Protected Area with Sustainable use of Natural Resources	1	0.3%
Areas assigned to an IUCN Management Category	**198**	**59.6%**
Areas not assigned to an IUCN Management Category	134	40.4%
Total number of MPAs	**332**	**100%**

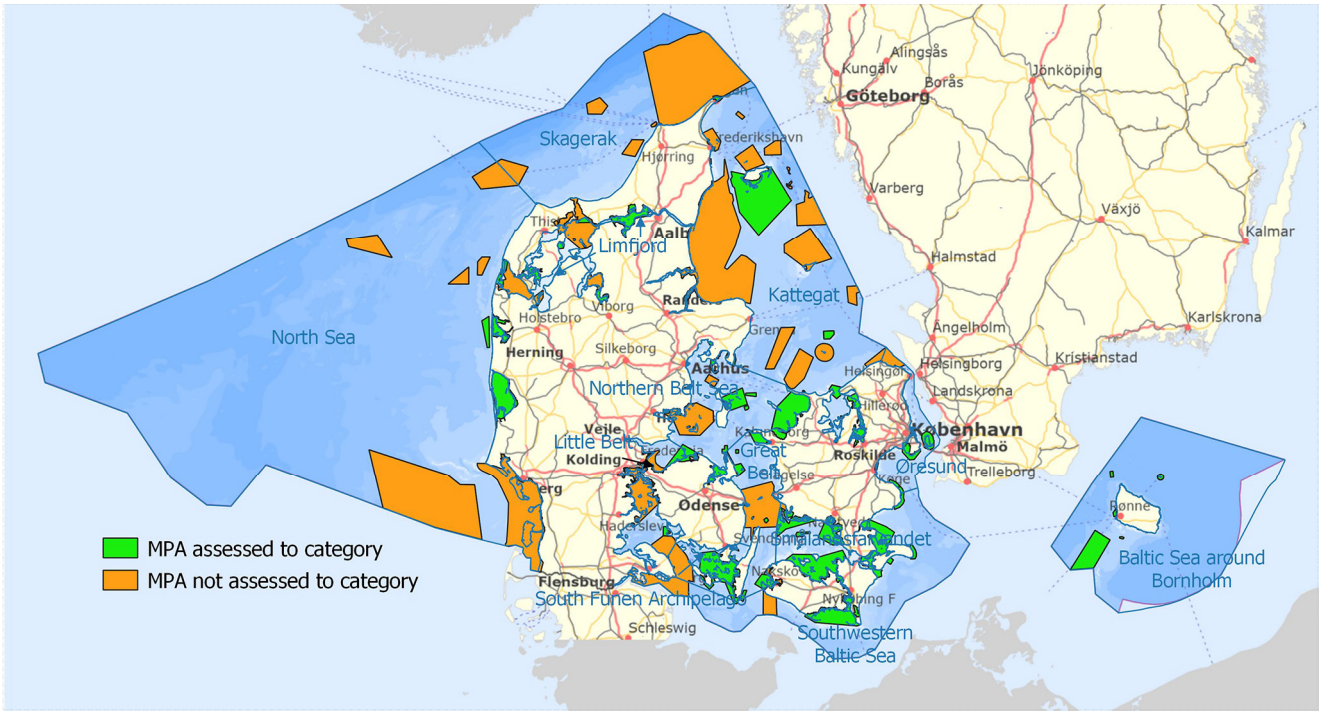


Figure 1. Geographical distribution of Denmark's MPAs that were assessed to fulfil (green) or not fulfil (orange) the IUCN definition for protected areas. Some MPAs are so small that they cannot easily be seen on the map.

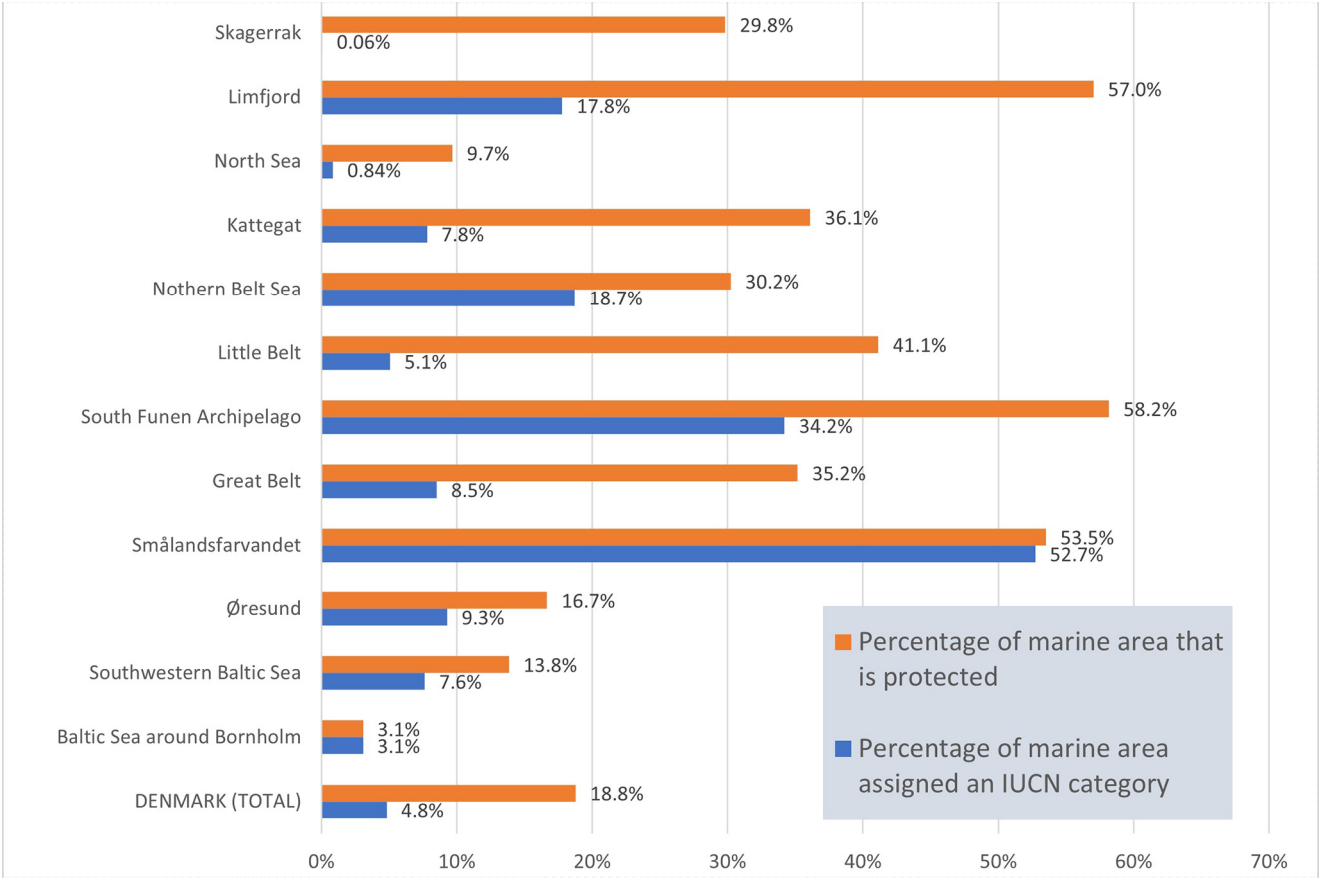


Figure 2. Percentage of marine area designated for nature protection (orange) and percentage fulfilling the IUCN definition for protected areas (blue). Shown for 12 different waters and Denmark as a whole.

Sea kayaking , Denmark © Anette Petersen

A total of 508,630 ha of marine area has been assessed to fulfil the IUCN definition. As shown in Figure 2, this corresponds to 4.8 per cent of Denmark's total marine area. Of the total marine area allocated for nature protection, about a quarter (25.8 per cent) is hence estimated to meet the IUCN definition. Figure 2 also shows the proportion of marine area in 12 different waters that has been laid out for nature protection and that has been assessed to meet the IUCN definition, respectively.

According to Aichi Biodiversity Target 11 under the Convention on Biological Diversity, which has been confirmed in Target 14.5 under UN Sustainable Development Goal 14, Life Below Water, at least 10 per cent of coastal and marine areas should be protected by 2020. The assessment of the MPAs in this project shows that Denmark with 4.8 per cent is approximately halfway to meeting this global target within its jurisdiction.

Finally, the MPAs were assigned an IUCN Governance Type based on available information on ownership and management. Of the 332 MPAs, 180 are governed by state (national ministry), 76 areas are governed through transboundary management (characterised by being managed by two or more countries), and 59 areas are governed by collaborative management, where both private and public organisations are in charge.

Of these three types of governance, the collaborative management type has the highest proportion of MPAs fulfilling the IUCN definition, namely, 65.9 per cent. Governance by state follows with 33.6 per cent and transboundary management with 18.4 per cent. For the latter, the low percentage can possibly be explained by the fact that regulation in these areas requires agreement between several countries, both EU and non-EU Member States, and hence effective nature protection may be more difficult to achieve than in solely national matters.

At the web portal, beskyttetnatur.dk, all 332 MPAs can be viewed on a clickable map of Denmark and assessment sheets with detailed information about the MPAs and how they meet the IUCN definition can be downloaded (in Danish).

ACKNOWLEDGEMENTS

We would like to thank the VELUX Foundation for financial support, which enabled us to conduct the study. Our thanks also go to Nigel Dudley, Equilibrium Research, UK for contributing with his great expertise and to Kirsten Engell-Sørensen, FishLab, Simon Leonhard, BioData and Anders Fischer, Sealand Archaeology for valuable inputs on marine ecology, archaeology and conservation.

ABOUT THE AUTHORS

Bo Normander is an ecologist, author, PhD and director of NaturTanken ('Nature Tank'), which conducts consultancy and advisory work on nature conservation in Denmark, Greenland and globally. He is a member of the IUCN Commission on Ecosystem Management (CEM).

Jan Woollhead is an ecologist and director of Parks'n Trails, which specialises in sustainable tourism in protected habitats. He is a member of the IUCN World Commission on Protected Areas (WCPA) and the IUCN European Policy Advisory Group.

Anette Petersen is a geologist and owner of GEON – Geology and Nature, which conducts consultancy and advisory work on UNESCO programmes. She is a member of WCPA and the European Association for the Conservation of Geological Heritage (ProGEO).

Ann-Katrine Garn is a zoologist at the Conservation Department of Copenhagen Zoo. She is a member of the IUCN Species Survival Commission (SSC) and the IUCN Conservation Planning Specialist Group Europe, which is based at Copenhagen Zoo, and the chair of the IUCN National Committee of Denmark.

Danish Fjord © Anette Petersen

REFERENCES

Borrini-Feyerabend, G., Dudley, N., Jaeger, T., Lassen, B., Pathak Broome, N., Phillips, A. and Sandwith, T. (2013). *Governance of Protected Areas: From understanding to action.* Best Practice Protected Area Guidelines Series No. 20. Gland, Switzerland: IUCN.

CBD (2011). Convention on Biological Diversity Strategic Plan for Biodiversity 2011 – 2020, Including Aichi Biodiversity Targets. https://www.cbd.int/sp/

Danish Maritime Authority (2021). Denmark's maritime spatial plan. https://havplan.dk/en/page/info

Danmarks Miljøportal (2021). The Danish Environmental Portal: One gateway to data on nature and the environment in Denmark. In Danish with an English description at https://miljoeportal.dk/english/

Day, J., Dudley, N., Hockings, M., Holmes, G., Laffoley, D., Stolton, S., Wells, S. and Wenzel, L. (eds.) (2019). *Guidelines for applying the IUCN protected area management categories to marine protected areas*. Second edition. Gland. Switzerland: IUCN.

Dudley, N. (Ed) (2008). *IUCN Guidelines for Applying Protected Area Management Categories*. Gland, Switzerland: IUCN.

Dudley, N., Shadie, P. and Stolton, S. (2013). *IUCN WCPA Best Practice Guidance on Recognising Protected Areas and Assigning Management Categories and Governance Types*. Best Practice Protected Area Guidelines Series No. 21. Gland, Switzerland: IUCN.

European Commission (2020). EU Biodiversity Strategy for 2030 – Bringing nature back into our lives. COM(2020) 380 final.

Garn, A-K., Woollhead, J. and Petersen, A. (2019). Lessons Learned from a Desktop Review of Conservation Areas in Denmark: Applying IUCN Management Categories for Protected Areas. *PARKS* 25(2): 93–102.doi:10.2305/IUCN.CH.2019.PARKS-25-2A-KG.en

UNEP-WCMC and IUCN (2020). Protected Planet: World Database on Protected Areas (WDPA). https://www.protectedplanet.net (Accessed September 2020).

Woollhead, J. and Petersen, A. (2018). *Rapport om rubricering af danske fredninger i IUCN-kategorier*. Report to the IUCN National Committee of Denmark (in Danish). Available at: https://mst.dk/service/nyheder/nyhedsarkiv/2018/sep/nyt-overblik-over-naturfredninger/

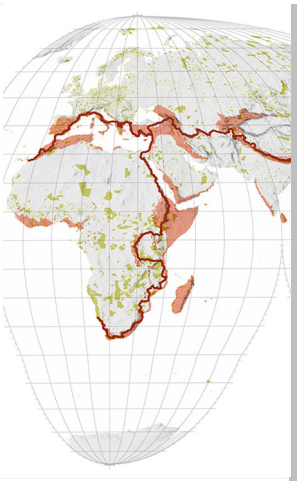
Woollhead, J., Petersen, A. and Normander, B. (2020). *Vurdering af danske beskyttede havområder efter international standard*. Parks'nTrails, GEON and NaturTanken for IUCN SSC Conservation Planning Specialist Group Europe (in Danish with an English summary). Available at: https://naturtanken.com/en/denmarks-marine-protected-areas-assessed-according-to-iucns-international-definition/

RESUMEN

Un equipo de miembros de las Comisiones de la UICN examinó las áreas marinas protegidas (AMP) de Dinamarca para evaluar si cumplen la definición internacional de la UICN para las áreas protegidas. De las 332 AMP evaluadas, se comprobó que 198 áreas se ajustaban a la definición y se les asignó una categoría de gestión, entre ellas 138 bajo la categoría IV (áreas de manejo de hábitats/especies), 54 bajo la categoría V (paisajes terrestres y marinos protegidos), y solo unas pocas áreas en las restantes categorías de gestión. La pesca de arrastre de fondo resultó ser un factor relevante para que las AMP no cumplieran los criterios de la UICN. Para las aguas danesas en su conjunto, el proyecto estimó que el 4,8% cumple la definición de la UICN para las áreas protegidas, lo que significa que Dinamarca está apenas a medio camino de cumplir la Meta 11 de Aichi para la Biodiversidad de proteger para 2020 al menos el 10% de las áreas costeras y marinas.

RÉSUMÉ

Une équipe de membres de la Commission de l'UICN a examiné les aires marines protégées (AMP) du Danemark afin de déterminer si elles répondent à la définition internationale de l'UICN pour les aires protégées. Sur les 332 AMP évaluées, 198 ont été jugées conformes à cette définition et se sont vu attribuer une catégorie de gestion de l'UICN, dont 138 dans la «Catégorie IV: Aire de gestion des habitats ou des espèces» et 54 dans la «Catégorie V: Paysage terrestre ou marin protégé», plus quelques autres dans les catégories restantes. Le chalutage de fond s'est avéré être un facteur principal de non-conformité chez les AMP qui ne remplissaient pas les critères de l'UICN. Pour les aires marines danoises dans leur ensemble, l'étude a estimé que 4,8 % répondent à la définition de l'UICN pour les aires protégées, ce qui implique que le Danemark n'est qu'à mi-chemin sur la voie d'atteindre l'Objectif 11 d'Aichi pour la biodiversité qui visait à protéger au moins 10 % des zones côtières et marines dès 2020.



SHORT COMMUNICATION: THE WORLD PARK PROJECT

Richard Weller

Email: rjweller@design.upenn.edu

The Ian L. McHarg Center for Urbanism and Ecology, Weitzman School of Design, University of Pennsylvania, Philadelphia, PA , USA

ABSTRACT

This article summarises the concept of a World Park whereby instead of continuing to invest in isolated fragments of protected areas to meet CBD targets, continuous tracts of land are connected with walking trails to catalyse landscape restoration efforts at a planetary scale. The article explains the rationale behind the creation of a World Park and argues for its potential benefits as a model of conservation that focuses on denuded lands in-between existing protected areas and opening up the possibility of large-scale landscape connectivity that actively includes humans in its construction and management.

Key words: connectivity, representation, hotspots

INTRODUCTION

For millennia, Indigenous peoples the world over have 'protected' and 'managed' land in ways that combine spiritual and material needs into a unified cosmology that situates humans as a part of rather than apart from what we now refer to as nature. In the Western canon, the Greeks, for example, set aside land in the form of sacred groves replete with temples venerating their various gods and goddesses. In the Middle Ages, although forests were feared as beyond the bounds of salvation, they were also conserved and policed as vital resources. Later, as a reaction to the ravages of the industrial revolution and inspired by the aesthetics of romanticism, the modern phenomenon of national parks was institutionalised with the protection of 3,471 square miles in Yellowstone in 1872. Later in the 20th century, building on the basis of national parks as picturesque places set aside from the ecological onslaught of modernity, the international movement to secure protected areas gained momentum and dominates global conservation efforts to this day. In 1962 there were 9,214 protected areas, today there are 265,920 amounting to a grand total of 15.6 per cent of the Earth's terrestrial area in over 266,000 different locations across 245 nations (The Global Database on Protected Areas Management Effectiveness, 2021).

By any measure, this is a remarkable achievement for the global conservation movement. But just as national parks have come in for criticism over the years, the global protected area estate also has its critics (Brockington et al., 2008; Büscher et al., 2014). The critics argue that protected areas are a land grab by a global environmental elite at the expense of not only industry, but also Indigenous communities who have in the past been evicted as their own lands are placed under 'protection' (Dowie, 2011). They also argue that protected areas are 'paper parks', more about nations meeting UN targets under the Convention on Biological Diversity (CBD) than really saving biodiversity on the ground. They argue that protected areas enshrine 'fortress conservation'; a worldview based on a nostalgic idea of wild nature over there, and culture over here.

These important criticisms notwithstanding, if well managed and inclusive, protected areas are not just beneficial (to our physical, emotional and spiritual well-being) but necessary. Biodiversity is invaluable: without it, entire ecosystems would collapse and, in all likelihood, take humankind with them. But the protected areas we have today are woefully inadequate because – as per the two most important words in the CBD – they are neither sufficiently 'representative' nor 'connected' (CBD, 2011). This means protected areas do not represent the world's 867 ecoregions and the full range of critically endangered species, and they are not connected with one another and with the broader landscape in a way that would allow species to migrate so as to adapt to climate change. Without being expanded and interconnected, today's protected areas are effectively big, isolated zoos, and climate change threatens to leave many of the species trapped within them, with little hope of adapting to rising temperatures and shifting ecotones.

Our best hope to halt or even reverse the loss of biodiversity and make the work of conservation and land management more inclusive, is a new form of conservation landscape that would bring nations, states, landholders and Indigenous custodians together in a cooperative effort to create, where appropriate, continuous trans-national tracts of protected and restored habitat for both conservation and recreation. Rather than perpetuating the ad-hoc collection of protected areas we have today, this approach would direct global conservation investments into a more holistic and coordinated initiative at a scale and in a form commensurate with the crisis. For argument's sake – and for want of a less colonial expression – let's call this a 'World Park'; a concept we have been developing here in the landscape architecture department at the University of Pennsylvania for several years now (Figure 1).

THE WORLD PARK PROJECT

Originally conceived to help reach the CBD Aichi Target 11 of protecting 17 per cent of the world's terrestrial area and now coinciding with the UN Decade on Ecosystem Restoration, the World Park Project is about bringing landholders and Indigenous custodians in 55 nations who preside over 19 of the world's biodiversity hotspots together in a cooperative effort to create continuous, restored habitat for recreation and the protection of endangered species at a planetary scale.

When we began this hypothetical project in 2016, the world's combined protected area was at 15.4 per cent. By our calculations the outstanding 1.6 per cent necessary to reach Aichi target 11 was the equivalent of approximately 700,000 Central Parks. If you put these Central Parks end-to-end they would go around the Earth close to 70 times. The research question we asked was where should this land be and what form should it take? In 2021 with protected areas (including Other Effective Area-based Conservation Measures) now at 16.64 per cent, the outstanding land area necessary to reach 17 per cent is equivalent to 150,000 Central Parks, enough to circumnavigate the Earth 15 times. The rationale of the World Park Project is that instead of adding these 150,000 Central Parks to the world's already fragmented protected areas, they should instead be amalgamated into one coherent large-scale landscape initiative focused, as a matter of priority, on the world's biodiversity hotspots and key biodiversity areas where endemic spaces are most threatened (Weller et al., 2017).

The reason there are 55 nations in 19 of the world's 36 hotspots included within the concept of the World Park is that the project of making such a park begins with the simple principle of creating recreational trails that pass through as many as possible biodiversity hotspots and protected areas in single continuous routes. Applying this principle leads to three trails; the first from

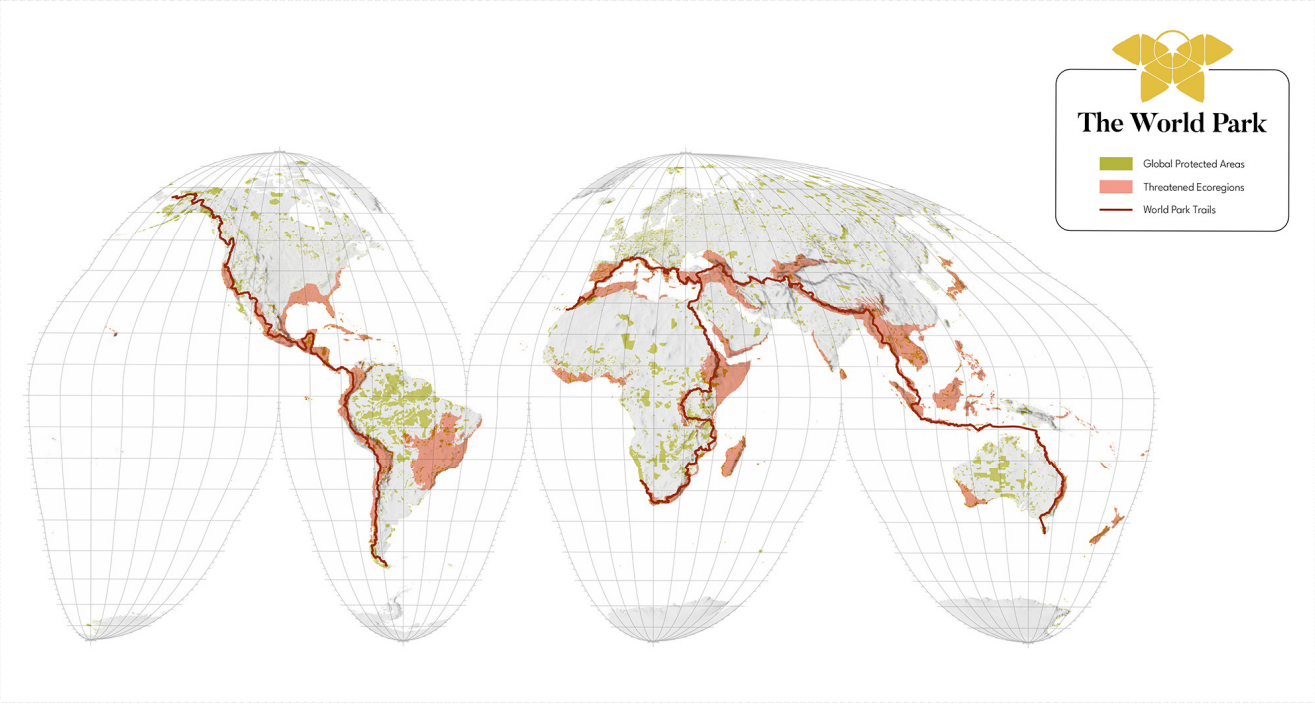
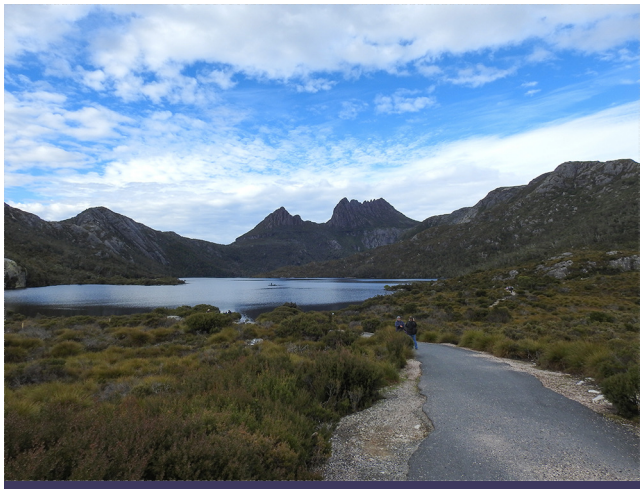


Figure 1. The World Park concept

Australia to Morocco, the second from Turkey to Namibia and the third from Patagonia to Alaska. Extending from and interconnecting many existing shorter trails, these three major trails are routed so as to pass through extant protected areas as well as lands in need of ecological restoration in-between. The trails would include infrastructure for camping and provision of other essential services calibrated to the average distance a person can reasonably be expected to cover on foot or by bike in a day. The trails serve as low-cost catalysts for attracting people out into these remote landscapes, which can in turn lead to bringing people together to not just 'walk the world' but to also 'work the world'; to stop and participate in and draw attention to the World Park's greater mission of restoring the ecological health of the degraded lands throughout its 163,000 km2 of territory.

The park's restoration programme would come under the umbrella of a 'World Park Rangers' programme operating similar to the way in which the Peace Corps does today and the way in which the US Conservation Corps did during the US New Deal in the 1930s. With the support of the 55 nations whose sovereign territory the park includes, as well as other nations who may wish to invest on behalf of their citizens, the World Park's potential to employ people in the work of landscape restoration is vast.

It is important to note that while the World Park's core principles are to restore lands in-between currently protected areas, and thus expand and interconnect protected areas, the actual design and planning of any such work cannot be executed in broad, top-down brush strokes. It is critical that the big 'top-down' idea of creating a World Park be met in equal measure by 'bottom-up' specificity and sensitivity to the full complexity of both ecological and cultural conditions on the ground. Every piece of land is a complex interweaving of culture and biology; every piece of land is laden with vested interests; every piece of land has a deep history; and every piece of land has multiple potential futures which need to be articulated and negotiated to balance benefits to both local and global culture. In this vein, although the walking trails achieve connectivity for humans at a planetary scale, it is not assumed that forging connectivity as a blanket approach to landscape restoration and extant protected areas is automatically correct for all biodiversity. The point is that the World Park functions to galvanise people and attract resources, not to impose a single scientific world view or set of abstract landscape ecology principles, but instead to make possible a mosaic of site-specific restoration efforts, where large-scale landscape connectivity is an option. Put another way, the idea of creating a World Park is to piece together many site specific restoration projects so that they may add up to something that is greater than just the sum of the parts.



Cradle Mountain - Lake St Clair National Park, Tasmania is at the southern end of the proposed World Park Trail © Marc Hockings

Of course, things quickly get very complicated when we ask how to finance and govern said World Park. Obviously, the concept requires an overarching and representative form of governance that builds on and includes not only the 55 nations but also Indigenous nations and landowners whose territory is – only with permission – incorporated into the park's jurisdiction. Working through existing UN institutions and the IUCN, the World Park would also need to include a strong representation of the world's environmental and conservation NGOs. Similarly, the World Park would require its own scientific network to develop its research programmes to not only steer the work of determining appropriate forms of restoration but to also direct ongoing monitoring. Indeed, the ethos of the park is not that it is a quick fix 'nature-based solution' but rather an ecological and socio-political experiment in designing and managing ecosystems about which we still have everything to learn – an experiment that could become the first citizen science programme coordinated on a planetary scale.

Regarding cost, in 2012 conservation scientist at BirdLife International in Cambridge, UK, Stuart Butchart calculated the cost of meeting Aichi Target 11 of conserving and maintaining 17 per cent (25 million km2) of the world's terrestrial area at US$76.1 billion, adjusted to today's dollar value the cost is US$91 billion (Cressey, 2012). Until the lands involved are properly analysed, it is impossible to say exactly how large and how expensive a World Park would be. According to our

extensive mapping of its potential territory (in terms of planning the trails and the land area required to achieve connectivity), it is reasonable to surmise that it is about 163,000 km2 – an area equivalent to 0.08 per cent of Aichi target 11. Using Butchart's calculus (Cressey, 2012), the cost of restoring and managing this amount of land would be in the order of US$7 billion per annum.

To be sure, this is an expensive park. But the better question to ask is not what it costs but what is it worth? In an ideal scenario, the World Park would not siphon money away from existing conservation projects but stand alone as a new form of conservation venture. For (a mere) US$7 billion, nations and philanthropists can come together to create something that would help solve two of conservation's biggest challenges: the lack of both landscape connectivity and ecological representation. For US$7 billion, a World Park could provide meaningful experiences and jobs for legions of the world's youth. For US$7 billion, a World Park presents a profound sign of hope that humanity can work together to be a constructive force for nature, instead of its destroyer. Thought of in these terms, the park's value far outweighs its cost.

ENDNOTES

[i]This figure rises to 16.64 per cent if you include OECMs (Other Effective area-based Conservation Measures) (The Global Database on Protected Areas Management Effectiveness, 2021).

[ii]For more information and detailed mapping of the World Park's proposed territory see: https://theworldpark.com

[iii]See Neil Maher, Nature's New Deal: The Civilian Conservation Corps and the Roots of the American Environmental Movement (New York: Cambridge University Press, 2008

ABOUT THE AUTHOR

Richard Weller is a professor and chair of landscape architecture at the University of Pennsylvania, where he is the executive director of The Ian L. McHarg Center for Urbanism and Ecology. He is the author of 6 books including Design with Nature Now (Lincoln Institute of Land Policy, 2019)

REFERENCES

Brockington, D., Duffy, R. and Igoe, J. (2008). *Nature Unbound: Conservation, Capitalism, and the Future of Protected Areas.* London: Earthscan.

Büscher, B., Dressler, W.H. and Fletcher, R. (2014). *Nature™ Inc.: Environmental Conservation in the Neoliberal Age.* Tucson: University of Arizona Press.

Convention on Biological Diversity (2011). Conference of the Parties Decision X/2: Strategic plan for biodiversity 2011–2020. Montreal.

Cressey, D. (2012). Cost of Conserving Global Biodiversity set at $76 billion. *Scientific American* 12 October 2012.

Dowie, M. (2011). *Conservation Refugees: The Hundred Year Conflict between Global Conservation and Native Peoples.* Cambridge: The MIT Press.

The Global Database on Protected Areas Management Effectiveness (2021). Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net (Last accessed 21 September, 2021).

Weller, R., Hoch, C. and Huang, C. (2017). *Atlas for the End of the World*. https://blogs.scientificamerican.com/observations/an-atlas-for-the-end-of-the-world/

RESUMEN

Este artículo resume el concepto de Parque Mundial, según el cual, en lugar de seguir invirtiendo en fragmentos aislados de áreas protegidas para cumplir los objetivos del CDB, se conecta extensiones continuas de tierra con senderos para catalizar los esfuerzos de restauración del paisaje a escala planetaria. El artículo explica los fundamentos de la creación de un Parque Mundial y aboga por sus beneficios potenciales como modelo de conservación centrado en las tierras denudadas entre las áreas protegidas existentes, y abre la posibilidad para favorecer la conectividad del paisaje a gran escala mediante la participación activa de los seres humanos en su construcción y gestión.

RÉSUMÉ

Cet article résume le concept de Parc Mondial selon lequel, au lieu de continuer à investir dans des fragments isolés d'aires protégées pour atteindre les objectifs de la CDB, des étendues de terre continues sont reliées par des sentiers pédestres pour catalyser les efforts de restauration des paysages à l'échelle planétaire. L'article expose la raison d'être de la création d'un Parc Mondial et plaide pour ses avantages potentiels en tant que modèle de conservation qui se concentre sur les terres dénudées entre les aires protégées existantes, et ouvre la possibilité d'une connectivité paysagère à grande échelle qui inclut de manière active les humains dans sa construction et sa gestion.

CORRESPONDENCE

Joint letter inspired by Hymas et al. (2021) "There's nothing new under the sun – lessons conservationists could learn from previous pandemics"

Raoul Manenti and Olivier Hymas

Keywords: COVID-19; wildlife; forest; conservation; anthropause

INTRODUCTION

The paper by Hymas et al. (2021) (henceforth Olivier) stimulated a discussion between one of the authors cited in the paper (Manenti et al., 2020) (henceforth Raoul) and the principal author of the paper. Instead of going down the usual road of writing a reply, and counter-reply, the authors of these two papers decided to talk directly to each other. This reply is the fruit of several discussions undertaken over a period of a month. These discussions had the objective to better understand each other's arguments, without trying to find consensus or unanimity of thought. This is not an exhaustive account of these discussions, but rather a summary of some interesting key points. In publishing this discussion, we hope to stimulate others to have their own discussions with people with different disciplinary backgrounds or career paths. After an initial introduction to each author and the original paper, this letter has an interview-like format, in which Raoul, sets out key point questions with the reasoning behind the question, and then Olivier brings in his own viewpoint and reasoning.

AUTHORS' BACKGROUND

While both authors work on conservation issues they come from different disciplinary backgrounds and have different career experiences. Olivier originally trained as an ecologist and later became an anthropologist. This change was due to his experiences in conservation that led him to 1) recognise the important role that people play in shaping ecology and conservation at various time and spatial scales, and 2) recognise that our cultural background influences how we do conservation and research. This recognition has led him to tweak the scientific methodology to question the cultural assumptions of the original observation that starts the scientific methodology cycle of observation, background research, hypothesis, experimentation and generalisation. This action research (Stephens et al., 2009) like approach, results in the researcher going to the field right at the start of the scientific methodology in order to 1) confirm that the original observation is applicable in the cultural settings of the field site, and 2) get to grips with what background research and types of experimentation methodologies (ecological, social science, historical, etc.) will be needed to answer the original observation. Raoul is a zoologist interested in general conservation, behavioural and evolutionary questions of different animal groups from amphibians and various freshwater invertebrates to humans. Recently he has been trying to address how behavioural patterns of dominant species, like humans and some top predator species, can affect the functionality of the communities of various ecosystems, especially ecotones (like springs) placed at the interface between surface (streams, ponds, woods) and underground (subterranean aquifers, caves). For Raoul, the COVID-19 pandemic represented an interesting phenomenon to be approached from a scientific perspective.

This discussion provided an array of interesting stimuli on how global and sudden phenomena, like pandemics, impact the environment and whether they provide a research opportunity. The paper by Hymas et al. (2021) is of interest as it looks outside the silo of the recent ecological literature and answers a challenging question on how COVID-19 is new and worthy of investigation from a biological conservation perspective.

INTERVIEW

Raoul's key point 1 – is there true novelty from the point of view of biological conservation in the situation created by the COVID-19 pandemic or should the recognition of similarities with analogous historical events undermine the current rise in conservation literature on the subject?

A large number of recent studies have suggested that the COVID-19 pandemic allowed scientists to investigate the effects of a reduction in the activity of the worldwide dominant species Homo sapiens (e.g. Bates et al., 2020; Rutz et al., 2020). Many of these studies also claim that the current pandemic is an unprecedented occasion in human history (Bates et al., 2021; Kumar et al., 2020; Lopucki et al., 2021; McElwee et al., 2020). The novelty and the importance of studying COVID-19 is referred to

as the effects that a human pandemic and its consequences on a dominant species like humans may have for the conservation of ecosystems and wildlife (Manenti et al., 2020), irrespective of the novelty of the disease. The emergence of previously unknown human diseases is well-documented in the natural history of Homo sapiens. However, the temporal and spatial scale of the COVID-19 pandemic and the possibility to document its effects, scientifically and globally, are new.

Olivier's reply to key point 1 – to be honest I initially struggled with this point. From a philosophy of science standpoint this is equivalent to throwing out the baby with the bath water, for I do not see why this should be considered a 'novel' situation as there is so much that can be learnt from past pandemics that are relevant to the current situation. However, I then realised that the issue is of temporal scale; historians and archaeologists work on very large time scales, while ecologists, who are faced with "pressing problems in ecology [that] often exist at the scale of decades" (Schneider, 2001), often work on much shorter time scales.

While it is true that scientific equipment is continually evolving, the scientific methodology itself has not fundamentally changed since the ancient Greeks (Stephens et al., 2009). Scientists, therefore, do not have to wait for advances in technology. If they did then there would be no point in doing science. We would not expect future scientists documenting a pandemic to ignore the current research on COVID-19 simply because they have more up-to-date technology which allows them to have access to live data collected through various chips and sensors implanted solar system wide in all humans, wildlife and ecosystems. There is only one case that I know of where scientists have waited for their gadgets to catch up before carrying out science and that is for the Herculaneum scrolls where scientists have patiently waited for over 250 years for new scientific equipment (Tack, 2016).

We need to recognise that "we stand on the shoulders of giants" (Merton, 1993); that knowledge and insight does not spring from nowhere but is dependent on the people who passed before us. Any situation is a novel starting point for research (e.g. COP26 is novel as we can study it using social media equipment). What makes the COVID-19 pandemic so special?

Does COVID-19 differ from the 1918 influenza pandemic? Relatively speaking both are very similar (Morens et al., 2021a, 2021b): both are zoonotic diseases (Lycett et al., 2019); the state of medical knowledge is relatively the same (transmission of disease, its control and the need for a vaccine was understood in 1918; though mRNA technology was not yet available); all current transport forms existed (the first commercial flight was in 1914; though flight was not at the scale known today, boats were used much more; i.e. longer periods of time with people in close proximity); spatially, people lived across the globe but were more dispersed with rural to urban migration, since 1918, resulting in "global depeasantization" (Araghi, 1995) and forest recovery (Robson & Berkes, 2011; Ellis et al., 2013); the effect of the 1918 pandemic was also documented (including scientifically); people also spread both diseases back into wildlife (Morens et al., 2021a); and, most importantly, they both had an effect on conservation and wildlife (e.g. in Gabon, Hymas et al., 2021).

Raoul's key point 2 – anthropause is an unprecedented pattern with implications for the management of protected areas

The actions taken to control COVID-19, such as lockdown and movement restrictions, have been considered a period of anthropause (Rutz et al., 2020), with several effects reported for a large number of animal and vegetal species (Kerber, 2020; Silva-Rodriguez et al., 2021; Stokes et al., 2020). Understanding the effects of current actions can allow us to replicate them for effective management of protected areas and conservation of endangered species. Focusing only on historical events may not offer insightful information for conservationists in the face of the COVID-19 pandemic and other global events.

Olivier's reply to key point 2 – though a siloed approach (Tett, 2015), either just historical or just ecological, allows experts to produce very specialised knowledge, it can only produce limited insight for conservationists investigating the impacts of COVID-19 on the environment, as this involves many different sets of disciplines. The other, generalist extreme, could be to bring all the different silos of knowledge together to find insight (e.g. economics, politics, religion, philosophy, psychology, medical, social and so on). While this would be unwieldy and impossible to carry out, many interesting insights would be produced. This raises the question of how can a generalist approach facilitate the bridging of silos, especially when the academic system (funding, departments, journals) is geared to the siloed expert (Campbell, 2005).

Raoul's key point 3 – the pristine myth and wilderness conservation: what insights come from the COVID-19 pandemic?

"Nature claims its space back" has been one of the commonest themes of the popular and scientific narrative during the COVID-19 pandemic and lockdowns. Both from considering past epidemics (Hymas et al., 2021) and analysing current patterns (Manenti et al., 2020), this claim appears exaggerated; however different effects occurred on wildlife although short lasting (Derryberry et al., 2020; Koju et al., 2021; Lopucki et al., 2021), suggesting that the actual pressure of humans on the environment is so high that even small reductions can positively affect the distribution and behaviour of animals. Moreover, evolutionary mechanisms can act more quickly than usually expected (Zhu et al., 2018; Melotto et al., 2020). Thus, replicating focused reductions of human impacts and pressures offers potential solutions for specific conservation purposes, at least in the short term. These reductions can both be spatially and temporally limited. An example could be the creation of community protected seascapes, where fishing is limited which can increase the density of fish populations outside these areas (Abesamis & Russ, 2005; Oliver et al., 2015); another example could be the nocturnal 'lockdown' of roads in spring to allow migrations of endangered amphibian species where overpasses and direct rescue are not effective (LeClair et al., 2021).

Olivier's reply to key point 3 – "Nature claims its space back" puts humans outside of nature, derived from Western religion (Gottlieb, 2006), reinforced in areas such as Africa by European colonial ideology that saw Africa as a wild continent empty of humans (Neumann, 1995). Yet humans are a part of nature, just like any other species, humans are impacted by nature and have an impact on nature. With few exceptions, humans are found in all of nature's environments. Dark earths, archaeological methods and colonial maps (Fig. 1) all attest to the fact that people existed in places that current ecologists previously thought were not populated. If nature and humans have been travelling along history's paths for time immemorial then the question arises, why did they disappear from some areas and how did this impact wildlife and conservation? There is therefore no need for a pandemic in order to investigate the results of totally excluding human presence from an area on wildlife and its implications on conservation.

CONCLUSION

In conclusion an ecological contextualisation of past historical events should merge and not contrast the

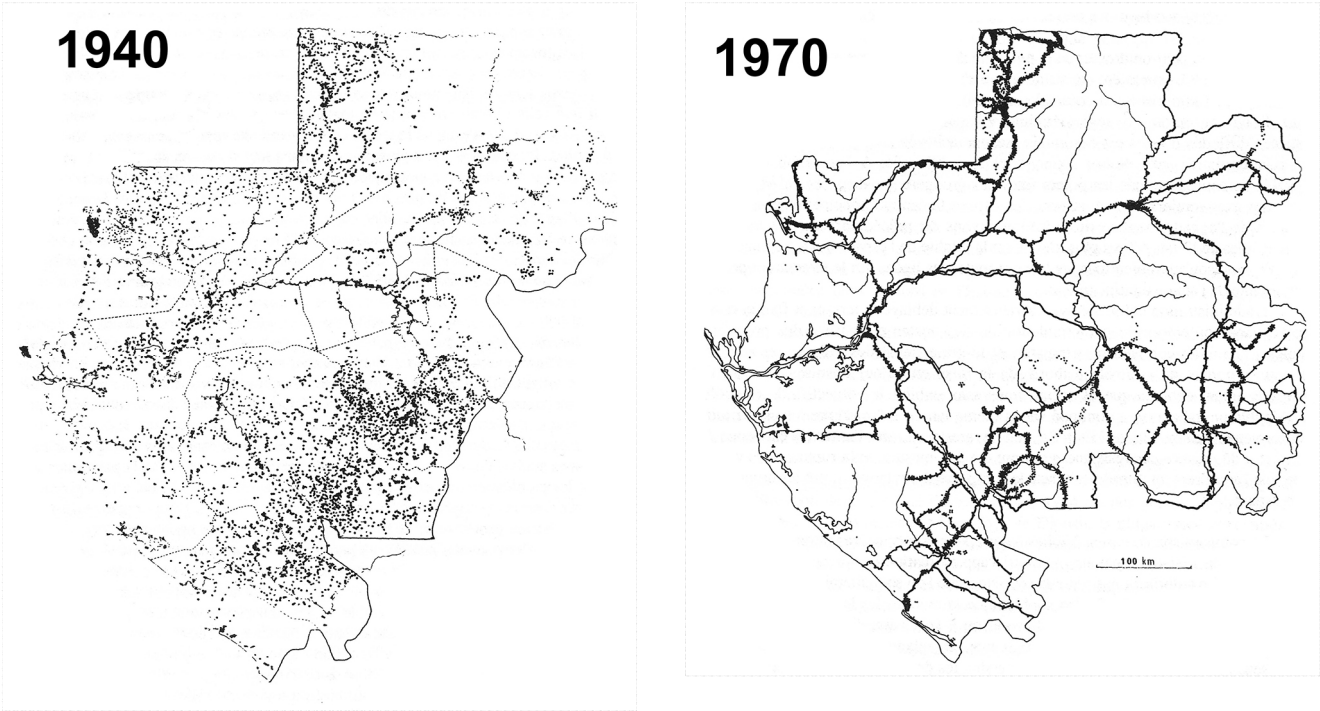


Figure 1. Population distribution of Gabon in 1940 and 1970. The province of Haute-Ogooué (Southeast) was added to Gabon in 1964 (adapted from Pourtier, 1989 and Sautter, 1966)

understanding of the effects of the current pandemics and global events involving the conflicts between humans and wildlife. It is not just history that needs to be included in ecological and conservation science, but a whole host of social sciences. We need to climb out of our silos to look around.

Ecologists, entering a new study site empty of human inhabitants, need to make the default assumption that people did inhabit the site at one time. The question is then what happened that resulted in their disappearance, why did humans not come back and what disruptions occurred in the ecology of the site. At the same time, entering into a landscape with high human dominance could lead to the question of what is possible to learn from the past to understand and even plan for the future consequences and changes of such human pressures.

REFERENCES

Abesamis , R.A. and Russ, G.R. (2005). Density-dependent spillover from a marine reserve: Long-term evidence. *Ecological Applications*, 15: 1798–2812. DOI: https://doi.org/10.1890/05-0174.

Araghi, F.A. (1995). Global Depeasantization, 1945–1990. The Sociological Quarterly, 36: 337–368. DOI:10.1111/j.1533-8525.1995.tb00443.x .

Bates, A.E., Primack, R.B., Biggar, B.S., Bird, T.J., Clinton, M.E., Command, R.J., Richards, C., Shellard, M. et al. (2021). Global COVID-19 lockdown highlights humans as both threats and custodians of the environment. Biological Conservation, 263: 109175. DOI: https://doi.org/10.1016/j.biocon.2021.109175.

Bates, A.E., Primack, R.B., Moraga, P. and Duarte, C.M. (2020). COVID-19 pandemic and associated lockdown as a "Global Human Confinement Experiment" to investigate biodiversity conservation. Biological Conservation, 248: 108665. DOI: https://doi.org/10.1016/j.biocon.2020.108665.

Campbell, L.M. (2005). Overcoming obstacles to interdisciplinary research. Conservation Biology
19: 574–577. DOI: https://doi.org/10.1111/j.1523-1739.2005.00058.xC

Derryberry, E.P., Phillips, J.N., Derryberry, G.E., Blum, M.J. and Luther, D. (2020). Singing in a silent spring: Birds respond to a half-century soundscape reversion during the COVID-19 shutdown. Science, 370: 575–579. DOI: https://doi.org/10.1126/science.abd5777.

Ellis, E.C., Kaplan, J.O., Fuller, D.Q., Vavrus, S., Goldewijk, K.K. and Verburg, P.H. (2013). Used planet: A global history. Proceedings of the National Academy of Sciences of the United States of America, 110: 7978–7985 DOI: https://doi.org/10.1073/pnas.1217241110.

Gottlieb, R.S. (2006). The Oxford Handbook of Religion and Ecology. Oxford University Press. DOI: 10.1093/oxfordhb/9780195178722.001.0001

Hymas, O., Rocha, B., Guerrero, N., Torres, M., Ndong, K. and Walters, G. (2021). There's nothing new under the sun – lessons conservationists could learn from previous pandemics. Parks, 27: 25–40. DOI: https://doi.org//10.2305/IUCN.CH.2021.PARKS-27-SIOH.en.

Kerber, G. (2020). "Everything Is Interrelated" The COVID-19 pandemic and integral ecology. Ecumenical Review, 72: 596–608. DOI: https://doi.org/10.1111/erev.12549

Koju, N. P., Kandel, R.C., Acharya, H.B., Dhakal, B.K. and Bhuju, D.R. (2021). COVID-19 lockdown frees wildlife to roam but increases poaching threats in Nepal. Ecology and Evolution 11, 9198–9205. DOI: https://doi.org/10.1002/ece3.7778.

Kumar, A., Malla, M.A. and Dubey, A. (2020). With Corona outbreak: Nature started hitting the reset button globally. Front Public Health, 8: 569353. DOI: https://doi.org/10.3389/fpubh.2020.569353.

LeClair, G., Chatfield, M.W.H., Wood, Z., Parmelee, J. and Frederick, C.A. (2021). Influence of the COVID-19 pandemic on amphibian road mortality. Conservation Science and Practice, 11: e535. DOI: https://doi.org/10.1111/csp2.535.

Lopucki, R., Kitowski, I., Perlinska-Teresiak, M. and Klich, D. (2021). How is wildlife affected by the COVID-19 pandemic? Lockdown effect on the road mortality of hedgehogs. Animals (Basel), 11: 868. DOI: https://doi.org/10.3390/ani11030868.

Lycett, S.J., Duchatel, F. and Digard, P. (2019). A brief history of bird flu. Philosophical Transactions of the Royal Society B-Biological Sciences, 374 : 20180257. DOI: https://doi.org/10.1098/rstb.2018.0257.

McElwee, P., Turnout, E., Chiroleu-Assouline, M., Clapp, J., Isenhour, C., Jackson, T., Kelemen, E., Miller, D.C., Rusch, G., Spangenberg, J.H., Waldron, A., Baumgartner, R.J., Bleys, B., Howard, M.W., Mungatana, E., Ngo, H., Ring, I. and Santos, R. (2020). Ensuring a post-COVID economic agenda tackles global biodiversity loss. One Earth, 3: 448–461. DOI: 10.1016/j.oneear.2020.09.011

Manenti, R., Mori, E., Di Canio, V., Mercurio, S., Picone, M., Caffi, M., Brambilla, M., Ficetola, G. F. and Rubolini, D. (2020). The good, the bad and the ugly of COVID-19 lockdown effects on wildlife conservation: Insights from the first European locked down country. Biological Conservation, 249: 108728. DOI: https://doi.org/10.1016/j.biocon.2020.108728

Melotto, A., Manenti, R. and Ficetola G.F. (2020). Rapid adaptation to invasive predators overwhelms natural gradients of intraspecific variation. Nature Communications, 11: 3608. DOI: https://doi.org/10.1038/s41467-020-17406-y.

Merton, R.K. (1993). On the Shoulders of Giants: A Shandean Postscript. University of Chicago Press ISBN: 978-0226520865. https://archive.org/details/onshouldersofgia0000mert

Morens, D.M., Taubenberger, J.K. and Fauci, A.S. (2021a). A centenary tale of two pandemics: The 1918 influenza pandemic and COVID-19, Part I. American Journal of Public Health, 111 : 1086–1094. DOI: https://doi.org/10.2105/AJPH.2021.306310.

Morens, D.M., Taubenberger, J.K. and Fauci, A.S. (2021b). A centenary tale of two pandemics: The 1918 influenza pandemic and COVID-19, Part II. American Journal of Public Health, 111: 1267–1272. DOI: https://doi.org/10.2105/AJPH.2021.306326.

Neumann, R.P. (1995). Ways of seeing Africa: Colonial recasting of African society and landscape in Serengeti National Park. *Ecumene*, 2: 149–169.DOI: https://doi.org/10.1177/147447409500200203

Oliver, T.A., Oleson, K.L.L., Ratsimbazafy, H., Raberinary, D., Benbow, S. and Harris, A. (2015). Positive catch & economic benefits of periodic octopus fishery closures: Do effective, narrowly targeted actions 'catalyze' broader management? PLoS ONE 10: e0129075. DOI: https://doi.org/10.1371/journal.pone.0129075.

Pourtier, R. (1989). Le Gabon Tome 2: Etat et Développement. Paris: L'Harmattan. ISBN 2-7384-0290-9

Robson, J.P. and Berkes, F. (2011). Exploring some of the myths of land use change: Can rural to urban migration drive declines in biodiversity? Global Environmental Change, 21: 844–854. DOI: https://doi.org/10.1016/j.gloenvcha.2011.04.009.

Rutz, C., Loretto, M.C., Bates, A.E., Davidson, S.C., Duarte, C.M., Jetz, W., Johnson, M., Kato, A., Kays, R., Mueller, T., Primack, R.B., Ropert-Coudert, Y., Tucker, M.A., Wikelski, M. and Cagnacci, F. (2020). COVID-19 lockdown allows researchers to quantify the effects of human activity on wildlife. Nature Ecology & Evolution, 4: 1156–1159. DOI: https://doi.org/10.1038/s41559-020-1237-z.

Sautter, G. (1966). De l'Atlantique Au Congo: Une Géographie Du Sous□Peuplement République Du Congo; République Gabonaise. Paris: La Haye, Mouton.

Schneider, D.C. (2001). The rise of the concept of scale in ecology. BioScience, 51: 545–553. DOI: https://doi.org/10.1641/0006-3568(2001)051[0545:TROTCO]2.0.CO;2.

Silva-Rodriguez, E.A., Galvez, N., Swan, G.J.F., Cusack, J.J. and Moreira-Arce, D. (2021). Urban wildlife in times of COVID-19: What can we infer from novel carnivore records in urban areas? Science of the Total Environment, 765: 142713. DOI: https://doi.org/10.1016/j.scitotenv.2020.142713.

Stephens, J., Barton, J. and Haslett, T. (2009). Action research: Its history and relationship to scientific methodology. Systemic Practice and Action Research, 22: 463–474. DOI: https://doi.org/10.1007/s11213-009-9147-7 .

Stokes, G.L., Lynch, A.J., Lowe, B.S., Funge-Smith, S., Valbo-Jorgensen, J. and Smidt, S.J. (2020). COVID-19 pandemic impacts on global inland fisheries. Proceedings of the National Academy of Sciences of the Un*ited States of America,* 117: 29419–29421. DOI: https://doi.org/10.1073/pnas.2014016117.

Tack, P., Cotte, M., Bauters, S., Brun, E., Banerjee, D., Bras, W., Ferrero, C., Delattre, D., Mocella, V. and Vincze, L. (2016). Tracking ink composition on *Herculaneum papyrus* scrolls quantification and speciation of lead by X-ray based techniques and Monte Carlo simulations. *Scientific Reports*, 6: 20763. DOI: https://doi.org/10.1038/srep20763.

Tett, G. (2015). The Silo Effect. The Peril of Expertise and the Promise of Breaking Down Barriers. Simon and Schuster.

Zhu, W., Liu, L.S., Wang, X.G., Gao, X.Y. Jiang, J.P. and Wang, B. (2018). Transcriptomics reveals the molecular processes of light-induced rapid darkening of the non-obligate cave dweller Oreolalax rhodostigmatus (Megophryidae, Anura) and their genetic basis of pigmentation strategy. BMC Genomics 19: 422. DOI: 10.1186/s12864-018-4790-y

Raoul Manenti
Department of Environmental Science and Policy,
Università degli Studi di Milano, Milano, Italy

Olivier Hymas
University of Lausanne, Faculty of Geosciences and Environment, Institute of Geography and Sustainability, Lausanne, Switzerland

BOOK REVIEWS

TAmerican Covenant: National Parks, their Promise, and our Nation's Future

By Michael A. Soukup and Gary E. Machlis (2021) Yale University Press, New Haven and London. 202pp., US$25.00 ISBN 9780300140354 Reviewed by Marc Hockings

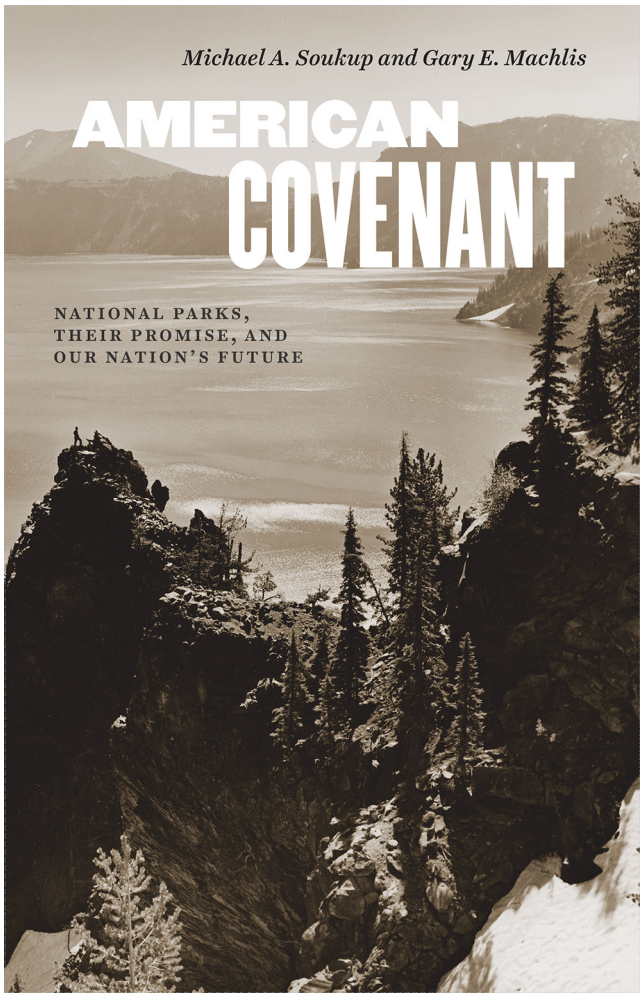
AMERICAN COVENANT: NATIONAL PARKS, THEIR PROMISE AND OUR NATION'S FUTURE

BY MICHAEL SOUKUP AND GARY MACHLIS

American Covenant: National Parks, Their Promise and Our Nation's Future by Michael Soukup and Gary Machlis is an insider's view from two scientists of the US National Parks Service and its stewardship of the national park system of that country. The book is driven by their love of the national parks, their belief in the potential of the parks to make a major contribution to American life and well-being. But this belief is alloyed with a concern that the management of the parks has suffered from a disconnect with science. In their words they "seek to champion a solid science foundation for park management as an absolute requirement for the salvation of America's grand National Parks System".

They start with personal histories that led them to be scientists of and advocates for the national parks and follow with a short history of the Parks Service, its origins and orientations. Their personal histories and connections recur throughout the book as they develop their thesis. Their aim is to guide the development of a National Parks Service fit the face the challenges of its second century.

The Everglades National Park and its degradation as a result of changing land uses, invasive species and other pressures including the political pressures driven by powerful industry lobby groups sets the scene for the central messages of the book. It highlights the critical role of science and understanding of park resources in maintaining the health of the parks and the all too frequent lack of interest in supporting and applying this science by a National Parks Service more focused on visitation and visitor facilities.



They point to the many challenges facing the National Parks and the National Parks Service, including the obvious but no less important impact of climate change but also the internal bureaucratic and budget challenges of the public administration such as separating park

researchers from park management. They also propose many potential solutions to the issues that they raise, focused around ensuring the park managers value science as a guide to their management and suggesting the means to provide that knowledge and input. Despite promising developments in some areas, especially in building internal science capacity and external but closely linked collaborations with other researchers. They fear though, that there are signs "that the NPS and national parks are reverting to their familiar default mode: visitor services".

One disappointment is that the book has little to say about the issues arising around involvement of Native Americans and the dispossession of their lands that now form the national parks of America. The topic is briefly acknowledged but not explored in any detail yet the resolutions of these issues will be a key aspect of the future of national parks. Perhaps the recent appointment of Charles Sams III as the first Native American Director of the National Parks Service will see more attention given to this challenging issue.

Many of the messages of this book are relevant to the management of conservation areas around the world. The issues faced by parks in America around degradation, ecological isolation and limited management resources are shared across many regions of the world. Of course, many of the most challenging issues for protected areas in other parts of the globe related to poverty, equity, sustainable livelihoods and illegal resource use are less prominent (or in some cases just less evident) in America. But the key message of this book that science has a key role to play in supporting effective science-based decision making is universal.

Marc Hockings, IUCN World Commission on Protected Areas, Australia