PARKS

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IUCN WCPA WORLD COMMISSION ON PROTECTED AREAS

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**

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- 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 fulfil their primary role in nature conservation while addressing critical issues such as ecologically sustainable development, social justice and climate change adaptation and mitigation;
- changing and improving protected area support and behaviour through use of information provided in the journal; and
- promoting IUCN's work on protected areas.

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CONTENTS

PROTECTED AND CONSERVED COASTAL AREAS IN CANADA: INSIGHTS WITH RESPECT TO TARGET 3 OF THE KUNMING-MONTREAL GLOBAL BIODIVERSITY FRAMEWORK

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ABSTRACT

Despite coastal area being recognised as an important subcomponent in protected and conserved areas targets for over a decade, it has been orphaned in both national and international reporting. In this paper, we provide the first progress report on protected and conserved coastal area in Canada. While 13.6 per cent of Canada's coastal area is protected and conserved, there is substantial variation across Canada's three oceans and Great Lakes, jurisdictional authorities, and marine/terrestrial ecosystems. Importantly, Manitoba (37.3 per cent) and the Yukon (45.1 per cent) have already achieved the 30 per cent coastal protection target of the *Kunming-Montreal Global Biodiversity Framework* (KM-GBF). However, Newfoundland and Labrador (7 per cent) and the Northwest Territories (8 per cent) currently fall significantly short. Very poor protection is evident in several marine bioregions and terrestrial ecozones, including across the Arctic, the Newfoundland and Labrador Shelves (0.7 per cent) and the Hudson Bay Complex (5.1 per cent). The Great Lakes require urgent and focused conservation attention, with lakes Ontario (3.6 per cent) and Erie (3.7 per cent) exhibiting a dismal amount of coastal protected and conserved area. Our results highlight the importance of explicitly reporting on the status of coastal area protection and we outline several considerations that can be used by the global conservation community to support more effective coastal protection, accounting and reporting *vis-à-vis* Target 3 of the KM-GBF.

Key words: protected areas, conserved areas, biodiversity, targets, planning, reporting, accounting

INTRODUCTION

While representing only 5 per cent of the world's terrestrial area, coastal areas contain disproportionate biological significance, including threatened and highly productive ecosystems, key habitats, and the provision of a wide variety of ecosystem services to billions of people the world-over (MEA, 2005). With approximately 40 per cent of the world's population living within 100 km of the coast, coastal regions support the livelihoods of billions of people (United Nations, 2017). At the same time, population-related development pressures have led to a loss of coastal biodiversity, reduced water quality, and impaired resilience to storms and other natural hazards (Herbert-Read et al., 2022; Sandifer & Sutton-Grier, 2014) . These impacts are being further compounded by the increasing threats posed by climate change (Hanley et al., 2020; IPCC, 2018) and collectively undermine the health and productivity of coastal ecosystems and the services they provide.

Despite their ecological and social significance, coastal areas have been poorly considered in conservation planning and reporting, especially as related to protected areas and "other effective area-based conservation measures" (OECMs). Aichi Biodiversity Target 11 of the United Nations (UN) Convention on Biological Diversity (CBD) *Strategic Plan for Biodiversity 2011–2020* called on Parties to conserve "*10 per cent of **coastal** and marine area…*" through protected areas and OECMs by 2020 (CBD, 2010) (emphasis added). However, *Protected Planet Report 2020,* the final report by UNEP-WCMC and IUCN on the global status of Aichi Biodiversity Target 11 (UNEP-WCMC IUCN & NGS, 2021), only reported marine and terrestrial protected and

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conserved area and did not explicitly report on the status of coastal area. We are also not aware of a single national report submitted to the CBD that accounted for coastal area protection *vis-à-vis* Aichi Biodiversity Target 11. Part of the reporting challenge may stem from the fact that there is no standard working definition of 'coastal area' (Neumann et al., 2015). While the coast is generally recognised as the place where marine and terrestrial environments interact (e.g. coastal protected areas are "within or adjacent to the marine environment…") (SCBD, 2004), defining or operationalising how far inland or seaward a coastal area boundary extends, varies with purpose and context (Alvarez-Romero et al., 2011; Mikhaylov & Plotnikova, 2021). Furthermore, because coastal areas overlap different, and often independent, marine and terrestrial governance and technical cultures, mapping and accounting extent of such areas requires a complicated degree of harmonisation between datasets (Bartier & Sloan, 2007).

Renewed and ambitious area-based conservation commitments, as well as the mounting severity of pressures being exerted on coastal ecosystems, compels the need for much greater focus on coastal areas by both the scientific and policy communities. These are critical ecosystems subject to pressures unique to the land–water interface and warrant specific conservation tracking and action. Reporting on implementation progress, as outlined in CBD Article 26, is required by Parties, and can assist countries in identifying commitments that are being successfully met, gaps and constraints to implementation (CBD, 2006). Reporting on the status of the effective implementation of coastal area protection in particular can assist relevant authorities, stakeholders and partners in formulating focused strategies to develop mutually supportive initiatives at various scales of implementation and address important gaps and needs including, but not limited to, integrated spatial planning at the land–water interface (including ecological representation and connectivity) and addressing concerns over the quantity vs. quality of protection, particularly in the marine realm (Lemieux et al., 2022).

Surrounded by oceans on three sides, Canada has the longest coastline in the world, including 243,042 km of marine coast and 10,014 km of freshwater coast along the Great Lakes/St. Lawrence River (Statistics Canada, n.d.). Canada also has some of the planet's largest expanses of coasts under very low anthropogenic pressure (Allan et al., 2023; Williams et al., 2022). Coastal ecosystems in the country support thousands of terrestrial and aquatic wildlife species, including many species at risk, aggregations of migratory birds, and provide essential nursery habitat for fish of commercial and cultural importance (Federal Provincial and Territorial Governments of Canada, 2010). Approximately 40 per cent of Canada's population lives along a marine coast or within the Great Lakes basin (NRCAN, 2023). Coastal tourism in Canada represents nearly 25 per cent of total tourism employment (excluding the Great Lakes) (Government of Canada, 2021) and access to ocean and coastal territories is particularly important to Indigenous 'cultural continuity' – including traditional management and harvesting practices (e.g. Lepofsky et al., 2021), inter-generational transfer of knowledge (e.g. Morin et al., 2018) and social and ceremonial purposes (Bennett et al., 2018).

Canada's coastal ecosystems are also under threat. Approximately two-thirds of Atlantic coastal saltmarshes have been lost, 70 per cent of Pacific estuary marshes in British Columbia have been lost or degraded (Environment Canada, 1991), and about 50 per cent of the original Great Lakes coastal wetlands have been lost (with some losses as high as 90 per cent in southwestern Ontario) (ECCC, 2022a; EPA, 2006). Climate change with its associated impacts such as sea level rise and increased coastal erosion, is now a significant issue for coastal areas across Canada, particularly in the North (Ford et al., 2018; Lemmen et al., 2017).

Despite these challenges, Canada is well-positioned to play a significant global role in coastal conservation. The federal government committed to conserving 30 per cent of terrestrial, inland water, marine and coastal area by 2030, consistent with Target 3 (the '30x30' target) of the recently adopted UN CBD *Kunming-Montreal Global Biodiversity Framework* (KM-GBF) (Trudeau, 2021). This commitment is important in light of current pressures and threats related to economic development on Canada's coast, including substantive fisheries and failures to protect species at risk (Auditor General of Canada, 2022), ongoing and proposed offshore hydrocarbon resource development (Noble et al., 2013), northern development expansion plans (Hirsh-Pearson et al., 2022), as well as anticipated population growth in coastal cities (primarily through immigration) and changing settlement patterns (Neumann et al., 2015). Finally, ongoing land claims and associated community planning, including the emergence of Indigenous Protected and Conserved Areas (IPCAs) and related Indigenous-led conservation initiatives, could positively influence conservation outcomes across many coastal ecosystems in Canada (ICE, 2018).

Given the gaps in knowledge and reporting on coastal conservation, our objectives are to: 1) establish the current status of protected and conserved coastal area in Canada; 2) stratify protected and conserved coastal

Inuit elders from Nunavik and Nunatsiavut visit their childhood homes in Nachvak Fjord, Torngat Mountains National Park, Newfoundland and Labrador. ©Parks Canada/ H. Wittenborn.

area by jurisdictional authority and broad ecosystem types (e.g. marine bioregions/terrestrial ecozones); and, 3) discuss future directions to support effective coastal protected and conserved area planning, accounting and reporting. In so doing, we provide an important baseline understanding of the status, trends and issues related to coastal protection in Canada. This is also important for measuring progress over the remainder of the decade given that the coastal area protection subcomponent from Aichi Target 11 persists in KM-GBF Target 3.

METHODS

Here we provide a summary of the case study area and our analysis approach. More detailed methods including limitations can be found in Supplementary Online Material 1. The 2021 Canadian Protected and Conserved Database (CPCAD) was used to assess the state of protected and conserved area (ECCC, 2022b). CPCAD is an authoritative database comprised of both spatial (e.g. boundary) and attribute data. CPCAD is managed by Environment and Climate Change Canada (ECCC), the national focal point to the CBD, and jurisdictional authorities (e.g. provinces/territories, private land organisations) submit their databases to ECCC on an annual basis. As of December 2021, more than 9,000 terrestrial conserved areas and 750 marine conserved areas encompass approximately 13.5 per cent and 13.9 per cent of Canada's total terrestrial and marine area, respectively.

The methodology to measure the spatial distribution of protected areas in the coastal zones of Canada was completed in ArcGIS Pro 2.9.x. There is no standardised approach for defining coastal area (Neumann et al., 2015). Our delineation is based on a 4 km 'buffer zone' that includes a 2 km inland and a 2 km water buffer that straddles the shoreline. The resulting buffer zone retained key shoreline attributes (e.g. Great Lake name, terrestrial ecozone, marine bioregion and province/territorial name), and underwent dissolve processes to simplify the rendering of the coastal zone by jurisdiction. Two spatial datasets were used to delineate shorelines, the input used to define the 'coastal zone'. Spatial data depicting the representation of Canada's diverse ecological makeup, divided into 18 terrestrial ecozones (Figure 1 Supplementary Online Material 1), 12 marine bioregions/ecozones (Figure 2 Supplementary Online Material 1) and one freshwater bioregion/ecozone, was provided by the National Ecological Framework and the National Framework for Marine Protected Areas (Government of Canada, 2011, 2013).

RESULTS

For the purposes of this article, we report on protected and conserved coastal area only. Results pertaining to protected and conserved coastal length is included in Supplementary Online Material 2. Area is the standard reported on at the national level in Canada and by Protected Planet/World Database on Protected Areas (WDPA).

Our analysis reveals that coastal protected and conserved area in Canada across all provinces and territories (and including all governance types) is 13.6 per cent (Table 1, Figure 1). This total is slightly above the total national terrestrial area protected and conserved (13.5 per cent)

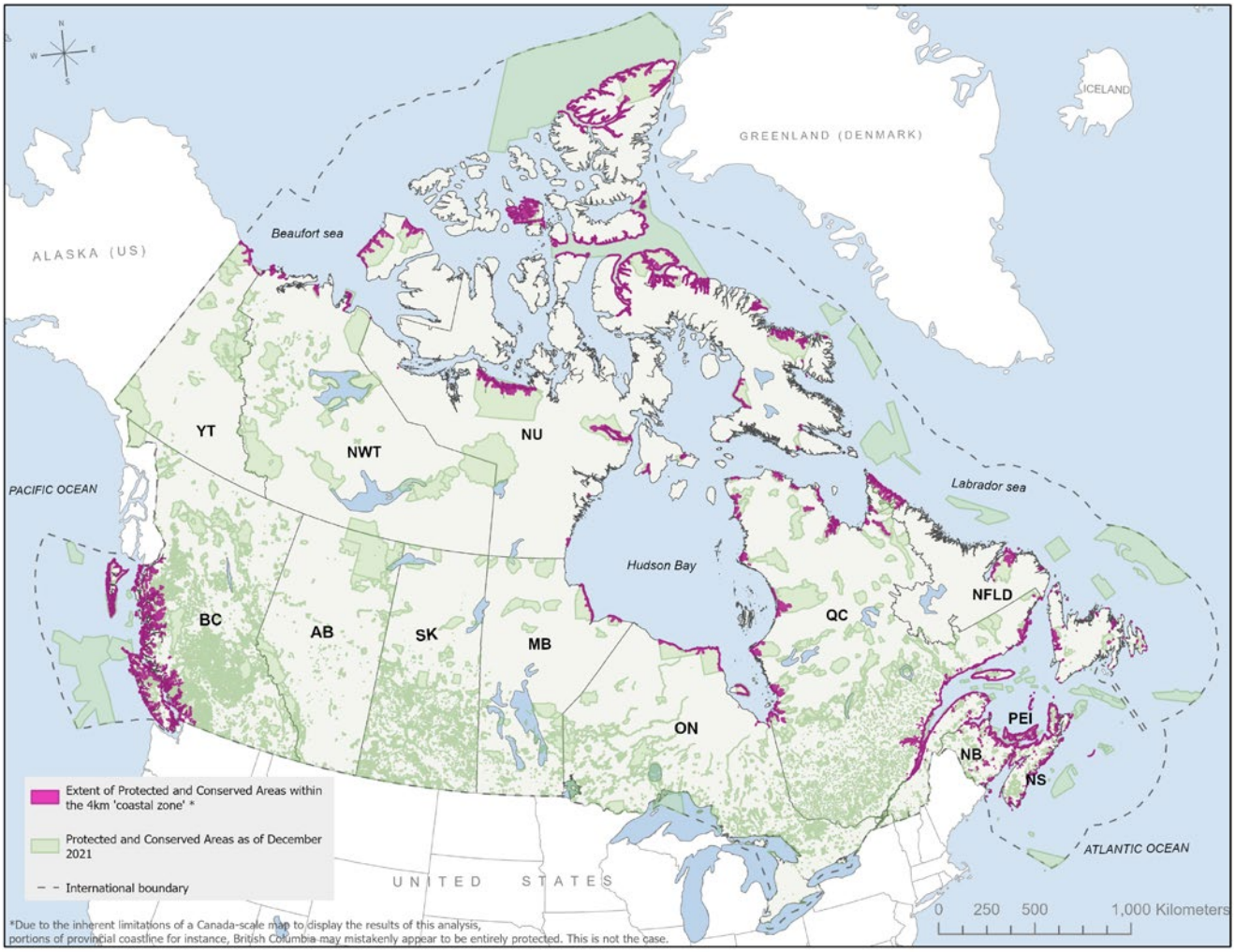

Figure 1a. Protected and conserved areas in Canada, with coastal protected and conserved areas delineated using a 4 km "buffer zone" that includes a 2 km inland and a 2 km water buffer.

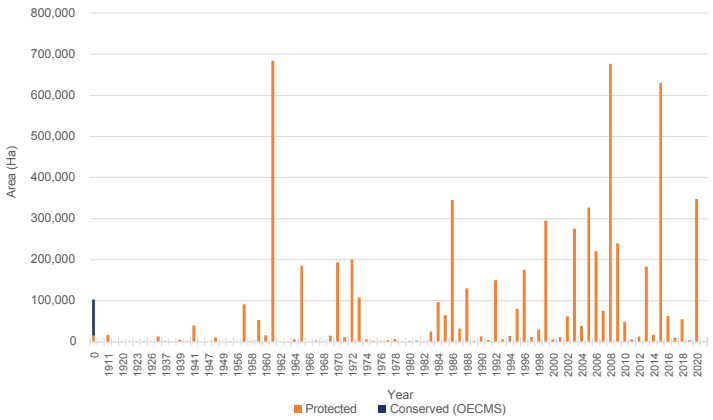

Figure 1b. Terrestrial protected and conserved coastal area establishment in Canada over time

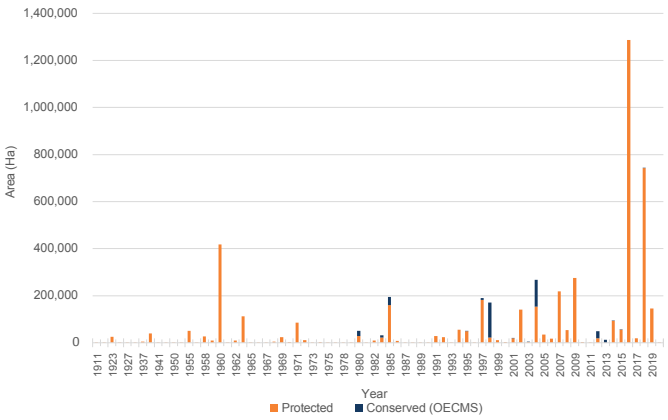

Figure 1c. Marine protected and conserved coastal area establishment in Canada over time.

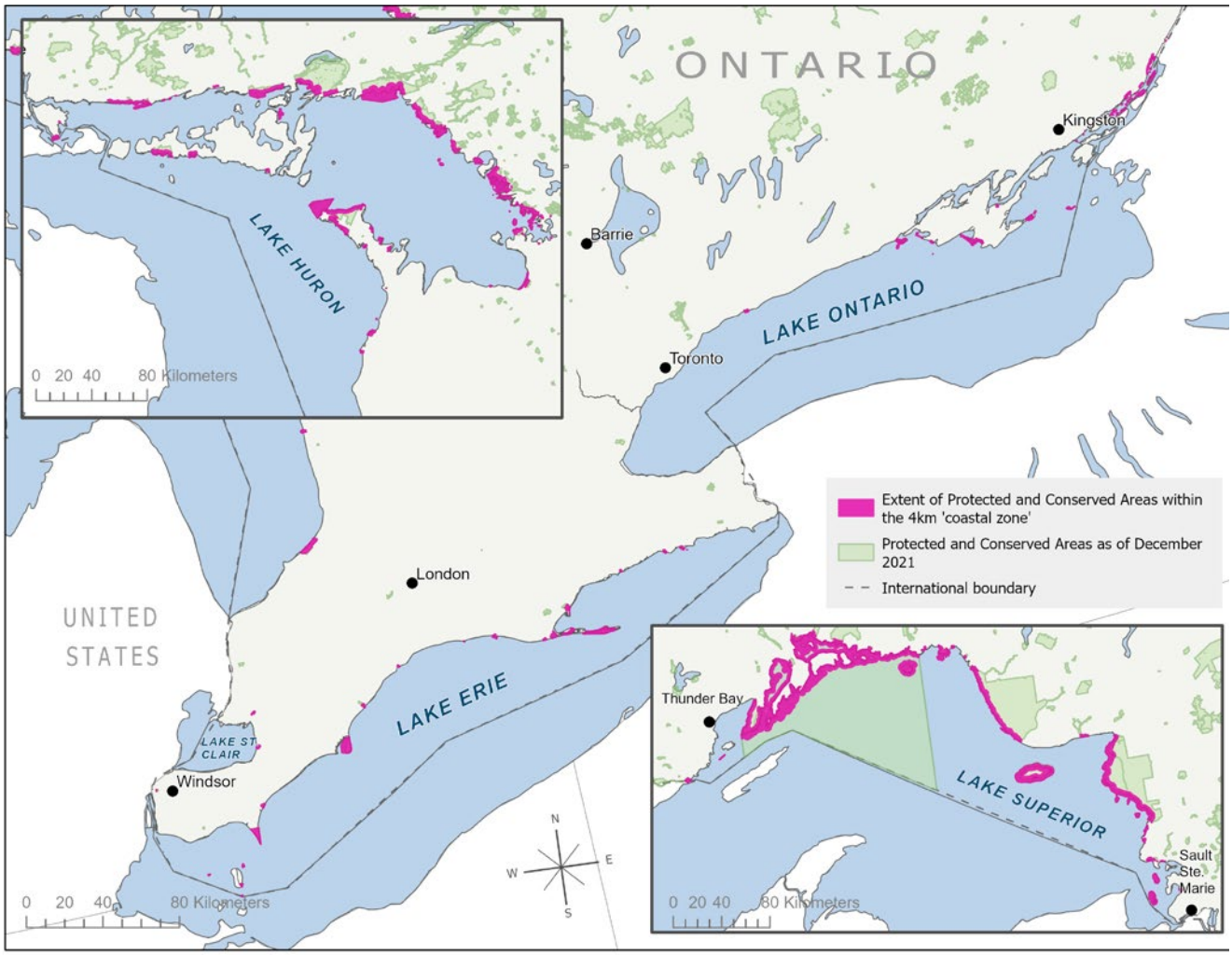

Figure 2. Coastal protected and conserved area in the Great Lakes region

but below the total marine area protected and conserved (13.9 per cent). However, substantial variations among provinces and territories exist. While Manitoba and Yukon have ostensibly achieved KM-GBF Target 3 for coastal protected and conserved area coverage, many others have much work to do over the remainder of the decade. Notable is the Northwest Territories, which protects and conserves only 8.0 per cent of its coastal area, and the maritime provinces (in particular Newfoundland and Labrador (7 per cent) and Nova Scotia (9.8 per cent)).

Trend analysis depicted in Figure 1 also reveals very little OECM establishment in coastal areas in recent years. Areas recognised as marine OECMs have largely occurred away from coastal areas. Finally, coastal protected and conserved area in the Great Lakes is currently poor (Table 2 and Figure 2). Lake Ontario (including the St. Lawrence River) and Lake Erie exhibit only 3.6 per cent and 3.7 per cent of their coastal area protected and conserved, respectively. While Lake Superior exhibits nearly 45 per cent coastal area protected and conserved, much of this is the result of a single, large National Marine Conservation Area (NMCA) (Lake Superior NMCA). Notably, no OECMs have been recognised along the Great Lakes coasts.

There is also a significant variation across *marine bioregions* (Table 3). Among Canada's three oceans, the Arctic coast is the least protected and conserved (14.5 per cent) and the Pacific coast the most (23.8 per cent). Apart from the Gulf of Saint Lawrence, no marine bioregion has achieved 30 per cent coastal area protected and conserved, with many bioregions exhibiting extremely poor overall protection. Perhaps not surprising, considering economic development activities such as nearshore hydrocarbon development and extensive fishing activities, the Newfoundland-Labrador Shelves has only 0.8 per cent of its coastal area protected and conserved. Hudson Bay also exhibits poor protection overall (5.1 per cent). Despite the proliferation in OECMs recognised in Canada in recent years (see Atlantic and Pacific Oceans in Table 3), none have been recognised in the Arctic Ocean.

Table 1. Coastal area protected[1] and conserved[2] in Canada, by province/territory (2 km inland and 2 km marine buffer).

Province/ territory	Total coastal area (ha)	Protected areas (total #)	Protected area (ha)	Total area protected (%)	Conserved areas (total #)	Conserved area (ha)	Conserved area (%)	Total area protected & conserved (%)
British Columbia	7488512.1	800	1719795.1	23.0%	19	88487.70	1.2%	24.1%
Manitoba	421504.2	4	157271.7	37.3%	0	0.00	0.0%	37.3%
New Brunswick	1478174.7	136	71607.1	4.8%	3	130939.50	8.9%	13.7%
Newfoundland and Labrador	9258034.5	64	617553.2	6.7%	7	29244.80	0.3%	7.0%
Northwest Territories	8098617.5	17	646187.7	8.0%	0	0.00	0.0%	8.0%
Nova Scotia	2288192.2	218	106072.3	4.6%	2	119158.60	5.2%	9.8%
Nunavut	48648012.5	48	5543286.3	11.4%	0	0.00	0.0%	11.4%
Ontario[3]	647100.1	8	176053.8	27.2%	0	0.00	0.0%	27.2%
Prince Edward Island	487746.1	188	15321.3	3.1%	9	79257.30	16.3%	19.4%
Quebec	7265618.9	908	2079954.1	28.6%	3	23668.30	0.3%	29.0%
Yukon	205063.0	3	92426.9	45.1%	0	0.00	0.0%	45.1%
TOTAL	**86286576.2**	**2,394**	**11225529.9**	**13.0%**	**43**	**470756.40**	**1.7%**	**13.6%**

[1] protected areas [2] conserved areas (OECMs) [3] marine area only (excludes Great Lakes)

Table 2. Coastal area protected and conserved[1], by Great Lake (2 km inland and 2 km marine buffer).

Province	Total coastal area (ha)	Protected areas (total #)	Protected area (ha)	Total area protected (%)
Lake Erie*	301,214.80	24	11,125.16	3.7%
Lake Huron**	1,255,436.13	52	118,308.48	9.4%
Lake Ontario***	497,863.01	39	18,047.68	3.6%
Lake Superior	716,182.80	35	316,049.20	44.1%
TOTAL	**2,770,696.74**	**150**	**463,530.53**	**16.7%**

[1] no conserved areas (OECMs) are reported for the Great Lakes

* includes Lake St. Clair and St. Clair River/Detroit River

** includes St Mary's River and adjoining channels

*** includes St. Lawrence River (up to Montreal, Quebec)

With respect to *terrestrial ecozones* (Table 4), once again the Great Lakes (Mixed Wood Plains) exhibits poor coastal protection (at 8 per cent), and the greatest protected and conserved area exists within the Pacific Maritime (24.3 per cent). Only the Hudson Plains has achieved the '30x30' target, and many Arctic terrestrial ecozones remain poorly protected and conserved. The largest terrestrial ecozone included in the study, the Northern Arctic, exhibits only 8.4 per cent protection, and many others have no coastal protected and conserved areas whatsoever (Taiga Cordillera, Taiga Plains). While the Boreal Shield terrestrial ecozone has a relatively high number of (relatively small) protected areas within the 2 km coastline buffer, overall representation remains low (at 8.8 per cent). Like the Mixed Wood Plains, most of this ecozone is within the province of Ontario.

Table 3. Coastal area protected[1] and conserved[2] in Canada, by marine bioregion (2 km inland and 2 km marine buffer).

Marine bioregion	Total coastal area (ha)	Protected areas (total #)	Protected area (ha)	Total area protected (%)	Conserved areas (total #)	Conserved area (ha)	Conserved area (%)	Total area protected & conserved (%)
ARCTIC	**24,719,826.5**	**46**	**3,577,484.5**	**14.5%**	**0**	**0.00**	**0.0%**	**14.5%**
Western Arctic	3,985,258.7	11	547,562.1	13.7%	0	0.00	0.0%	13.7%
Arctic Archipelago	6,076,326.3	4	975,013.9	16.0%	0	0.00	0.0%	16.0%
Eastern Arctic	6,643,275.3	10	1,645,771.8	24.8%	0	0.00	0.0%	24.8%
Hudson Bay Complex	8,014,966.3	21	409,136.7	5.1%	0	0.00	0.0%	5.1%
ATLANTIC	**6,217,367.6**	**544**	**604,960.8**	**9.7%**	**24**	**382,268.60**	**6.2%**	**15.9%**
Newfoundland-Labrador Shelves	3,506,707.1	12	18,851.6	0.5%	4	7,598.40	0.2%	0.8%
Scotian Shelf	796,203.4	20	3,794.2	0.5%	2	148,470.30	18.7%	19.1%
Gulf of Saint Lawrence	1,914,457.1	512	582,314.9	30.4%	18	226,199.90	11.8%	42.2%
PACIFIC	**2,682,887.6**	**194**	**551,211.6**	**20.5%**	**19**	**88,487.72**	**3.3%**	**23.8%**
Strait of Georgia	497,014.5	58	26,926.1	5.4%	17	1,562.49	0.3%	5.7%
Southern Shelf	288,432.3	28	64,135.3	22.2%	0	0.00	0.0%	22.2%
Northern Shelf	1,897,440.8	108	460,150.2	24.3%	2	86,925.23	4.6%	28.8%
TOTAL	**33,620,081.7**	**784**	**4,733,656.9**	**14.1%**	**43**	**470,756.40**	**1.4%**	**15.5%**

[1] protected areas [2] conserved areas (OECMs)

Table 4. Coastal area protected[1] and conserved[2] in Canada, by terrestrial ecozone (2 km inland and 2 km marine buffer).

Terrestrial ecozone	Total coastal area (ha)	Protected areas (total #)	Protected area (ha)	Total area protected (%)	Conserved areas (total #)	Conserved area (ha)	Conserved area (%)	Total area protected & conserved (%)
Arctic Cordillera	3,532,624.6	7	592,722.3	16.8%	0	0	0.0%	**16.8%**
Atlantic Maritime	3,368,943.8	603	209,269.0	6.2%	16	342,173.8	10.2%	**16.4%**
Boreal Shield	4,979,208.5	244	395,802.5	7.9%	8	40,094.9	0.8%	**8.8%**
Hudson Plains	1,328,867.3	18	424,398.5	31.9%	19	88,487.7	6.7%	**38.6%**
Mixed Wood Plain (Great Lakes)	170,063.1	80	13,575.4	8.0%	0	0.0	0.0%	**8.0%**
Northern Arctic	25,085,511.2	23	2,107,426.0	8.4%	0	0.0	0.0%	**8.4%**
Pacific Maritime	4,802,831.3	606	1,168,583.5	24.3%	0	0.0	0.0%	**24.3%**
Southern Arctic	5,994,674.6	18	1,040,202.0	17.4%	0	0.0	0.0%	**17.4%**
Taiga Shield	2,889,352.6	11	539,893.7	18.7%	0	0.0	0.0%	**18.7%**
Taiga Cordillera	8,975.2	0	0.0	0.0%	0	0.0	0.0%	**0.0%**
Taiga Plain	503,379.3	0	0.0	0.0%	0	0.0	0.0%	**0.0%**
TOTAL	**52,664,431.6**	**1610**	**6,491,872.9**	**12.3%**	**43**	**470,756.4**	**0.9%**	**13.2%**

[1] protected areas [2] conserved areas (OECMs)

DISCUSSION

Our results revealed mixed progress in coastal protected and conserved area in Canada. As Canada continues to make progress towards 30 per cent protected and conserved area coverage, considerable work will also be required to achieve the subcomponents of Target 3 (that were not achieved in Aichi Biodiversity Target 11) related to equity, connectivity and effectiveness. To this end, our discussion addresses considerations in three key areas: 1) elevating Indigenous-led conservation; 2) mainstreaming integrated coastal management and systematic conservation planning; and, 3) developing national protected and conserved area database accounting and reporting. While by no means comprehensive, our discussion can be used to advance further discussion on coastal area protection and reporting in Canada and indeed internationally.

Consideration 1: Elevate Indigenous-led conservation in coastal regions

In recent decades, more protected areas have developed cooperative management agreements in a coastal area context with respective Indigenous peoples. The various forms of agreements, which can range from relationship building to consensus management bodies, can help reinforce a foundation for self-determination, traditional stewardship practices, Indigenous knowledge systems, and human well-being (ICE, 2018). As an example, at Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site, the Haida Nation and the Government of Canada have developed the 'Gwaii Haanas Gina 'Waadluxan KilGuhlGa Land-Sea-People Management Plan' (Haida Nation and Parks Canada, 2018). This landmark plan demonstrates how two nations can achieve coastal conservation through cooperation and consensus. Unfortunately, it remains one of very few examples of this type of initiative in Canada (and indeed globally).

IPCAs also enable Indigenous-led conservation and contribute to biodiversity conservation targets in an equitable manner (ICE, 2018). Although CPCAD can include IPCAs, none were identified within the CPCAD database at the time of this assessment. However, in 2021 the Mamalilikulla First Nation declared the Gwaxdlala/Nalaxdlala IPCA under its own laws and recently Canada announced fisheries closures and the establishment of a marine refuge to help further protect this IPCA (Fisheries and Oceans Canada, 2023). More broadly, Gwaxdlala/Nalaxdlala is also part of the Northern Shelf Bioregion Marine Protected Area (MPA) Network, whose action plan provides a blueprint for conservation and collaborative governance between 15 First Nations, the province of British Columbia and the Government of Canada (MPA Network BC Northern Shelf Initiative, 2023). Future coastal area assessments and updates to CPCAD will no doubt include IPCAs (Assembly of First Nations, 2023), but also other opportunities to recognise Indigenous-led area-based conservation and advance 'land-sea-people' thinking which is critical for coastal conservation.

Consideration 2: Mainstream integrated coastal management and systematic conservation planning

Our results revealed that Canada must still protect over 5 million ha of coastal area to achieve the 30x30 target in addition to ensuring that protected and conserved areas are representative, well-connected and are of particular importance for biodiversity.

Integrated coastal management (ICM) and coastal governance structures (Gonçalves & Pinho, 2022; Pittman & Armitage, 2016; Eger et al., 2021) are essential to coastal conservation and explicitly supported by the CBD (CBD, 2022a). Canada's *Oceans Act* (2014) represented a significant step towards ICM, however implementation has been slow and uncoordinated. Early attempts at integrating planning through the 'Great Lakes Heritage Coast' initiative was abandoned by the Ontario government in the early 2000s. However, some promising new initiatives are emerging. A *Coastal Marine Strategy Policy Intentions Paper* for British Columbia was released in 2022 (Government of British Columbia, 2022) that presents a vision for protecting the ecological, cultural and economic benefits provided by the coastal marine environment and was informed by First Nations knowledge, Western science and existing planning documents, and is expected to inform coastal policy in British Columbia. With recent initiatives in ICM and commitments to achieve the KM-GBF, the timing seems propitious to revisit past efforts and synthesise insights from ongoing ones to identify how various governance arrangements can be used to take a systematic planning approach to coastal conservation. Ensuring ecological representation is necessary for meeting the KM-GBF targets and has been a central tenant of terrestrial and marine protected areas planning in Canada, including national parks and many provincial park planning initiatives for nearly half a century (e.g. Parks Canada, 1997). However, Canada has yet to undertake an integrated, systematic approach to conserving the full diversity of Canada's coastal areas. Our study can be used to identify regions where additional coastal protected and conserved areas should

be prioritised to ensure representation including the Northern Arctic, Boreal Shield and the Great Lakes.

Many coastal sites that are of particular importance for biodiversity remain unprotected (e.g. seagrass ecosystems (Griffiths et al., 2020). Systematic planning for coastal protected and conserved areas can be supported by global and domestic initiatives to identify Key Biodiversity Areas (KBAs) (IUCN, 2016; WCS Canada Coalition, 2021). While there is continual improvement in our knowledge and mapping of coastal ecosystems (e.g. Costa et al., 2020) that can guide conservation efforts, the classification, range and conservation status of most coastal ecosystems remains unknown. Furthermore, very little is known about how the inclusion of ecosystem services provided by coastal areas can be more effectively integrated into systematic conservation planning (e.g. carbon storage, flood control, health and well-being benefits derived from tourism and recreation).

A national systematic planning framework, focused on inventorying coastal areas and flows of ecosystem services, could offer scope for identifying synergies between area-based conservation (including OECMs), climate change mitigation and adaptation, and ecosystem services. Establishing a national coastal protected and conserved area working group that convenes practitioners and knowledge-holders in protected and conserved areas, coastal and ocean management, and watershed management to collaborate in a national-level working group (or advisory panel) could work to advance both systematic conservation planning and ICM management strategies. The working group could identify KBAs at the coastal interface, governance challenges with respect to ICM, track progress in coastal conservation, and provide insights into effective and equitable governance across regions, all in relation to the various quantitative and qualitative dimensions of KM-GBF Target 3.

Consideration 3: Develop coastal area accounting and reporting in Canada

Even with the call in Aichi Target 11, and echoed again in the KM-GBF Target 3, to explicitly protect coastal areas, there has been a lack of systematic assessment and reporting of these areas in Canada. By assuming coastal areas are captured in marine targets fails to account for their terrestrial component, and that coastal systems reflect a land and water interface (MEA, 2005). As mentioned, one reason for this, as we have attempted to address here, is the challenge of recognising that the coast is a distinct area, where governance and management needs to be observed in two directions, effectively integrating both aquatic and terrestrial areas (Van Assche et al., 2020).

Our accounting approach captures the land–water interface within a 4-km shoreline buffer. While it may be considered robust, in the sense that it recognises protection if it is either land or water based, we recognise that the most desirable design is where land and water protection are connected. Here we found that only 5.6 per cent (23,445 km) of Canada's marine and 14.1 per cent (2,942 km) of Canada's Great Lakes shoreline included protection that straddled this land and water interface.

While CPCAD is an essential source of data for reporting coverage, it has limitations for completing coastal area assessments. For instance, the quality of boundary digitisation for many protected areas demonstrated a mismatch with the shoreline vector, and metadata limitations made it difficult to know if the boundary followed the HWM or another cadastral boundary. Thomas et al. (2014) noted similar concerns with boundaries in their evaluation of marine protected areas (MPAs) using the WDPA. Further, a single IUCN category was assigned to the entire site, which could obscure differences in zoning within a site (e.g. areas of strict protection versus sustainable use). Designation of the Great Lakes, and other inland waters, as a terrestrial biome is also counter to the marine conservation aspirations of both the US and Canada and made identification of marine areas calculations more challenging.

The subcomponents of KM-GBF Target 3 related to connectivity, equity and effectiveness were not examined in our assessment. Data limitations constituted the primary reason for not addressing them. For instance, while there are some local and regional efforts underway to assess coastal connectivity (e.g. Friesen et al., 2019), there was no national scale assessment to draw upon. Similarly, while equity is beginning to receive the attention it needs, there was no established reporting system available (Gurney et al., 2023). In terms of effectiveness, the Protected Planet's Protected Areas Management Effectiveness database revealed that some form of assessment had been completed for approximately 28 of the coastal sites, but this coverage was incomplete (UNEP-WCMC IUCN & NGS, 2021). With that said, a more robust monitoring and reporting process has been proposed in the KM-GBF that includes not only the headline indicator (e.g. coverage of protected and conserved area for Target 3), but indicators for subcomponents such as effectiveness, equity and connectivity (CBD, 2022b).

Pinery Provincial Park on Lake Huron, Ontario has rare and fragile Oak Savanna and Coastal Dune ecosystems © Chris Lemieux.

CONCLUSIONS

Our analysis provides the first baseline assessment of coastal protected and conserved areas in Canada. While past conservation and reporting has focused on terrestrial and marine realms, the new KM-GBF 30x30 target is an opportunity to broaden these important efforts to explicitly consider inland waters (Moravek et al., 2023) and coastal areas. As this paper has shown, there is a need to increase coastal protected and conserved area across Canada. Filling the gaps in coastal protection and representation to meet KM-GBF Target 3 by 2030 is an enormous challenge. To some extent, this could be the result of both a lack of a comprehensive picture of what coastal area protection should look like *vis-à-vis* integrated planning at the national and regional levels, and a lack of guidance in relation to the implementation of subcomponent elements of international area-based conservation targets.

Canada has an unparalleled global opportunity to effectively conserve coastal ecosystems. The country's marine and Great Lakes coasts are not just expansive, but in many areas remain intact and support important biodiversity and ecosystem services. Yet, many regions remain critically under-protected. The lack of protected area in several (mostly) undeveloped regions, including the Arctic, presents an opportunity to continue important work with (and being led by) Indigenous communities to implement best practices in protected and conserved areas design, including subcomponents of Target 3 (e.g. representation, equity, connectivity). For example, the draft *Nunavut Land Use Plan* includes increased limited-use designations that benefit species such as Barren-ground Caribou and limiting ice breaking along critical migratory pathways (Nunavut Planning Commission, 2021). It also acknowledges the importance of conservation planning for parks, conservation areas, and the protection of other areas of community interest (including coastal areas). The effective protection, conservation and restoration of coastal ecosystems will also support national and sub-national climate change mitigation and adaptation strategies (CCA, 2022). We hope that our analysis will provide a baseline to monitor progress towards protecting and conserving 30 per cent of Canada's coastal ecosystems by 2030 and provide a case study to encourage all countries to include coastal ecosystems in protected and conserved areas planning and KM-GBF Target 3 accounting and reporting going forward.

SUPPLEMENTARY ONLINE MATERIAL

1. Detailed methods
2. Results by length of coast protected

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RESUMEN

A pesar de que desde hace más de una década se reconoce que la zona costera es un subcomponente importante en los objetivos de las áreas protegidas y conservadas, ha quedado huérfana en los informes nacionales e internacionales. En este documento, presentamos el primer informe de situación sobre la superficie costera protegida y conservada en Canadá. Aunque el 13,6% de la superficie costera canadiense está protegida y conservada, existen variaciones sustanciales entre los tres océanos y los Grandes Lagos de Canadá, las autoridades jurisdiccionales y los ecosistemas marinos y terrestres. Es importante señalar que Manitoba (37,3%) y el Yukón (45,1%) ya han alcanzado el objetivo de protección del 30% de las costas establecido en el Marco Mundial para la Biodiversidad de Kunming y Montreal. Sin embargo, Nunavut (3,5%) y Terranova y Labrador (7%) están muy por debajo. La protección es muy deficiente en varias biorregiones marinas y ecozonas terrestres, como en el Ártico, las plataformas de Terranova y Labrador (0,7%) y el complejo de la bahía de Hudson (5,1%). Los Grandes Lagos requieren una atención urgente y centrada en la conservación, ya que los lagos Ontario (3,6%) y Erie (3,1%) presentan una cantidad ínfima de superficie costera protegida y conservada. Nuestros resultados ponen de relieve la importancia de informar explícitamente sobre el estado de la protección de las zonas costeras y esbozamos varias consideraciones que pueden ser utilizadas por la comunidad conservacionista mundial para apoyar una protección de las costas, una contabilidad y una presentación de informes más eficaces de cara a la Meta 3 del KM-GBF.

RÉSUMÉ

Bien que les zones côtières soient reconnues depuis plus d'une décennie comme une sous-composante importante des objectifs en matière d'aires protégées et conservées, elles sont restées orphelines dans les rapports nationaux et internationaux. Dans cet article, nous présentons le premier rapport d'avancement sur les zones côtières protégées et conservées au Canada. Alors que 13,6 % des zones côtières du Canada sont protégées et conservées, il existe des variations substantielles entre les trois océans et les Grands Lacs du Canada, les autorités juridictionnelles et les écosystèmes marins/terrestres. Il est important de noter que le Manitoba (37,3 %) et le Yukon (45,1 %) ont déjà atteint l'objectif de 30 % de protection côtière du Cadre mondial pour la biodiversité Kunming-Montréal (KM-GBF). Toutefois, le Nunavut (3,5 %) et Terre-Neuve-et-Labrador (7 %) sont encore loin du compte. La protection est très faible dans plusieurs biorégions marines et écozones terrestres, notamment dans l'Arctique, sur les plateaux de Terre-Neuve et du Labrador (0,7 %) et dans le complexe de la baie d'Hudson (5,1 %). Les Grands Lacs requièrent une attention urgente et ciblée en matière de conservation, les lacs Ontario (3,6 %) et Érié (3,1 %) présentant une quantité lamentable de zones côtières protégées et conservées. Nos résultats soulignent l'importance d'un rapport explicite sur l'état de la protection des zones côtières et nous soulignons plusieurs considérations qui peuvent être utilisées par la communauté mondiale de la conservation pour soutenir une protection côtière plus efficace, la comptabilité et le rapport en ce qui concerne la cible 3 de la KM-GBF.

CA|RDS LITE: A RAPID ASSESSMENT OF SITE MANAGEMENT AGAINST THE CONSERVATION ASSURED | RIVER DOLPHIN STANDARDS

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ABSTRACT

This paper introduces the inaugural rapid evaluation of river dolphin habitats, coinciding with managed sites in Asia and South America. Covering all six river dolphin species (including the sole freshwater porpoise worldwide), each is classified as Endangered or Critically Endangered on the IUCN Red List. The Conservation Assured | River Dolphin Standards (CA|RDS) offer tailored guidelines for the proficient oversight of protected areas for river dolphins. The abbreviated CA|RDS version, termed CA|RDS Lite, involves a questionnaire-based survey conducted by managers and stakeholders at 40 sites across 10 of the 14 countries within the river dolphin range. Both continents face river dolphin endangerment from fishing and climate change. In Asia, risks are more diverse, with smaller populations compared to South America. Insufficient funding and management capacity emerge as significant hurdles. Inadequate collaboration with areas outside the protected area boundary impedes effective river dolphin population management. Encouragingly, the survey highlights active involvement of local communities and stakeholders in site management. CA|RDS Lite offers a quick overview of site management efficacy, pinpointing crucial management requirements and urgent river dolphin sites necessitating intervention. It also sets the stage for the complete application of CA|RDS standards and their use as an accreditation and management instrument.

Key words: IUCN Red List, climate change, management capacity

INTRODUCTION

River dolphins are highly specialised freshwater cetaceans that inhabit some of the world's largest and most iconic rivers. They are among the more threatened mammals on the planet, facing a multitude of threats ranging from habitat loss and degradation to pollution, deliberate and accidental killing and climate change (Braulik et al., 2023). Despite the important role that river dolphins play in freshwater ecosystems, these cetaceans have received relatively little attention compared to terrestrial species (Schipper et al., 2008). Levels of river pollution are particularly severe in parts of Asia (Strokal et al., 2021) and the rise in human populations as well as increased economic activities have fuelled anthropogenic threats. Biodiversity loss and ecosystem collapse are considered to be the one of the greatest global risks to global GDP (The Global Risks Report, 2023).

There are six remaining species of river dolphins found in the world (Figure 1), after the extinction of the Yangtze River Dolphin (Baiji) last seen in 2002 (IUCN Cetacean Specialist Group). These six extant species are found in 14 countries within South America and Asia and are classified as Endangered or Critically Endangered by the IUCN Red List of Threatened Species (Table 1). We use the term 'river dolphins' for all river cetacean species, including the only freshwater porpoise (Yangtze Finless Porpoise), and three riverine subpopulations of the Irrawaddy Dolphin (Ayeyarwady, Mekong and Mahakam rivers).

Protected and conserved areas (PCAs), a term which includes protected areas along with other effective area-based conservation measures (OECMs) (Conservation Assured, 2021) are critical to the survival of threatened species (Rodrigues et al., 2004) and mitigation of the impacts of climate change (Campbell et al., 2018). Currently, there are 119 PCAs that are known to overlap

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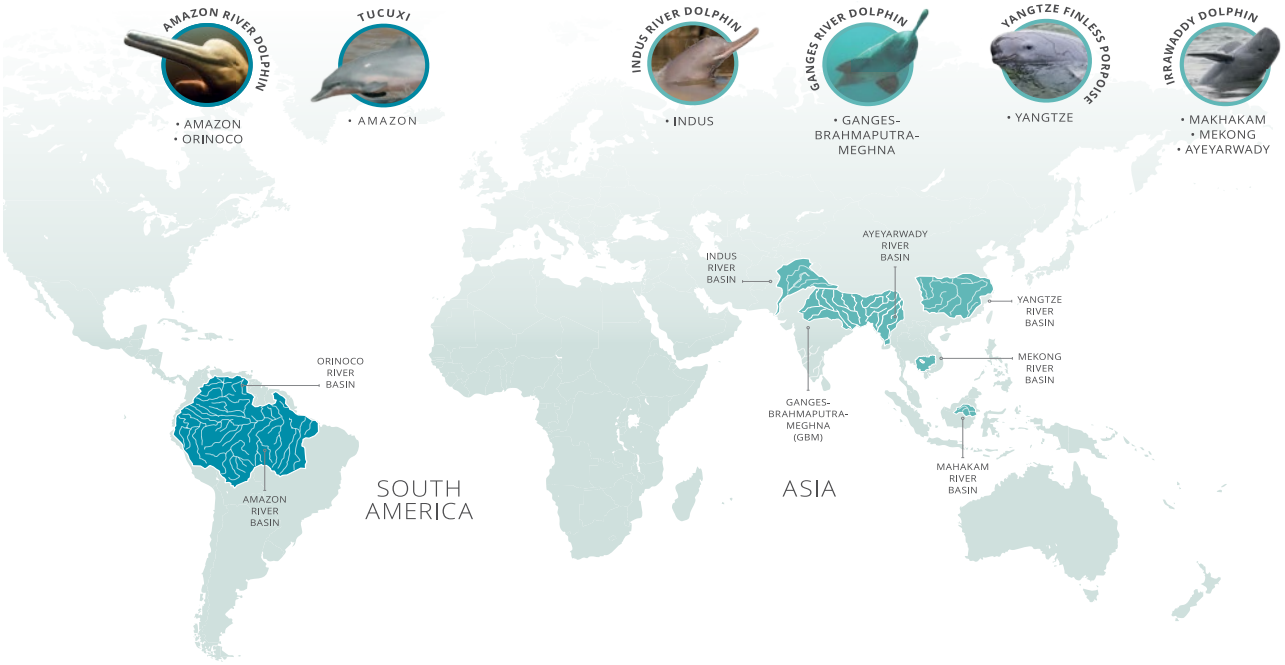

Figure 1. Where river dolphins live: Bangladesh, Bolivia, Brazil, Cambodia, China, Colombia, Ecuador, India, Indonesia, Myanmar, Nepal, Pakistan, Peru and Venezuela. Source: WWF (2023)

river dolphin ranges; 88 in South America and 31 in Asia (Conservation Assured, 2021). In Asia, with the exception of the Ganges River Dolphin, the population abundance of the species is monitored and known, and most of their range is legally protected. In Cambodia, Indonesia and Myanmar, almost the entire Irrawaddy Dolphin's river ranges are in a protected status; in China around 50 per cent and in Pakistan 70 per cent of the population lives within PCAs. This compares with Bangladesh, India and Nepal where a low percentage of the Ganges River Dolphin's range is officially designated under protection, and large areas have not been surveyed to assess population abundance (Kelkar et al., 2022). In South America, large areas have not been surveyed to assess population abundance and most river dolphins are believed to live outside legally protected areas (WWF, 2023).

The role of PCAs in maintaining populations of river dolphins is still poorly understood (Mintzer et al., 2020). The current survey therefore aimed to provide a preliminary snapshot of the effectiveness of these areas for river dolphin conservation around the world, as part of an ongoing process to strengthen management of these species, several of which are severely threatened (WWF, 2023).

Conservation Assured and CA|RDS Lite

Conservation Assured is an approach to developing conservation standards tailored to individual species or groups of species. These standards can then be used as the basis for independent assessment, and if desired accreditation, of sites against these standards. Conservation Assured provides a platform that helps to achieve effective site-based conservation through collaborative effort. It comprises a framework which acts as a verifier as well as an indicator of optimal practices. This is done by providing shared standards to site managers to achieve the conservation objectives specific to their sites. It allows for site managers to oversee and gauge their individual efforts to contribute to the collaborative conservation process through independent reviews and auditing procedures (Conservation Assured, 2021). Conservation Assured creates financial incentives for conservation, by giving governments and donors assurance that funds are not being wasted and a clear measure against which to assess progress. This has been demonstrated in the Conservation Assured | Tiger Standards (CA|TS) that have been promulgated within tiger ranges in 128 sites so far (Conservation Assured, 2022).

Conservation Assured | River Dolphin Standards (CA|RDS) is a set of standards for good management of river dolphins in PCAs. It is designed to understand whether river dolphins are being effectively protected and thus strengthens management. CA|RDS was

produced after extensive research and analyses among river dolphin experts around the globe who contributed to the documentation of global best practices to conserve river dolphins (Willems et al., 2021). CA|RDS comprises a total of eight pillars (broad subject areas) to evaluate effective site management (Figure 2).

'CA|RDS Lite' is a questionnaire-based rapid assessment using a simplified and condensed version of CA|RDS. The assessment provides a baseline for management effectiveness of river dolphin conservation and gives insights on how sites can be optimally managed to protect river dolphins. CA|RDS Lite may lead park managers and other stakeholders to apply full CA|RDS standards to their sites, making detailed site-specific management more effective in the future.

METHODOLOGY

The CA|RDS Lite survey was sent to 119 PCAs considered important for river dolphins and completed by park managers. Surveys were carried out at sites either independently or through interviews (in person or virtual) to complete the questionnaires. The survey was completed between June and December 2022. Responses were checked and verified by river dolphin experts from both continents involved; verification involved checking that all questions were completed, checking for any errors and checking data was accurately transferred to the master database. Any changes to data were checked with the data providers.

Around a third (40 sites in total) responded: 16 in Asia and 24 sites in South America. The 40 sites covered all the six species of river dolphins and 10 of the 14 range countries (Bangladesh, Bolivia, Cambodia, China, Colombia, Indonesia, Myanmar, Nepal, Pakistan and Peru – see Tables 1 and 2 for number of sites per country).

It was an agreed protocol that published data from countries would not include site details, but this exercise has created a very detailed database which WWF and partners can use to support river dolphin conservation and track changes in conservation outlook in the future if repeat assessments are carried out.

CA|RDS Lite survey

The survey comprised three sections.

1. A questionnaire based around 39 questions related to management actions identified within the eight CA|RDS pillars (Figure 2). Each question was scored by the respondents on a scale reflecting whether associated management actions were a) fully implemented (score of 1.0), b) in the process of being implemented (score of 0.75), c) planned (score of 0.50), d) recognised as being needed but no action yet taken (score of 0.25), or e) not recognised as being needed (score of 0).
2. A threat assessment where respondents were asked to identify and rank threats (from 0 not a threat to 5 a severe threat) (Table 2 and Figure 3) that their specific river dolphin population(s) were facing: 1) within the site, 2) originating outside the site, and 3) potential future threats; this final category did not specify whether the threat was internal or external to the site. Space was also provided to add to the 21 threats in the list.
3. A set of site attributes including the name, location of site, basic site details, identification of up to two river dolphin species present, and several quantitative and qualitative assessments related to the percentage of national total river dolphin populations protected by the site, population estimates (Table 1), and conservation importance of river dolphins.

The full survey is available in Supplementary Online Material.

Figure 2. The eight pillars of effective site management used in CA|RDS. Source: WWF (2023)

Data analysis

The survey scores were examined by country, pillar and continent. The scores were totalled for each pillar and percentages were calculated; this gives the average score for each main management issue. A percentage score was given for all the scores together to provide an overall indication of site-level effectiveness. It would have been useful to include analysis per river dolphin species, but in Latin America two species often live in sympatry in the Amazon river system so this was not attempted.

RESULTS

Protection status of sites

Out of the 40 sites included in the survey, it was reported that one site in Nepal and two Ramsar sites in Colombia were not legally protected areas (nor are they recognised OECMs) while all other 37 sites were legally protected areas.

Population abundance

Information on species population and abundance was collected and is presented in Table 1. As noted above, in many sites river dolphin populations are poorly understood so the data presented is broad and in many places an estimate.

Extinction risk

The respondents were asked as part of the site attributes section of CA|RDS Lite whether if no conservation action took place the dolphins at their site were likely to be completely extirpated (lost or nearly lost) within the next 20 years. 37 sites responded (15 in Asia and 22 in South America), out of which 38 per cent of the sites predicted the probability of local extinction.

Threats

The threat assessment indicated important regional differences, with Asian sites reporting a wide range of immediate threats and South American sites identifying growing threats in the future. Specifically, sites in Asia reported three times the level of threat to their river dolphins compared with South American sites. Asia faces all the threats listed within the survey. Out of all the threats ranked by respondents from sites in Asia and South America, climate change impacts, illegal fishing and overfishing and underwater noise remained consistent challenges. The top five threats in Asia and South America are given in Figure 3.

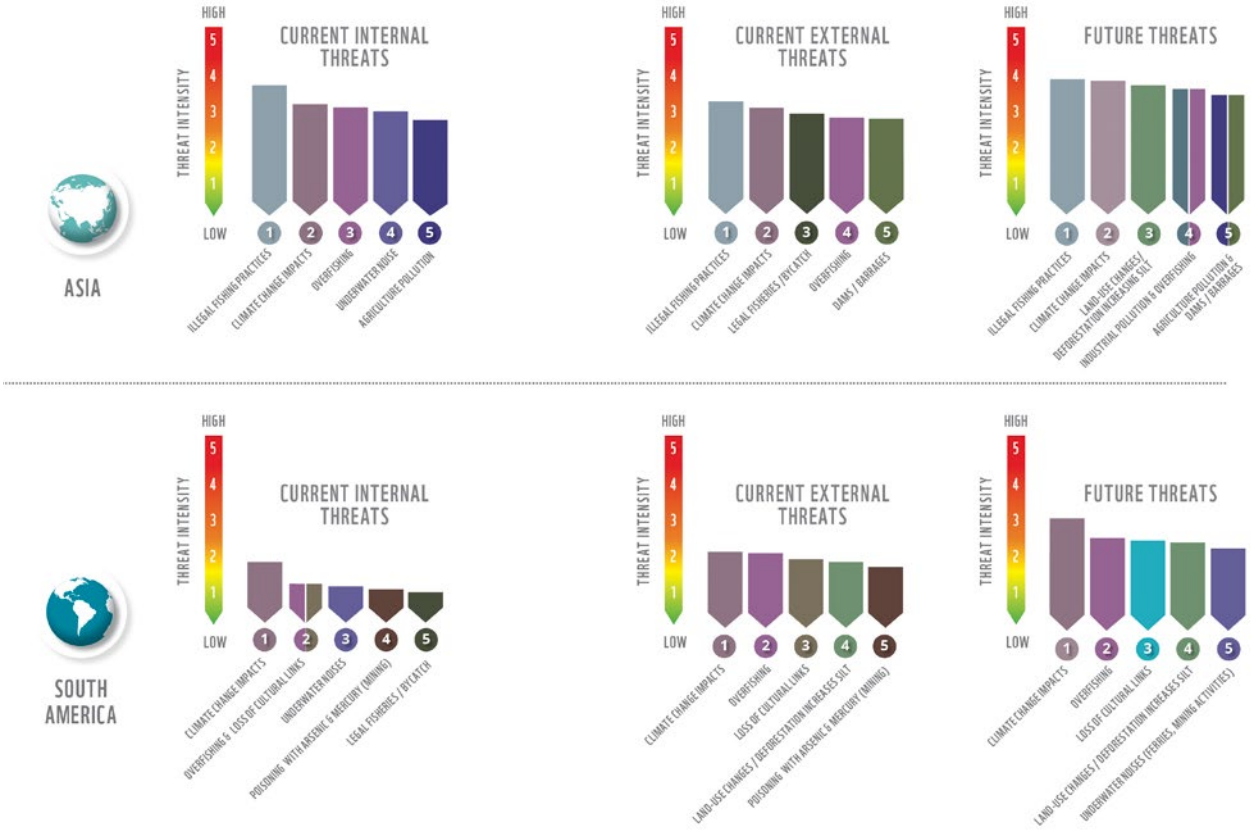

Figure 3. Combined highest ranked threats reported from each site by continent. Source: WWF (2023)

Table 1. Range countries, status and population abundance data

Country	Species	IUCN Red List Status of river dolphins	Estimated percentage of the total population represented in each site in the survey	Estimated total population
Asia				
Bangladesh	Ganges River Dolphin (*Platanista gangetica*)	Endangered (Kelhar et al., 2022)	1–10% (in each of the 6 sites that completed the survey)	Not known
Cambodia	Irrawaddy Dolphin (*Orcaella brevirostris*)	Critically Endangered (Brian & Beasley 2004)	91–100% (1 site)	89 (2020) Eam et al., 2020
China	Yangtze Finless Porpoise (*Neophocaena asiaeorientalis* ssp. *asiaeorientalis*)	Critically Endangered (Wang et al 2018)	1–10% (in each of the 2 sites)	1,249 (2023) Chinese Ministry of Agriculture and Rural Affairs, 2023
Indonesia	Irrawaddy Dolphin (*Orcaella brevirostris*)	Critically Endangered (Jefferson et al., 2008)	91–100% (1 site)	74–76 (2021) Kreb. Pers comm. 2023
Myanmar	Irrawaddy Dolphin (*Orcaella brevirostris*)	Critically Endangered (Smith 2004)	31–40% (for 1 site) / 41–50% (for 1 other)	79 (2020) Wildlife Conservation Society and Fisheries Department, 2020
Nepal	Ganges River Dolphin (*Platanista gangetica*)	Endangered	81-90% (1 site)	52 (2016) Department of Wildlife Conservation and National Park, 2016
Pakistan	Indus River Dolphin (*Platanista minor*)	Endangered (Braulik et al., 2022)	51–60% (for 1 site) / 1–10% (in each of the 2 sites)	1,987 (2018) Aisha et al., 2018, Aisha & Khan, 2021
South America				
Bolivia	Amazon River Dolphin (*Inia geoffrensis*)	Endangered (da Silva et al. 2018)	1–10% (in each of the 9 sites)	Not known
Colombia	Amazon River Dolphin (*Inia geoffrensis*)	Endangered	1–10% (in 2 of the 8 sites; data for the other 6 sites was not available)	Not known
	Tucuxi (*Sotalia fluviatilis*)	Endangered (da Silva et al. 2020)	No data available	
Peru	Amazon River Dolphin (*Inia geoffrensis*)	Endangered	1–10% (in 6 of the 7 sites; data for 1 site not available)	Not known
	Tucuxi (*Sotalia fluviatilis*)	Endangered	1–10% (in 5 of the 6 sites; data for 1 site was not available)	

Implementation of site management for river dolphin conservation

The average score for all the pillars (Figure 2) across all sites for river dolphin management implementation was 52 per cent of the possible maximum score. Only five sites scored above 75 per cent and more than half (22 out of 40) scored below 50 per cent. Scores varied considerably across sites, ranging from 27 to 96 per cent, indicating that there is significant variation in how sites are managed.

Out of all the sites, four within Asia (one site each in Cambodia and Indonesia, along with two sites in China) reported the highest scores; exceeding 80 per cent across all the questions. These sites support critically endangered (sub)populations of species. The high scores reflect the substantial amount of investment made for the

Irrawaddy Dolphin fluke caught in a fishing net © WWF Cambodia

purpose of managing these sites as can be seen from the high scores on all elements of management (e.g. question 3.4 on adequate, sustainable funding, 2.1 on effective up-to-date management plans, 2.2 suitable trained staff, 2.3 necessary equipment and infrastructure, etc.) (see Supplementary Material for the full questionnaire).

In Asia, the highest proportion of responses (36 per cent) suggested that management needs were recognised, but no action was being planned. Bangladesh, Myanmar, Nepal and Pakistan were identified as having the highest need to move actions into the planning and implementation phase. South America reported low scores in site management; 19 per cent of the questions were scored as zero, compared with 5 per cent in Asia, with a zero-score indicating that specific management interventions have not been considered.

Strengths and weaknesses of river dolphin site management

The eight pillars (Figure 2) provided valuable insight into the strengths or weaknesses of site management across the countries taking part in the survey (Table 2).

Pillar 1: Conservation needs, design and site designation

Across all sites, questions relating to conservation needs, design and site designation scored 56 per cent. There was considerable variability among sites, with some scoring very well, such as Cambodia and China (above 90 per cent), but none scoring below 40 per cent.

Most of the sites recognise river dolphins as a conservation priority. However, ten sites in South America reported that river dolphins are not recognised as priority targets for conservation in those sites, and thus are not included in their management plans. The lowest scoring question in this section related to how well the site is integrated within the management of the entire basin. Only Chinese sites have addressed this concern minimally.

Pillar 2: Management planning and capacity

Site managers need capacity in terms of resources and staff to develop management plans that are designed to meet conservation objectives. There was a huge variation in the average scores per country for this pillar – from 20 per cent to 95 per cent. When asked if they have capacity for river dolphin management, 63 per cent of the responses from the Asia sites noted the need for action was recognised but no action initiated. These are almost all sites outside Cambodia, China and Indonesia. The responses from South America were quite different. In general, the responses to these questions were higher in South America (55 per cent) than in Asia (48 per cent). However, when asked about the site having a management plan that sets out priorities, strategies and actions for river dolphins, the pattern of responses between continents was reversed.

Pillar 3: Financial systems and funding

Raising and managing funds is an important task for site managers. The responses per site for the two questions covering these issues averaged 51 per cent but the scores by country ranged from 25–100 per cent. The results showed that capacity varied from site to site: some sites possess the funding and also the capacity to manage funds, however, most do not. Sites in Bangladesh, Myanmar and Nepal in Asia, and Bolivia and Colombia in South America, reported that funding was inadequate.

Pillar 4: Human rights and equity

The responses to the questions regarding human rights and equity recorded on average 71 per cent; the highest ranking for all the pillars. This indicates that site management teams throughout the river dolphin range take into consideration the engagement of stakeholders such as the local communities when it comes to managing the site. South American countries recorded high scores (average 77 per cent) for this pillar. The three countries that reported the lowest average scores were Myanmar (48 per cent), Nepal (39 per cent) and Pakistan (48 per cent).

The question with the lowest score in this pillar was about benefit-sharing mechanisms (e.g. income from tourism-based dolphin watching) which was 44 per cent across all sites. Within four South American sites, the management teams reported that it was not applicable. In other places, for example in Peru, benefit-sharing is a

Table 2. River dolphin management score

Region	Country	No of sites	Average score (%) arranged in ascending order	Score for pillars as a percentage of maximum score							
				1 Conservation needs, design and designation of the site	2 Management Planning and Capacity	3 Financial Systems and Funding	4 Human rights and equity	5 Resource use (fishing, hunting, river transport)	6 Pressures (threats)	7 River dolphin and prey monitoring	8 Habitat and landscape approaches
Asia	Myanmar	2	36	40	20	31	48	40	38	31	41
	Bangladesh	6	37	46	28	44	58	37	23	38	22
	Nepal	1	44	58	35	25	39	45	64	50	38
	Pakistan	3	53	53	45	58	48	42	46	63	67
	Indonesia	1	81	75	60	63	93	85	94	100	81
	China	2	90	96	90	100	98	83	90	100	88
	Cambodia	1	93	96	95	88	82	85	91	88	94
South America	Bolivia	9	45	52	53	38	68	42	35	31	39
	Colombia	8	45	52	46	34	72	44	35	36	40
	Peru	7	65	57	66	80	93	74	45	43	63

major method to strengthen the buy-in for river dolphin conservation.

Pillars 5 and 6: Resource use (fishing, hunting, river transport) and Pressures (threats)
The average score per site was 42 per cent for management scores for threat mitigation, which was the lowest ranking of all the pillars. In Asia the lowest score was for actions to curtail threats from river transport (navigation) (27 per cent). South America scored lowest on monitoring and managing the health and mortality of river dolphins (4 per cent).

Pillar 7: River dolphin and prey population monitoring
Many sites are not conducting much river dolphin population related monitoring, with five sites not even monitoring population. The average score for Asia sites for this pillar was 69 per cent, (although five sites reported they were not monitoring population status) while the South America sites only averaged 25 per cent. Twenty-one out of the 24 South America sites reported they were either not considering monitoring or had plans to develop monitoring but these were not (yet) implemented.

Pillar 8: Habitat and landscape approaches
Management of freshwater is essential for preserving and/or repopulating river dolphin populations. The conservation or restoration of freshwater systems to maintain river dolphins had the highest score in this pillar (66 per cent), yet 45 per cent of the sites have not yet taken any action.

Most sites (55 per cent) indicated that they did not manage their local river dolphin population using a metapopulation approach. However, sites in China, Pakistan and Peru all show that they are managed as part of a broader species and metapopulation approach.

DISCUSSION

Freshwater biodiversity is declining far faster than in any other ecosystems, either marine or terrestrial (Collen et al., 2014; Costello, 2015), and populations of freshwater species have seen a global decline of 83 per cent (WWF, 2022). The survival of the river dolphin species relies on the management of freshwater PCAs. With the Kunming-Montreal Global Biodiversity Framework the world has committed to substantially increasing PCA coverage and establishment of habitat connectivity, including inland waters. But there are diverse and serious challenges that must be addressed for effective management of these areas for river dolphins.

The development of CA|RDS is an ideal opportunity for site managers to assess and improve their conservation status. Conservation Assured | Tiger Standards (CA|TS) (Conservation Assured, 2018) have proven to be extremely effective for the tiger sites, for example in Nepal (DNPWC, 2022).

Considering the severity of the threats reported in the CA|RDS Lite assessment, management actions are needed across both continents to ensure river dolphin populations are safeguarded. In general, results suggest that sites in South America have greater capacity while those in Asia had more robust management plans; the latter probably driven by the higher threats to river dolphins faced in the region.

South America and Asia sites differ significantly in their management implementation, prioritisation, and responsiveness to threats. In Asia, management investment is concentrated on dealing with the immediate threats posed by high human population density and increasing economic activity within the site. Conversely, in South America, managers have more scope to adopt a preventative approach since they face fewer anthropogenic threats currently, possibly because the habitat is widespread, so the range is greater compared to the Asian species which are more restricted in their distribution and range. Critically endangered (sub)populations seem to have the best conservation management or the most comprehensive set of ongoing activities for example in China and Cambodia.

Most site managers recognised the significance of actively engaging with stakeholders, such as local and Indigenous communities, which is a positive result derived through this survey. Coordination with stakeholders paves the way for effective site management and could potentially be connected with river dolphin population monitoring that could, for instance, be carried out through a citizen science approach.

The results however indicate some clear warning signs of serious concerns with regards to river dolphin management. The lowest scoring question in pillar 1 related to how well the site is integrated within the management of the entire basin, which is alarming considering the implications of external threats and that large dolphin populations occur outside the PCAs. In some cases, sites with high management scores have declining populations (for example Cambodia), possibly due to a history of conservation efforts focused on the most imperilled populations facing a crisis situation. In South America, protected areas were designated for other species and objectives, and river dolphins just 'happen to be there'. However, there is a need to recognise the role of PCAs in the conservation of the relevant river dolphin

Ganges River Dolphin, Bangladesh © Rezaul/UNDP

species to align with management actions and goals accordingly.

There are clear ways to progress. Areas that require immediate attention include population and threat monitoring, which is recognised as being of high importance but is often inadequate or lacking. A high score in engagement with stakeholders and communities is certainly an asset for all sites. It is critical that site managers continue to actively engage and coordinate with stakeholders who are involved in river dolphin conservation off-site. Extensive work is needed to address the challenge of mitigating threats, both current and projected future threats, which also requires more capacity and resources. Several sites also lacked river dolphin management actions in their management plan, and some do not even recognise the presence of river dolphins within their borders. In these cases, capacity building amongst staff will be an important priority.

All river dolphin sites reported here are connected to large river systems. River dolphin populations cannot be managed in isolation without considering external factors both upstream and downstream. Looking into the possibilities of habitat restoration and connectivity in and among critical sites to facilitate the growth of the population is essential given that the threats are becoming more intense over time.

The site-level scores held within the WWF database can also help prioritise conservation actions and guide policy makers. For example, sites can be divided into four categories below. Investment can then be prioritised in sites which contain river dolphin populations, and which fall into category D.

Category A: high scores and highly critical populations, intense threats

Category B: high scores and less critical populations

Category C: low scores and low threats/less critical population

Category D: low scores and important populations and high threats.

This CA|RDS Lite survey was restricted to only 40 out of a total of 119 PCAs with known river dolphin populations and it was carried out through self-assessment. Some of the sites that comprised a wide habitat range did not respond to the survey. This could have led to results being biased towards sites that may have had more institutional capacity and interest in the survey topic. Therefore, the results do not encapsulate the entire area that is home to river dolphins. Furthermore, there was no site-based validation of the survey responses. A full implementation of CA|RDS would provide more comprehensive insights based on independent reviews.

CONCLUSION

CA|RDS Lite is a rapid assessment that found that there is some level of active conservation attention and management for river dolphins across their ranges. However, the complete CA|RDS system is necessary to fully assess the quality of management implementation and improve effective river dolphin management.

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SUPPLEMENTARY ONLINE MATERIAL

CA|RDS Lite survey

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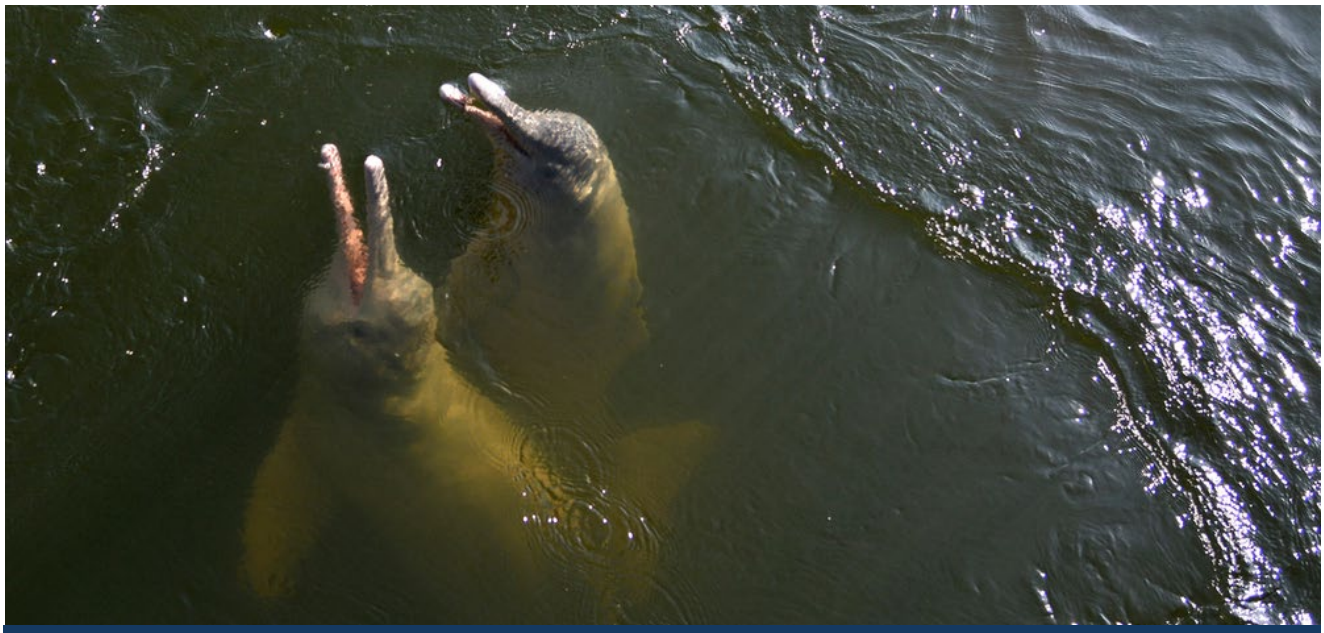

Amazon River Dolphin underwater © WWF Brazil/Andriano Gambarini

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RESUMEN

Este documento presenta la evaluación rápida inaugural de los hábitats de los delfines de río, coincidiendo con sitios gestionados en Asia y Sudamérica. Cubriendo las seis especies de delfines de río (incluyendo la única marsopa de agua dulce del mundo), cada una está clasificada como En Peligro o En Peligro Crítico en la Lista Roja de la UICN. Los Estándares para la Conservación Asegurada de los Delfines de Río (CA|RDS) ofrecen directrices a medida para la supervisión competente de las áreas protegidas para los delfines de río. La versión abreviada de los CA|RDS, denominada CA|RDS Lite, consiste en una encuesta basada en un cuestionario realizada por administradores y partes interesadas en 40 sitios de 10 de los 14 países del área de distribución del delfín de río. Ambos continentes se enfrentan al peligro de extinción del delfín de río debido a la pesca y al cambio climático. En Asia, los riesgos son más diversos, con poblaciones más pequeñas en comparación con América del Sur. La financiación y la capacidad de gestión insuficientes aparecen como obstáculos significativos. La colaboración inadecuada con áreas fuera de los límites de las áreas protegidas impide la gestión eficaz de las poblaciones de delfines de río. Resulta alentador que la encuesta destaque la participación activa de las comunidades locales y las partes interesadas en la gestión del sitio. CA|RDS Lite ofrece una visión rápida de la eficacia de la gestión de los sitios, señalando los requisitos cruciales de gestión y los sitios urgentes de delfines de río que requieren intervención. También prepara el terreno para la aplicación completa de las normas CA|RDS y su uso como instrumento de acreditación y gestión.

RÉSUMÉ

Cet article présente la première évaluation rapide des habitats des dauphins de rivière, qui coïncide avec des sites gérés en Asie et en Amérique du Sud. Couvrant les six espèces de dauphins de rivière (y compris le seul marsouin d'eau douce au monde), chacune est classée comme étant en danger ou en danger critique d'extinction sur la liste rouge de l'UICN. Les normes CA|RDS (Conservation Assured | River Dolphin Standards) offrent des lignes directrices sur mesure pour une surveillance efficace des zones protégées pour les dauphins de rivière. La version abrégée des CA|RDS, appelée CA|RDS Lite, implique une enquête par questionnaire menée par des gestionnaires et des parties prenantes sur 40 sites dans 10 des 14 pays de l'aire de répartition du dauphin de rivière. Sur les deux continents, les dauphins de rivière sont menacés par la pêche et le changement climatique. En Asie, les risques sont plus diversifiés, avec des populations plus petites qu'en Amérique du Sud. L'insuffisance des financements et des capacités de gestion constitue un obstacle majeur. Une collaboration inadéquate avec les zones situées en dehors des limites des aires protégées empêche une gestion efficace des populations de dauphins de rivière. Il est encourageant de constater que l'enquête met en évidence l'implication active des communautés locales et des parties prenantes dans la gestion des sites. CA|RDS Lite offre une vue d'ensemble rapide de l'efficacité de la gestion des sites, mettant en évidence les besoins cruciaux en matière de gestion et les sites de dauphins de rivière nécessitant une intervention urgente. Il prépare également le terrain pour l'application complète des normes CA|RDS et leur utilisation en tant qu'instrument d'accréditation et de gestion.

IDENTIFYING CONSERVATION VALUES: A CASE STUDY IN TRANS-HIMALAYAN REGION OF THANPATTAN, LAHAUL-SPITI, HIMACHAL PRADESH.

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ABSTRACT

The rugged topography, harsh climate and limited livelihood options have resulted in pastoralism being the predominant land use in the Himalayan landscape. To identify the most significant sites in this landscape, we employed the concept of 'High Conservation Value Areas' (HCVAs) in Thanpattan, one of the largest pastureland in Lahaul-Spiti. We have examined this region as a potential HCVA, providing information on biological diversity, pastoralism and related threats. The Gaddi community of Chamba and Bharmour districts relies on these pastures for their livelihoods, and several threatened flora and fauna species also call the area home. We found that Thanpattan fulfils all six criteria for HCVAs and is undoubtedly an HCVA due to its biodiversity values and the dependency of the indigenous communities on the region.

Key words: pastoralism, pastureland, Gaddi community, livestock grazing

INTRODUCTION

Mountainous areas have socio-economic, aesthetic and ecological significance, not only for the people living there but for those living beyond, especially those in the lowlands who benefit from its ecological services (Wester et al., 2019). The Himalayan ecosystem in India is of critical importance for its biodiversity and ecosystems. It also forms an important life-support system for many remote and agro-pastoral communities that depend on it (Ning et al., 2013). The Trans-Himalayan region spanning over 2.6 million km^2, including the Tibetan Plateau and the Tibetan marginal mountains, represents an ecosystem where major parts of the area have been utilised for traditional pastoralism and agro-pastoralism for several millennia (Handa, 1994; Schaller, 1998). This region also harbours wild herbivores, such as the Asiatic Ibex (*Capra sibirica*), Bharal (*Pseudois nayaur*) and predators such as the Snow Leopard (*Panthera uncia*), as well as a unique assemblage of medicinal and aromatic plants. However, these mountainous ecosystems are under severe threat due to the high dependence of local communities. In the Himachal landscape, large tracts of the mountains are heavily grazed by livestock adversely impacting the wild prey population even within the protected areas (Bhatnagar et al., 2008; Suryavanshi et al., 2013). Domesticated herbivores at high densities remove significant quantities of forage (Namgail et al., 2007) and cause inter-specific competition with wild ungulates leading to further decline in their population (Ghoshal, 2017). Negative interaction with humans involving carnivore species like Snow Leopard and Tibetan Wolf (*Canis lupus*) has been reported in the Trans-Himalayan landscape, mainly due to the damage they cause to domestic livestock (Fox et al., 1988; Mallon, 1988; Oli et al., 1994).

Considering the threats prevalent in such a rich yet fragile ecosystem, identification of high conservation value areas (HCVAs) in these vast landscapes is necessary. The HCVA approach demarcates areas based on six criteria, namely species diversity, landscape-level ecosystems, ecosystems and habitats, ecosystem services, community needs and cultural values (Brown et al., 2013). High conservation value (HCV) as a concept focuses on the conservation of biodiversity in its entirety instead of directing all efforts towards conservation of

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one species. This study helps understand the biodiversity values as well as the potential threats prevalent in the region. The HCVA approach is designed to maintain or enhance environmental and social values in production landscapes. The HCVA encompasses regions that are crucial due to their significant ecological, biological, social or cultural significance, as stated by Areendran et al. (2020). The HCVA theory and its evaluation focus on a few critical attributes such as ecological and socio-economic factors (Jennings & Jarvie, 2003) and offer a framework that can be employed by policymakers, landscape conservation planners, conservationists and forest managers (Ibie et al., 2016). This concept can be applied across various ecosystems. HCVAs not only target biodiversity value but also human values, in the form of identifying areas crucial for local communities in a region (HCV 5), as well as the cultural values (HCV 6) of a region. Thus, it involves a continuous process of stakeholder consultation throughout the identification, monitoring and management phases, resulting in a comprehensive outcome (Brown et al., 2013).

In this study we have attempted to identify values and important areas without the need for a resource-intensive study by using few criteria and limited data generated from a questionnaire survey of local communities and rapid surveys across the region.

The study had two objectives (1) to assess the biodiversity values and evaluate the region's potential for HCVAs based on known HCVA criteria and (2) to identify the primary threats in the pastoral landscape.

STUDY AREA

The study was carried out in the Thanpattan pastureland, which spans approximately 570 km² and is located in the Lahaul Valley of Lahaul-Spiti district in Himachal Pradesh (Figure 1). The Lahaul-Spiti district is situated between the Pir Panjal ranges of the Greater Himalayas and the Trans-Himalayas (Aswal & Mehrotra, 1994), covering an area of around 6,700 km². The climate in this region ranges from dry temperate to alpine, and the area is snow-covered for approximately six months each year. The temperature ranges from -19° to 32° C, and the region receives an average snowfall and rainfall of 120–400 cm and 10–300 mm per year, respectively. The landscape is characterised by high, steep and undulating terrain and diverse land cover types, such as coniferous forests, alpine and subalpine vegetation, grasslands and agricultural land (Joshi et al., 2006). The mammalian fauna in the area includes Snow Leopard, Asiatic Ibex and Musk Deer (*Moschus* sp.). The local communities in the area are predominantly Hindus and Buddhists who depend on local biodiversity for subsistence. Agriculture and pastoralism are the primary

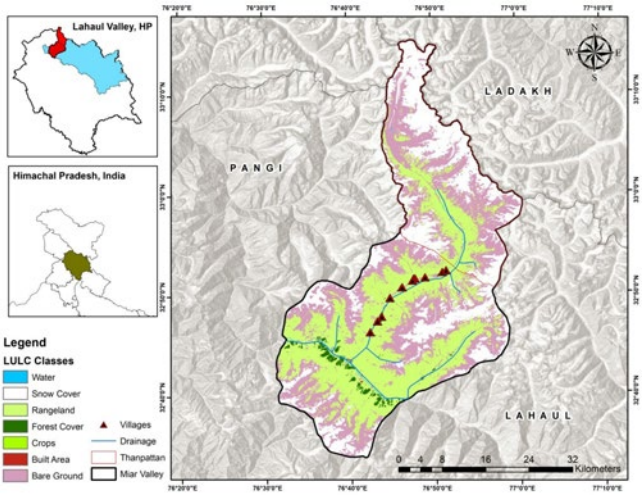


Figure 1. Study Area: Thanpattan pastureland in Miar Valley, Lahaul-Spiti district, H.P.

livelihood activities, with two types of livestock in the Lahaul Valley: non-migratory domestic animals kept by residents in permanent villages in the lower hills, and migratory transhumant herding groups of Gaddi communities, primarily from Chamba and Bharmour districts, who visit the pastures of the valley to graze their livestock at higher elevations during the summer season.

METHODS

Thanpattan is one of the largest known grazing land in the district of Lahaul-Spiti, as well as the state of Himachal Pradesh, however very few studies relate to the area (Dev et al., 2005; Dev et al., 2009). We aimed to evaluate the conservation value of the landscape by utilising the HCVA approach, which considers important aspects of biodiversity conservation. We employed two tools, namely stakeholder consultations through questionnaire surveys and field surveys to validate available environmental data.

Rationale and approach for assessment of the HCVs

Identification and maintenance of the high conservation values (HCVs) of a landscape or a region is the main concept of HCVAs; it encompasses exceptional or critical ecological/biological attributes, ecosystem services and social as well as cultural values (Table 1) (Jennings, 2004). The first three HCV categories, HCV 1: species and diversity, HCV 2: landscape-level ecosystems and HCV 3: rare, endangered and threatened ecosystems and habitat, focus on the ecological and biodiversity values of utmost importance; HCV 4: ecosystem services, focuses on the supporting and regulating services; HCV 5: community needs and HCV 6: cultural values, these criteria emphasise the importance of basic needs of the local communities which might be dependent on the area, as well as the cultural beliefs of the indigenous community.

Table 1 Description of the six HCV criteria used in the current study (from Jennings, 2004)

HCV criteria	Description
HCV 1	Species and Diversity: Regions/areas containing globally, regionally or nationally significant concentrations of biodiversity values. In the current scope of study, the following has been considered as HCV 1: • A high overall species occurrence or diversity within a defined area. • Sites supporting rich biodiversity of high value medicinal and aromatic plants in the landscape.
HCV 2	Landscape-level Ecosystems: Areas with large landscape or ecosystems that are sufficiently large and relatively undisturbed, enough to support viable populations of the naturally occurring species. The following rules have been adapted and considered as HCV 2: • Large areas that are relatively far from human settlement, roads or other access. • Areas that form or are part of a linkage between larger forest/meadow complexes and can thus provide connectivity between fragments for the movement of animals from one complex to another.
HCV 3	Rare, Endangered and Threatened Ecosystem and Habitat: Areas with rare, threatened or endangered ecosystems or habitat. The following rules have been adapted from Jennings & Jarvie (2003) & Brown et al. (2013), and considered as HCV 3: • Naturally rare ecosystems, facing higher risk of extinction and heavy dependency of local communities that may have decreased or would lead to decline in their extent in near future.
HCV 4	Ecosystem Services: Areas which are providing supporting and regulating ecosystem services that are necessary like protection of water catchments and control of erosion. The following rules have been adapted from Jennings & Jarvie (2003), Brown et al. (2013) and considered as HCV 4: • Forests/Meadows that are necessary for maintaining terrain stability and controlling erosion. • Areas providing supporting & regulating services in the form of water catchments & alpine meadows.
HCV 5	Community Needs: Areas with sites and resources fundamental for satisfying the necessities of local communities or Indigenous people. The following rules have been adapted from Brown et al. (2013) & the HCVF Toolkit Bulgaria (2016), and considered as HCV 5: • Areas where livestock raising is done on a small or subsistence scale and there is a presence of permanent or nomadic pastoralists grazing their livestock. • An area from where local communities obtain essential fuelwood, food, fodder, medicines (medicinal and aromatic plants) or building materials.
HCV 6	Cultural Values: Areas with sites, resources, habitats and landscapes of global or national cultural, historical significance, or religious/sacred importance for the traditional cultures of local communities. The following rules have been adapted from Brown et al. (2013) and considered as HCV 6: • Sites recognised as having a high cultural value for the local communities of the region. • Sites with official designation by the national government and/or an international agency like Archaeological Survey of India/UNESCO. • Religious or sacred sites with recognised and important historical or cultural values or that have importance to local or Indigenous people like sacred groves, monastery and/or sacred lake.

Literature review

To gain insights into the ecological and biological diversity of the landscape, we conducted a literature review related to biodiversity in the Trans-Himalayas and north-west Himalayas, as well as the concept of high conservation value (HCV) forests/areas. We searched for keywords such as the Trans-Himalayan landscape, north-west Himalayas, Lahaul Valley, Thanpattan pastureland, HCVAs, biodiversity and conservation. We used data from grey literature that had been collected through standard methods such as species distribution modelling and quadrat vegetation sampling.

Questionnaire survey

To collect data for the study, group discussion sessions were organised, and a semi-structured open-ended questionnaire (Supplementary Online Material 1) was used to gather information. The Thanpattan pastureland is part of the Miar Valley located in the northernmost part of the valley, and 14 villages were identified for the study. Of these, 11 villages were sampled for the group discussion sessions (Supplementary Online Material 2). On average there were 12 participants per session , with representation of varying socio-economic statuses. The exclusion of some areas from the study was due to either a small village population or the unavailability of informants during the survey. A total of 129 informants

Table 2 Criteria used to determine the potential range of various species in the landscape

Species name	Elevation	Habitat type
Himalayan Musk Deer	2800–3800 m	Alpine scrubs & forested areas > 2800 m
Himalayan Brown Bear	3000–4000 m	Sub-alpine and alpine areas
Asiatic Black Bear	1200–3000 m	Open forested areas
Asiatic Ibex	3200–5400 m	Slope >30 degrees, rugged terrains, cliffs
Snow Leopard	3200–5400 m	Alpine regions & snow bound areas

participated in the discussion sessions, representing 129 households. In the sampled villages, a total of 251 households were recorded.

The categories of respondents interviewed included Forest Department officials, livestock herders, former hunters, medicinal plant collectors, tourist guides and community-based organisations such as youth groups and local women's groups. The questionnaire focused on gathering information on wildlife presence in the landscape, human–wildlife interaction, associated impacts, and the dependency of local people on natural resources. To understand the distribution and presence of different plant species of value to communities and biodiversity, a questionnaire-based survey was conducted with key informants, including medicinal plant collectors/cultivators, Forest Department officials, and herbal healers known locally as amchis. The presence of various mammalian species was confirmed by the respondents using pictorial guides (Menon, 2014; Prater, 1965), which showed images of different carnivore and mountain ungulate species that occur in the landscape.

Field validation

To validate and verify the biodiversity values of the Thanpattan pastureland in Miar Valley, a field visit was conducted. The entire study area was surveyed systematically, and rapid surveys were performed to cover maximum areas. Expert knowledge from local informants, encounter trails, interview-based data collection, and available published or grey literature were utilised during the surveys. The presence or absence of different medicinal and aromatic plants was assessed by recording the species present in the region, taking photographic records and collecting plant samples for identification.

A combination of direct and indirect methods was used to understand the distribution of mammalian species, where indirect evidence such as animal faeces (pellet groups, scats, droppings) and tracks (pug marks, hoof marks, scrapes) were recorded, and direct sightings of animals were also observed. Thirteen trails, each approximately 1 km in length, were surveyed in Thanpattan (Supplementary Online Material 3).

Distribution mapping of the mammalian species: To understand the distribution and habitat utilisation of various mammalian species present in the region, rule-based maps for some selected species in the landscape such as Snow Leopard, Asiatic Ibex, Asiatic Black Bear (*Ursus thibetanus*), Tibetan Wolf (*Canis lupus*), Musk Deer and Himalayan Brown Bear (*Ursus arctos*) were prepared. These maps were generated based on factors such as elevation range, slope, land use land cover (LULC), aspect and preferred habitat type for each species, drawing upon information from previous studies (Bhatnagar et al., 2008; Fox et al., 1992; Ghoshal, 2017; Sathyakumar, 2001; Sathyakumar et al., 2015) (Table 2) (Supplementary Online Material 4).

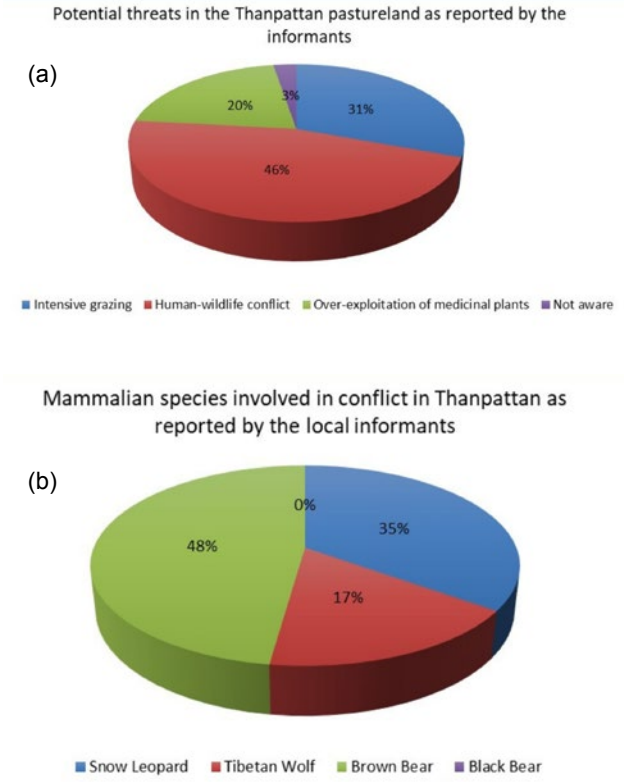


Figure 2 Pie chart representing (a) percentage of potential threats in the pastureland as reported by the informants, and (b) percentage of different mammalian species involved in conflict in the landscape. A total of 129 participants representing 129 households in the valley were consulted, and in the villages sampled for the study, a total of 251 households were recorded in the valley.

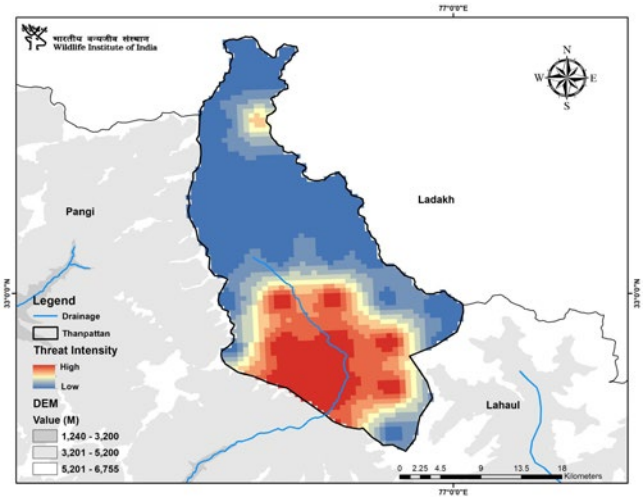


Figure 3. Threat intensity map of the Thanpattan pastureland extrapolated based on threats identified in the landscape. Intensity refers to the severity of the threat. Intensity for human–wildlife conflict has been assessed on the basis of the number of species involved in conflict in the area, and for over-exploitation of medicinal plants, it has been assessed by surveying areas rich with medicinal plants and the most exploited regions for either personal use or trade respectively. For grazing it has been assessed on the number of livestock visiting the pastures as per the consultation with the local community and the Forest Department officials.

Threat evaluation

To evaluate the level of threats in the Thanpattan pastureland, information was gathered on the type and severity of threats such as human–wildlife conflicts, overgrazing and resource exploitation. The study population consisted of local and migratory herders, medicinal plant collectors, residents and Forest Department officials (Figure 2, Supplementary Online Material 5). The intensity of human–wildlife conflicts was assessed based on the number of species involved in conflicts in the area, while the over-exploitation of medicinal plants was evaluated by surveying areas rich in medicinal plants and identifying the most exploited regions for personal use or trade. Grazing pressure was estimated by consulting with the local community and Forest Department officials on the number of livestock visiting the pastures.

To map the threats in the Thanpattan pastureland, grids of 5 x 5 km size were generated along with their respective centroids. The centroids were assigned numeric values based on the intensity of threats, which were rated on three levels – high, medium and low, or as no data. The rating was done in consultation with key informants. To calculate the threat level in the landscape, the Kernel density tool was used with an output raster cell size of 500 x 500 m, and the relative threat level attribute was used as the weighting function (Figure 3).

RESULTS AND DISCUSSION

Biodiversity values in the landscape

Lahaul is home to a diverse range of 23 mammal species, of which six are considered threatened, with two species classified as vulnerable (VU), one as critically endangered (CR), two as endangered (EN) and one as near threatened (NT) (Joshi et al., 2020). Among the notable species found in this region are predators such as the Snow Leopard, Himalayan Brown Bear, Tibetan Wolf and Himalayan Red Fox, as well as herbivores like the Asiatic Ibex and Himalayan Musk Deer. The Thanpattan pastures are located in close proximity to the Sechu Tuan Wildlife Sanctuary of Pangi, Chamba, and the Union territory of Ladakh, serving as a crucial corridor for species with extensive range requirements. This area plays a vital role in maintaining connectivity and home ranges for the Snow Leopard and other key species within the landscape. Prominent avifaunal species and medicinal plants found in the region have been listed in Table 3.

Migratory herders of Thanpattan valley – the Gaddi community

In northern and western regions of India, seasonal and migratory pastoralism is a common practice among transhumant tribes who typically graze their livestock, mainly sheep and goats, in higher altitudes of alpine ranges during the summer months (Bhasin, 2011; Saberwal, 1996). The Gaddi community, comprising over 100,000 people, have a long-standing tradition of practising transhumant pastoralism in the Himalayan region of Himachal Pradesh, where they move up to alpine pastures during the summer and descend to lower

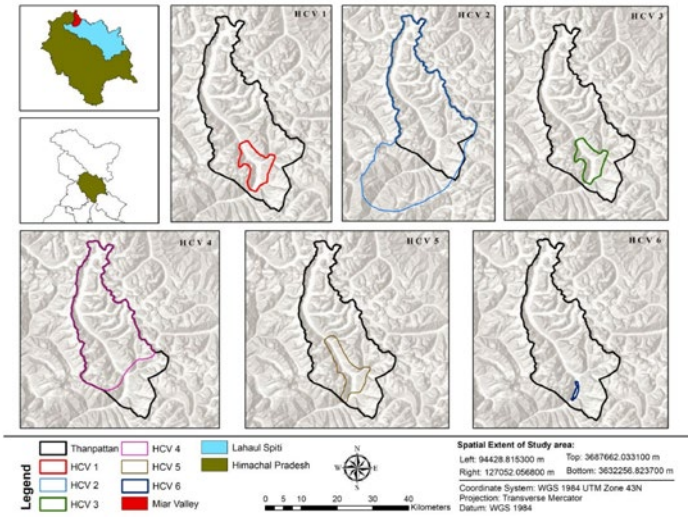


Figure 4. Map representation of various potential HCV areas as identified in the Thanpattan – Miar Valley of the Lahaul Valley, Himachal Pradesh

Table 3 The biodiversity and socio-cultural values associated with the pastureland of Thanpattan as per the six HCV criteria

HCV criteria	Description
HCV1 – Species and Diversity	1. Faunal species, as reported by key informants, in the area are Snow Leopard, Asiatic Ibex, Himalayan Musk Deer, Himalayan Brown Bear, Tibetan Wolf, and Royle's Pika. 2. A few of the important medicinal plant species recorded in the area are *Picrorhiza kurroa*, *Meconopsis betonicifolia, Aconitum violaceum, Betula utilis, Caragana sp., Aconitum heterophyllum, Rheum sp., Podophyllum hexandrum* and *Zurinea dolomiaea.* 3. *Alectoris chukar* (Chukar), *Tetraogallus himalayensis* (Himalayan Snowcock), C*uculus canorus* (Common Cuckoo), *Pyrrhocorax pyrrhocorax* (Red-billed Chough), *Pyrrhocorax graculus* (Yellow-billed Chough), *Eremophila alpestris* (Horned Lark), *Troglodytes troglodytes* (Eurasian Wren), *Cinclus cinclus* (White-throated Dipper), *Phoenicurus leucocephalu* (White-capped Redstart), *Phoenicurus ochruros* (Black Redstart) and *Motacilla citreola* (Citrine Wagtail) are a few of the avifaunal species reported from the region (Ebird, 2018).
HCV2 – Large Landscape-level Ecosystems	1. Thanpattan pastureland lies in the northern extent of the Miar valley, far from human settlement and roads. Khanjar village is the last village of the Miar valley near Thanpattan. 2. The valley shares its boundary with Sechu Tuan Wildlife Sanctuary of the Pangi valley on the western boundary and pastures of Pattan valley (Lahaul valley) on the eastern boundary, and Ladakh in the north and is critical for maintaining connectivity of home ranges for Snow Leopard and associated key prey species.
HCV3 – Ecosystem and Habitat	1. As the region lies adjacent to the Sechu Tuan Wildlife Sanctuary, it is important from an ecosystem and habitat viewpoint as well, as it serves as a habitat for top-predator species including threatened species like Snow Leopard and Himalayan Brown Bear. 2. The large areas of sub-alpine scrubs and forested tracts surrounding the region serve as a habitat for wild-prey species including an endangered species i.e., Himalayan Musk Deer & the undulated terrain supports substantial populations of Asiatic Ibex.
HCV4 – Ecosystem Services	1. In Thanpattan, near Zardong, amidst the meadows lies a grove of around 100 Betula utilis trees. The vast alpine meadows and the sub-alpine scrubs of the pastureland assist in prevention of natural hazards (floods and landslides) and help in carbon sequestration and storage in biomass and soil. 2. Forested areas help in regulating the flow of water within a catchment, prevent soil erosion and provide natural resources (e.g., fodder plants) for energy production and construction. 3. The alpine meadows and the forested patch of the region provide biodiversity values as well as ecosystem services in the form of supporting and regulating services.
HCV5 – Community Needs	1. The resident livestock herders of the adjoining Miar valley, utilise the southern part of the pastureland to graze their livestock in the summer season. 2. Thanpattan, being the largest grazing patch of Lahaul valley, is an area of high importance for herders of the Gaddi community of Chamba and Bharmour districts, who are highly dependent on the pastures for grazing their livestock for two to three months in the summer season. 3. For each herder of the Gaddi community visiting the pastures of Thanpattan during the summers, these grazing permits are issued by the Forest Department for a span of three years.
HCV6 – Cultural Values	1. The demarcated area in the Thanpattan pastureland has a *Gompa* which is of religious significance for the local community of the valley. 2. It is believed by the locals that before entering the pastureland they must pay their respect at this *Gompa* for a safe journey.

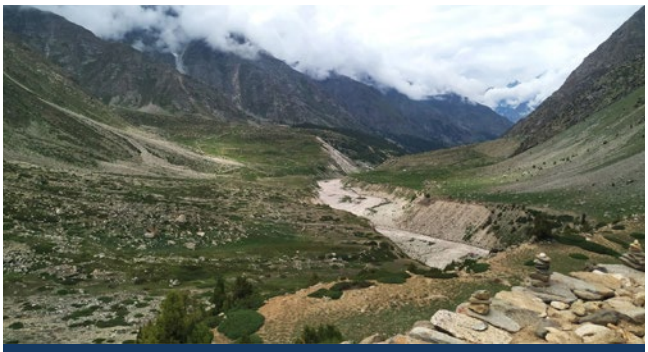
elevations in the winter due to snow cover at higher altitudes (John & Badoni, 2013; Saberwal, 1996). The Thanpattan region is of great significance to the local livestock herders and Gaddi communities of the Chamba and Bharmour districts. The grazing rights were given by British officials to the herders in the 1870s. These rights to pastureland were formalised by issuing grazing permits to the communities (John & Badoni, 2013). For each herder of the Gaddi community visiting the pastures of Thanpattan during the summers, these grazing permits are issued by the Forest Department for three years. The grazing area of the Gaddi community is spread over three ecological zones, with distinct pasture types: subtropical grazing of the lower hills; sub-temperate pastures of the middle hills; and alpine pastures of the high hills (Bhasin, 2011). It is an important source of revenue in the case of the high-altitude ranges of the Himalayas. The land revenue generated as grazing dues is collected from the Gaddi community, and its collection has been entrusted to the Forest Department since 1953 (Pandey, 1991) (Supplementary Online Material 6). The Gaddi community's herders typically use the pastures at lower elevations for around one month before moving up to the adjacent area. The intensive grazing has an impact on the availability and depletion of medicinal plants in the region, but herders also gather rare medicinal plants from the alpine pastures and distant forests. While high-value medicinal and aromatic plants are mainly extracted from the valley for marketing, a portion is also kept for personal consumption (Bhasin, 2011).

Thanpattan as an HCVA

Thanpattan, in Miar Valley is a pastureland of high importance in the district of Lahaul-Spiti, as well as the state of Himachal Pradesh (Dev et al., 2005). The area was assessed against the six HCVA criteria and fits all six. The associated value of the pastureland for each high conservation value category is outlined in Table 3 with the approximate distribution of each given in Figure 4.

Potential threats and challenges

Livestock grazing: The Gaddi community's herders use Thanpattan's pastures for grazing their livestock during the summer season, typically for two to three months. The Forest Department issues grazing permits to these herders, but according to key informants, the number of livestock allowed on each permit often exceeds the permissible limit. This overstocking not only compromises herd production, but also causes weed invasion, rangeland degradation and undermines conservation efforts in areas where livestock and wildlife coexist (Mishra et al., 2001; Tyagi & Singh, 1988).



The landscape of rangeland of Thanpattan © Dharani M

Livestock trends in the Thanpattan pastures also suggest that selective grazing and overstocking are leading to competition for limited resources and the depletion of palatable forage available for wild ungulates. Furthermore, intensive grazing by domestic livestock is causing the destruction of high-value medicinal plants. In the cold deserts of the Trans-Himalayas, domestic livestock is known to deplete the density and diversity of wild herbivores by imposing resource limitations and competitive exclusion of the species (Bagchi et al., 2004). Thirty-one per cent of the total respondents interviewed also identified intensive grazing as an issue in the landscape.

Identifying areas of high conservation value assists in identifying the regions being used the most for grazing, and sensitive regions can be protected to allow regeneration. This information is crucial for taking steps to revive the region and also for yielding information about areas that must not be disturbed by anthropogenic activities.

Disease transmission: As reported by key informants, the presence of transhumant tribes in the region has led to a higher likelihood of contact between domestic and wild animals, resulting in the spread of diseases from domestic livestock to wild ungulates in the valley. This transmission of diseases between wild and domestic animals has become a growing concern over time (Gortázar et al., 2007; Johnsingh et al., 1999).

Human–wildlife conflict: is an inevitable issue that arises from coexistence between wildlife and humans in the same region, and is exacerbated when wildlife is deprived of its natural habitat due to anthropogenic disturbances (Bhatnagar et al., 2008). According to forty-six per cent of the informants, human–wildlife conflict is a pressing issue in the landscape, with livestock depredation by large carnivores, Himalayan Brown Bears and Snow Leopards being the most common.

Over-exploitation of medicinal and aromatic plants: is also a critical issue in the study area, with 20 per cent of respondents reporting it as a concern. This pressure on medicinal plants has increased due to commercialisation

Gaddi herder © Shiv Kumar

and rising demand in the market, driven by the growing human population (Maikhuri et al., 2003). The herders of the region are known to extract medicinal plants from the alpine pastures of Thanpattan and adjoining forests of the valley (Bhasin, 2011). However, premature harvesting of rare and endangered therapeutic medicinal and aromatic plants by both local and migratory herders and outsiders, as well as excessive grazing pressure in high altitude rangelands of Thanpattan, threatens the survival of these species in parts of the region.

CONCLUSION

The high conservation value concept stresses the importance of involving local stakeholders in both the process and systematic survey of proposed sites, as well as making them an integral part of the decision-making process to facilitate participatory management. Thanpattan satisfies all six criteria of HCVAs, making it an area of significant importance for biodiversity values and the dependency of Indigenous communities, particularly the Gaddi community, on the region. Identifying such HCVAs is essential for more innovative and inclusive conservation, including other effective area-based conservation measures (OECMs), and for working towards the Kunming-Montreal Global Biodiversity Framework. Identifying such areas can be useful in fulfilling both the country's and global targets for 30 by 30 (Target 3) that aims for 30 per cent of the world's terrestrial, inland water, and coastal and marine areas to be effectively conserved by 2030 through the systems of protected areas and OECMs.

However, anthropogenic activities have increased pressure on pastures, causing damage to biodiversity and the livelihood of herders. Training forest officials and local communities on new fronts like wildlife monitoring, wildlife law, and legislation is needed to mitigate these pressures. Additionally, implementing pastureland management schemes like demarcation of areas for livestock grazing within the pastures of Thanpattan would avoid competition, regulate pastureland degradation, and prevent the spread of diseases between livestock and ungulates. Medical camps near entry points for the Gaddi community could help with disease surveillance. Achieving primary conservation goals of managing human–wildlife conflict and regulating livestock grazing and resource-use would only be possible with the active participation of the Forest Department and development of a suitable conservation plan.

Although stakeholder consultations were conducted and surveys were carried out in the landscape, there are some limitations to our data because of the inaccessibility of the landscape for most of the year and the small datasets for highly elusive species like the Snow Leopard. Although our study identified connectivity between various areas and regions that species with large home ranges could use, we could not determine the specific wildlife corridors used by species. Despite these caveats, our research reveals that the landscape supports numerous threatened species, and we have identified the intensity of threats in the proposed HCVAs. To plan rangeland management actions for domestic livestock and wild herbivores, we suggest conducting a detailed study and assessment on grazing impacts and their control. We did identify potential areas under HCV 4 – ecosystem services but lacked the data required to properly quantify the areas.

SUPPLEMENTARY ONLINE MATERIAL

1. Questionnaire
2. List of villages where surveys were conducted
3. Map of Thanpattan pastureland showing survey effort
4. Rule-based distribution maps for the selected mammalian species for Thanpattan, Miar Valley, Lahaul.
5. Threats reported for each village
6. Revenue collected and migratory livestock recorded in Lahaul Valley, Himachal Pradesh

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Khanjar Village in Miar Valley of Lahaul Tehsil is the last village in the valley, after this the pastureland of Thanpattan starts © Dharani M

RESUMEN

La accidentada topografía, la dureza del clima y las limitadas opciones de subsistencia han dado lugar a que el pastoreo sea el uso predominante de la tierra en el paisaje del Himalaya. Para identificar los lugares más significativos de este paisaje, hemos empleado el concepto de "Áreas de Alto Valor de Conservación" (AAVC) en Thanpattan, el mayor pastizal de Lahaul-Spiti. Hemos examinado esta región como un AVC potencial, proporcionando información sobre la diversidad biológica, el pastoreo y las amenazas relacionadas. La comunidad Gaddi de los distritos de Chamba y Bharmour depende de estos pastos para su subsistencia, y varias especies amenazadas de flora y fauna también tienen su hogar en la zona. Descubrimos que Thanpattan cumple los seis criterios de los AVC y es sin duda un AVC debido a sus valores de biodiversidad y a la dependencia de las comunidades indígenas de la región.

RÉSUMÉ

La topographie accidentée, le climat rigoureux et les moyens de subsistance limités ont fait du pastoralisme l'utilisation prédominante des terres dans le paysage himalayen. Pour identifier les sites les plus importants de ce paysage, nous avons utilisé le concept de "zones à haute valeur de conservation" (HCVA) à Thanpattan, le plus grand pâturage de Lahaul-Spiti. Nous avons examiné cette région comme une HCVA potentielle, en fournissant des informations sur la diversité biologique, le pastoralisme et les menaces qui y sont liées. La communauté Gaddi des districts de Chamba et de Bharmour dépend de ces pâturages pour sa subsistance, et plusieurs espèces de flore et de faune menacées ont également élu domicile dans la région. Nous avons constaté que Thanpattan remplit les six critères d'une HCVA et qu'il s'agit sans aucun doute d'une HCVA en raison de la valeur de sa biodiversité et de la dépendance des communautés indigènes à l'égard de la région.

THE VALUE OF NATURAL CAPITAL IN CANADA'S NATIONAL PARKS AND NATIONAL MARINE CONSERVATION AREAS

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ABSTRACT

Growing attention is being given to protected areas and the ability of their natural capital assets to provide a varied and long-term stream of benefits to individuals and society in general. These areas are often heralded for ensuring natural capital assets persist, but value is often limited to the economic impact of visitor expenditures and the associated effects on regional and national economies. Few studies have attempted to quantify the economic value of natural capital assets in protected areas, especially in Canada. This study uses a benefit transfer approach to produce an initial estimate of the potential economic value of ecosystem services and natural capital associated with the terrestrial and marine environments in Canada's federal system of national parks and national marine conservation areas. The results suggest that the economic value of these assets ranges between CA$ 156 billion and CA$ 588 billion annually.

Key words: protected areas, ecosystem services, benefits transfer.

INTRODUCTION

Thirty years ago, Costanza and Daly (1992) used the term natural capital to define stocks of natural assets, such as forests and water bodies, that provide a future flow of goods and services. The authors advanced the positions that the maintenance of the Earth's total natural capital at current levels was a necessary minimum condition of sustainability, and that growth cannot be indefinitely sustainable on a finite planet. Their subsequent study (Costanza et al., 1997) resulted in the first known published estimate of the economic value of planetary ecosystem services, which in their words addressed a central problem: "*A large part of the contributions to human welfare by ecosystem services are of a purely public goods nature. They accrue directly to humans without passing through the money economy at all. In many cases people are not even aware of them*" (p. 257). The social benefit of planetary ecosystems services was estimated to be US$ 33 trillion per year; by contrast, the annual total global gross national product at the time was estimated at US$ 18 trillion. The authors argued that their valuation represented a starting point for further study and was intended to demonstrate the importance of ecosystem services and the potential impact to societal welfare if compromised. They further laid the groundwork for ecosystem service valuations in resource management decision making.

Since their early work, advancements have been made in understanding society's dependencies on natural capital assets, valuation methods, and their integration into societal decision making. The 2005 Millennium Ecosystem Assessment established scientific consensus that humans had extensively changed ecosystems in a short time span and if policy and practice do not bring about a change in human activities, nature's capacity to provide for the needs of future generations was at risk (M.E.A., 2005). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services found that while there has been a multifold increase in the global value of crop production and timber harvest since 1970, these gains have contributed to declines in essential regulatory and maintenance services (IPBES, 2019). Other major initiatives, including The Economics of Ecosystems and Biodiversity (TEEB, 2013), Wealth Accounting and the Valuation of Ecosystem Services (World Bank, 2021), The Economics of Biodiversity: The

10.2305/EKNN8645

Ivvavik National Park © Fritz Mueller, Parks Canada

Dasgupta Review (Dasgupta, 2021), and the Mapping and Assessment of Ecosystems and their Services (European Commission, 2021), have further explored the inherent problem in accounting for the intangible value of nature to human well-being.

In North America, Sutton et al. (2019) attempted to account for the total value of national parks in the contiguous United States by conducting a land cover analysis and benefits transfer method using the TEEB global database of ecosystem service values. The authors drew attention to the US$ 3 billion annual budget (2016) for national parks as being unable to address the deferred maintenance of built infrastructure of US$ 12 billion and as a public good having value beyond the US$ 32 billion contribution to the US economy and close to 300,000 local jobs. Using a benefits transfer approach, the authors estimated total annual ecosystem services at US$ 98.7 billion per year (from 7.7 million ha). The authors further posit that if the natural capital asset was managed like a built asset and the annual value of ecosystem services was used as a substitute for gross earned revenue, the annual budget for the US National Park Service would be in the order of US$ 27 billion (30 per cent of US$ 98 billion) (Sutton et al., 2019).

Early efforts in Canada to value ecosystem services of protected areas has been limited to case studies. As part of a federal government interdepartmental project on Measuring Ecosystem Goods and Services (MEGS), the ecosystem services for Thousand Islands National Park were estimated to be CA$ 14.7 million annually (2012 CAD) (Statistics Canada, 2013); Wilson (2012) estimated approximately CA$ 12.5 million annually (2011 CAD) in benefits from proposed land for Rouge National Urban Park. These two studies built on the work of Troy and Bagstad (2009) who used a land cover approach to apply monetary values for multiple regulatory and cultural services across landscapes in southern Ontario, included protected areas. Vogt, Troy and Johnson (2013) used artificial intelligence and standard value transfer analyses to estimate ecosystem services at several provincial parks in the Province of Ontario.

Early studies contributed to the growing body of knowledge surrounding natural capital in national parks and tested the use of remotely sensed land cover extent and a benefits transfer approach to produce valuation estimates. The concept of ecosystem services is a valuable tool for economic analysis and should not be discarded because of disagreements among economists and their assumptions regarding sustainability, justice and efficiency (Farley, 2012; Kadykalo et al., 2019; Schröter et al., 2014; Small et al., 2017). Many approaches for estimating ecosystem service value exist, but their appropriateness under specific conditions or logistical limitations are not uniform (Whitham et al., 2015). The land cover extent and value of ecosystem services from the Canadian network of federally protected areas has not been estimated to date and represents a knowledge gap. This study uses spatially explicit, remotely sensed

satellite data to understand the land cover extent of the natural capital asset and applies estimates of monetary value from other Canadian studies in similar landscape settings to transfer benefits. This paper represents a first effort to understand the extent and potential economic value of the ecosystem services and natural capital assets within Canada's system of national parks and marine conservation areas. This work can be regarded as a foundation upon which to build a natural capital appraisal programme in the future focused on asset extent, condition and economic value, and will help to further demonstrate the important contribution protected areas make to the well-being of Canadians.

Protected areas in Canada

Canada has 37 national parks, 10 national park reserves, one national urban park and five national marine conservation areas (collectively referred to as national parks and marine conservation areas or protected areas henceforth), protecting an area of terrestrial and marine/freshwater ecosystems approximately equivalent to the size of Sweden. This system protects and preserves the country's natural landscapes and marine areas for present and future generations, is representative of the country's ecosystems, and is managed according to the principle of ecological integrity. These protected areas are also an integral part of Canada's tourism industry. They attract millions of visitors annually, 25 million in 2019–2020 alone (Parks Canada, 2019), and visitor-related spending contributes approximately CA$ 3.0 billion to Canada's gross domestic product (Parks Canada, 2018). The natural environment is integral to the economic contribution earned by communities and governments, but no equivalent analysis of the value of their natural environment has been undertaken to date. A natural capital appraisal approach could make a significant contribution as Canada moves to establish new protected areas as part of the Government of Canada's commitment to protect 30 per cent of its lands and waters by 2030 (Government of Canada, 2021).

METHODS

This study uses a natural capital appraisal and benefits transfer approach (unit value transfer) to estimate the economic value of ecosystem services associated with federally administered national parks and national marine conservation areas in Canada. Natural capital appraisal is rooted in social cost-benefit analysis, the estimation of economic surplus, and is aligned with the natural capital approach as a way of conceptualising nature as a system of stocks, flows and services that benefit humanity (Faccioli et al., 2023). The methodology was also informed by environmental accounting efforts (King et al., 2022) and case studies in Dartmoor and Exmoor National Parks in England (Faccioli et al., 2023) and their efforts to measure stock extent and the creation of flow accounts using exchange and welfare values. However, no attempt is made in this study to link natural capital in protected areas to Canada's system of national economic accounts. Landsat satellite data were employed to determine asset extent, and ecosystem service values were taken from the scientific literature with applicability to the Canadian context, to produce initial estimates of the potential economic value of ecosystem services from Canadian protected areas. The study approach builds on earlier studies and is pragmatic in that it uses both market and non-market values from the literature to estimate the economic value of the natural capital asset.

To ensure consistency in geographic coverage and land cover classifications ('asset types'), satellite data were used to quantify land cover ('asset extent') in national parks and marine conservation areas. The Landsat data provide a consistent land cover to determine asset type and extent and allow for aggregation at the individual site level, administrative region or the system of protected areas. The most recent Landsat satellite data (2020 data; released publicly in 2023) at a 30-metre resolution were obtained from the Commission for Environmental Cooperation for the North American Land Change Monitoring System (NALCMS). The land cover data are among the higher spatial resolutions publicly available and are used extensively by governments and other organisations to inform environmental planning, wildlife habitat mapping and ecosystem monitoring (C.E.C., 2022). The 19 land cover classes in NALCMS are based on the Land Cover Classification System standard developed by the Food and Agriculture Organization of the United Nations.

A geographic information system was used to integrate a spatial area boundary layer of protected areas, available publicly from the Canadian Protected and Conserved Areas Database (CPCAD) (Government of Canada, 2022), with the land cover data from NALCMS. The digital boundary for each national park and marine conservation area was clipped to the NALCMS raster image, extracted in pixels, and converted to hectares by GIS specialists for accuracy and analysis. A total of 46,953,339 million hectares were extracted from across 53 federal protected areas. Total hectares by land cover type (14 in total were relevant) were converted for each protected area. The land cover types were aggregated to eight to help with interpretation and align with monetary values: barren lands, forested lands, grasslands, shrublands, water, wetlands, snow and ice, and marine.

Ecosystem service values (ESV) were assigned to the extent of each asset type in each protected area. The ideal scenario would be to assign monetary values to the ecosystem services associated with each land cover type from economic valuation studies of lands managed in Canada's protected areas. No known study to date has yielded values for ecosystem services for a system of protected areas under the jurisdiction of the Government of Canada, nor have similar studies been done for protected areas operated by other levels of government (e.g. provincial parks) that would provide sufficient national coverage in geographic scope and environmental diversity. To address this gap, a benefit transfer approach was employed to derive the value of ecosystem services for each land cover type. To be a valid transfer of benefits, the study site and the policy site must have similar ecosystem type, ecosystem service characteristics and contextual factors (Unai & Muradian, 2010).

Table 1 summarises the ESVs (CA$ per hectare per year) by land type or 'asset type' that were drawn from published literature with a priority placed on Canadian monetary values, where available, that were a best fit for similar land cover types present in NALCMS. ESVs were often not singular in nature, but were composed of a number of value estimates based on different services and valuation methods, a common artefact in this field of work. For example, ESVs for grasslands may include market pricing for such factors as agricultural products, replacement cost of global climate regulation, non-market values for erosion control, pollination services and biodiversity habitat. A single ESV for all asset types was not employed, as it was not deemed practical given the national scope of this study and diversity of protected areas.

Table 1 Ecosystem Service Values (ESV) employed by asset type

	ESV (CA$/hectare/year)		
Asset type	**Low**	**Medium**	**High**
Barren lands[1]	$6,896	$6,896	$6,896
Forests[2]	$4,557	$17,875	$31,193
Grasslands[3]	$1,219	$3,682	$6,144
Shrublands[4]	$564	$1,229	$1,894
Freshwater[5]	$154	$8,165	$16,175
Wetlands[6]	$3,767	$34,237	$64,705
Marine[7]	$3,411	$3,411	$3,411

Sources:
1 - Anielski & Wilson, 2010 (A)
2 - TD Bank Group and the Nature Conservancy of Canada, 2017 (B), Dupras et al., 2016 (C)
3 - B, C and Wilson, 2014. (D).
4 - D and A
5 - A and C
6 - C and D
7 - Costanza et al., 2014.

Multiple values for the same land type were identified in the literature, in some cases with significant range. ESVs for fresh water, for example, ranged from a high of CA$ 16,175 (2020 CAD) to a low of CA$ 154 (2020 CAD) per hectare. To address the variation in values, high, medium and low monetary values were identified. Where only two values were identified, a medium estimate was calculated as the average of the available values. Considering a range for a preliminary estimate is prudent as it is indicative of a level of uncertainty when estimating ESVs for such a large and diverse protected system. Best fit ESVs for all land cover types were identified from the literature except for snow and ice; no value could be identified for this asset. All values used were in Canadian dollars; where best fit values were in other currencies, they were converted to Canadian dollars (2020) to ensure consistency. The total annual value of ecosystem services was estimated by multiplying per hectare monetary values by total hectares of each land cover type (asset extent) in each of the 53 protected areas and then summed.

RESULTS

The natural environment protected in Canada's federal system of national parks and national marine conservation areas is diverse and extensive. Table 2 summarises the geographic extent and the estimated potential annual ecosystem services of the system by asset type. In terms of terrestrial area, barren lands comprised the largest acreage (9.164 million ha or 19.52 per cent) followed by forested lands (7.259 million ha or 15.46 per cent). Wetlands, an important natural environment for water retention and regulation, was among the smallest of the identified asset types; wetlands accounted for 2.533 million hectares (5.40 per cent) of natural assets. The marine component of the protected areas encompasses 12.248 million hectares and approximately 26 per cent of the total geographic area.

The potential economic value of the ecosystem services from Canada's national parks and national marine conservation areas is estimated to range from a low of CA$ 156 billion to a high of CA$ 588 billion annually, with a medium estimate of CA$ 372 billion annually. Forested lands represent the largest contributor. The large expanses of deciduous and coniferous forests that define many national parks had annual services valued at between CA$ 33 billion and CA$ 226 billion annually, with a medium estimate of approximately CA$ 130 billion (or approximately 35 per cent of annual

Table 2 Estimated total potential ESV by asset type

Asset type	Area		Total annual ESV** (CA$ billion/year)		
	Hectares (million)	%	Low estimate	Medium estimate	High estimate
Barren lands	9.164	19.52	$63	$63	$63
Forests	7.259	15.46	$33	$130	$226
Grasslands	5.283	11.25	$6	$19	$32
Shrublands	3.151	6.71	$2	$4	$6
Freshwater	3.341	7.12	$0.5	27	$54
Wetlands	2.533	5.39	$10	$87	$164
Marine	12.248	26.09	$42	$42	$42
Snow and ice*	3.972	8.46	$0	$0	$0
Total	**46.953**	**100**	**$156**	**$372**	**$588**

*No ESVs available; **in 2020 CAD

Table 3 Estimated total potential ESV by service type

Service	Annual ecosystem services (CA$ billion/year)		
	Low estimate	Medium estimate	High estimate
Climate regulation	$80	$94	$107
Habitat /refugia	$18	$89	$161
Nutrient cycling	$40	$47	$55
Waste treatment	$3	$34	$66
Disturbance regulation	$0	$29	$57
Water supply	$7	$26	$45
Water regulation	$0	$18	$35
Pollination	$1	$9	$18
Pest and disease control	$1	$9	$16
Gas regulation	$0	$6	$11
Erosion control	$1	$4	$8
Other	$5	$7	$9
Total	**$156**	**$372**	**$588**

services). Grassland environments had an annual service value at between CA$ 6 billion and CA$ 32 billion (medium estimate of approximately CA$ 19 billion). The three forms of water-related assets (freshwater, wetlands, marine) contributed between CA$ 53 billion and CA$ 260 billion in annual services, with marine environments representing 27 per cent (CA$ 42 billion; medium estimate) of the contribution.

When viewed through the lens of natural functions, Canada's federal protected areas contribute a diverse suite of services that have broader benefits to Canadians. Table 3 summarises the estimated total potential annual service by type. Approximately CA$ 94 billion (medium estimate) (25 per cent) of annual potential ecosystem services is associated with climate regulation, such as oxygen production, water vapour and carbon capture. Another CA$ 90 billion (24 per cent) is associated with wildlife habitat and refugia. The supply of fresh water through glacial and snowmelt runoff and the fluvial functions of lakes/rivers yielded CA$ 26 billion (medium estimate) (7 per cent) of the service functions. Other significant functions include waste treatment (CA$ 35 billion or 9 per cent), water supply (CA$ 26 billion or 7 per cent) and regulation of water levels (CA$ 18 billion or 5 per cent).

National parks and national marine conservation areas are as diverse as the landscapes they protect. Table 4 summarises annual potential total ecosystem service value for each of the protected areas by region of the country. Protected areas in Canada's north collectively have the largest overall valuation, with total ecosystem valuation estimated to range from a low of CA$ 125 billion to a high of CA$ 390 billion annually, with a medium estimate of CA$ 258 billion annually. In terms of individual areas, Wood Buffalo National Park is the largest terrestrial park with an area of approximately 4.56 million hectares, and protects large expanses of forested lands, shrublands and grasslands. It has the largest ecosystem valuation of the protected areas studied (a range of between CA$ 14 billion and CA$ 148 billion annually or CA$ 3,070 to CA$ 32,456 per hectare). By comparison, Point Pelee National Park is among the smallest of Canada's national parks. Comprised mainly of forests and wetlands, it sits within critical North American bird and Monarch Butterfly migratory routes at Canada's most southerly latitude. With a studied land area of only 1,515 hectares, Point Pelee National Park has an estimated ecosystem valuation of between CA$ 5 million and CA$ 41 million annually (CA$ 3,300 to CA$ 27,063 per hectare). These two ecologically diverse parks are equally rich in ecosystem services, despite their differences in size, geography and assets.

Table 4 Estimated total potential ESV by protected area*

	Area	Natural Asset (% of hectare)							Annual ecosystem service value (CA$ billion/year)		
Protected area	Hectares* (million)	Barren land	Forest	Grass land	Shrub land	Fresh water	Wet lands	Marine	Low estimate	Medium estimate	High estimate
Atlantic region	**2.44**	**26.96**	**35.34**	**10.01**	**6.28**	**8.67**	**11.61**	**1.54**	**$10.09**	**$32.52**	**$55.11**
Akami Uapishku Kakkasuak Mealy Mountains	1.07	1.80	56.44	5.09	7.03	8.69	20.54	0.41	$3.85	$19.54	$35.22
Cape Breton Highlands	1.00	0.20	73.35	0.98	7.77	1.29	15.72	0.24	$0.38	$1.78	$3.19
Fundy	0.02	0.01	97.62	0.05	0.00	0.84	0.05	0.15	$0.09	$0.36	$0.63
Gros Morne	0.18	4.22	46.11	0.00	16.48	10.55	22.14	0.38	$0.62	$3.16	$5.71
Kejimkujik	0.04	0.01	83.38	0.07	0.00	15.41	0.00	0.88	$0.16	$0.65	$1.15
Kouchibouguac	0.02	0.12	67.20	2.02	0.03	3.12	10.16	15.79	$0.10	$0.39	$0.68
Prince Edward Island	0.00	8.40	40.83	4.97	0.15	6.29	2.64	14.16	$0.01	$0.03	$0.05
Sable Island	0.00	0.07	0.57	40.81	0.30	17.51	0.10	39.67	$0.01	$0.01	$0.02
Terra Nova	0.04	0.16	73.69	0.00	4.10	7.22	12.64	1.78	$0.16	$0.67	$1.31
Torngat Mountains	0.96	63.96	0.27	18.98	3.91	8.84	0.00	2.63	$4.71	$5.93	$7.15
Central region	**1.52**	**0.01**	**17.86**	**0.10**	**0.49**	**74.35**	**0.06**	**6.88**	**$1.80**	**$14.49**	**$27.20**
Bruce Peninsula	0.02	0.03	84.91	1.77	0.10	8.82	0.03	0.00	$0.06	$0.25	$0.44
Fathom Five	0.00	0.00	11.37	0.17	0.00	88.41	0.00	0.00	$0.01	$0.11	$0.20
Forillon	0.02	0.00	95.53	0.04	0.83	0.15	0.04	2.77	$0.11	$0.42	$0.74
Georgian Bay Islands	0.00	1.70	84.44	2.40	1.08	9.60	0.00	0.00	$0.01	$0.02	$0.04
La Mauricie	0.05	0.00	82.49	0.25	8.03	8.69	0.03	0.00	$0.21	$0.84	$1.47
Lake Superior	1.09	0.00	0.43	0.01	0.03	99.53	0.00	0.00	$0.19	$8.93	$17.67
Mingan Archipelago	0.01	1.02	74.08	0.60	5.10	3.19	7.52	0.00	$0.04	$0.16	$0.28
Point Pelee	0.00	0.07	67.85	0.00	1.06	22.38	3.96	0.00	$0.00	$0.02	$0.04
Pukaskwa	0.18	0.00	93.09	0.49	1.11	5.28	0.01	0.00	$0.79	$3.16	$5.54
Rouge	0.00	0.09	13.92	0.06	0.11	0.17	0.49	0.00	$0.01	$0.02	$0.03
Saguenay-St. Lawrence	0.12	0.00	0.13	0.01	0.00	15.93	0.00	83.87	$0.36	$0.52	$0.68
Thousand Islands	0.00	0.36	86.77	0.80	1.16	7.82	0.72	0.00	$0.01	$0.04	$0.07

	Area	Natural Asset (% of hectare)							Annual ecosystem service value (CA$ billion/year)		
Protected area	Hectares* (million)	Barren land	Forest	Grass land	Shrub land	Fresh water	Wet lands	Marine	Low estimate	Medium estimate	High estimate
Western region	**4.73**	**18.73**	**39.48**	**7.19**	**3.73**	**5.90**	**13.86**	**9.66**	**$19.20**	**$67.28**	**$115.26**
Banff	0.69	42.06	39.20	8.41	3.00	1.93	0.03	0.00	$3.30	$7.15	$11.00
Elk Island	0.02	0.00	65.33	2.70	11.96	16.54	2.06	0.00	$0.06	$0.27	$0.48
Glacier	0.14	25.28	42.30	9.44	11.43	0.77	0.01	0.00	$0.52	$1.33	$2.15
Grasslands	0.08	6.93	0.26	85.33	1.94	0.74	0.20	0.00	$0.12	$0.30	$0.47
Gulf Islands	0.00	0.65	72.98	0.68	0.87	0.41	0.00	22.78	$0.02	$0.05	$0.09
Gwaii Haanas	0.50	1.14	26.68	0.78	1.30	0.47	0.00	70.36	$1.82	$3.53	$5.25
Jasper	1.12	40.29	41.72	7.47	3.30	2.12	0.33	0.00	$5.40	$12.18	$18.96
Kootenay	0.14	23.96	55.07	13.97	4.32	0.97	0.00	0.00	$0.60	$1.67	$2.73
Mount Revelstoke	0.03	16.61	51.92	8.32	18.72	0.74	0.02	0.00	$0.10	$0.29	$0.48
Pacific Rim	0.05	0.07	51.37	0.03	0.51	3.36	0.00	44.34	$0.20	$0.57	$0.93
Prince Albert	0.40	0.00	66.91	2.25	3.04	12.75	14.73	0.00	$1.45	$7.20	$12.92
Riding Mountain	0.31	0.00	86.74	0.16	1.10	6.69	4.86	0.00	$1.27	$5.43	$9.58
Wapusk	1.15	0.73	18.44	5.29	4.34	13.64	50.32	7.24	$3.61	$25.5	$47.35
Waterton Lakes	0.05	15.71	23.74	32.94	22.78	3.97	0.00	0.00	$0.13	$0.36	$0.58
Yoho	0.13	35.39	46.95	6.00	4.08	1.34	0.00	0.00	$0.60	$1.45	$2.29
Northern region	**38.00**	**20.05**	**11.21**	**12.36**	**7.41**	**4.53**	**4.19**	**30.65**	**$125.27**	**$257.79**	**$390.18**
Aulavik	1.22	14.11	0.00	34.08	46.77	4.31	0.00	0.73	$2.05	$3.88	$5.70
Auyuittuq	1.95	31.23	0.00	14.66	0.01	7.22	0.00	4.87	$4.90	$6.73	$8.56
Ivvavik	0.98	23.81	3.00	10.49	49.77	2.92	9.12	0.89	$2.51	$6.41	$10.32
Kluane	2.20	31.41	9.52	1.44	4.71	1.83	0.02	0.00	$5.84	$9.12	$12.39
Nááts'įhch'oh	0.49	30.07	36.52	13.34	18.45	1.06	0.43	0.00	$1.97	$4.68	$7.39
Nahanni*	3.00	21.57	48.60	13.71	8.56	1.56	5.65	0.00	$12.42	$38.62	$64.82
Qausuittuq	1.10	19.64	0.00	62.33	5.10	1.86	0.00	11.07	$2.78	$4.67	$6.57
Quttinirpaaq	3.79	57.14	0.00	1.70	0.00	3.85	0.00	6.57	$15.87	$17.20	$18.52
Sirmilik	2.22	36.44	0.00	26.74	1.01	2.67	0.00	1.39	$6.42	$8.37	$10.32
Tallurutiup Imanga	10.84	0.08	0.00	0.06	0.00	0.02	0.00	99.85	$37.00	$37.00	$37.00
Thaidene Nene	1.41	1.61	22.56	21.52	19.74	27.68	6.90	0.00	$2.55	$13.80	$25.03
Tuktut Nogait	1.90	19.20	2.63	62.22	10.09	5.86	0.00	0.00	$4.28	$8.90	$13.42
Ukkusiksalik	2.09	71.77	0.02	3.82	0.08	9.61	0.00	14.70	$11.52	$13.33	$15.14
Vuntut	0.44	8.12	4.35	18.91	42.98	8.35	17.29	0.00	$0.84	$4.06	$7.28
Wood Buffalo	4.56	0.04	43.73	8.63	12.44	9.69	25.42	0.00	$14.32	$81.02	$147.72

* 0.00 ha means less than 12,000 hectares (most <3,000 hectares)

Marsh with Canoeists, Point Pelee National Park © Scott Munn, Parks Canada

DISCUSSION

National parks and national marine conservation areas sustain ecologically representative and biologically diverse environments delivering essential services. The study presented here is in keeping with global efforts to value, in as many ways as possible, nature's importance to human welfare and to foster further environmental protections.

Efforts to measure the extent and value of natural capital, and change over time where possible, helps decision-makers understand the natural capital managed and can support decision making. Approximately 80 municipalities in Canada currently recognise natural assets, including those in their parklands, as infrastructure. They have undertaken inventory exercises and valuations of annual ecosystem services under their jurisdiction to help manage them and support community well-being (e.g. flood control, water filtration, mitigate urban heat island effects) (Eyquem et al., 2022). Natural capital in national parks and national marine conservation areas is managed for current and future generations. In the context of protected areas, measuring the extent and value of natural capital, and by extension demonstrating benefits of healthy environments, can assist with justifying investments in land acquisition to expand the network of protected areas, expand the size of a protected area, or connect protected areas through ecological corridors. It can also help inform and justify restoration efforts to yield the most value. Further, overlaying ecosystem services and valuations with built infrastructure, such as hiking trails, boardwalks and parking lots, can help better integrate environmental and tourism related planning in protected areas.

As countries worldwide move towards a more sustainable future, the contributions humanity has freely received from nature can no longer be valued at nothing. This study presented a natural capital and benefit transfer approach to produce an initial estimate of the potential economic value of ecosystem services associated with the terrestrial and marine environments in Canada's federal system of protected areas. The results suggest that between CA$ 156 billion and CA$ 588 billion in potential total ecosystem services are being managed annually in the country's national parks and national marine conservation areas.

To scope the magnitude of the total ecosystem services calculated in this study, several comparative examples are provided as a sensitivity analysis. The IPBES Regional Assessment Report estimates the monetary value of ecosystem services for Canada at US$ 3,590 per hectare per year (or CA$ 4,783) (IPBES, 2018). When applied to 46.953 million hectares in this study, regardless of asset type, it yields an estimated economic value of CA$ 225 billion in annual ecosystem services for Canada's federal protected areas. When the TEEB values used by Sutton et al. (2019) are converted to 2020 CAD and applied to this study's extent and asset types, it yields an estimated economic value of CA$ 178 billion. The economic value of this comparative example would be substantially higher if values were added for perennial ice/snow (4.0 million ha) and the coastal marine area (12.2 million ha) in US parks. Hrkac (2021) applied values from the Ecosystem Services Valuation Database (ESVD) to the land cover of British Columbia's provincial parks and protected areas (14.1 million ha) to estimate the value of ecosystems services at approximately CA$ 132 billion per year. Using the author's 2020 CAD values applied to this study's extent and asset types, it yields an estimated economic value of CA$ 440 billion per year for federal national parks and marine conservation areas. The above noted examples (CA$ 132 billion to CA$ 440 billion) serve

as simple benchmarks, suggesting that the preliminary estimate undertaken here (between CA$ 156 billion and CA$ 588 billion) is reasonable and the range is broadly within scope for such an extensive natural capital asset.

This initial monetary assessment is preliminary and exploratory in nature, drawing on accepted methodologies in the literature. It is acknowledged that there are some limitations. First, monetary values could not be assigned to the nearly 4 million hectares of identified snow and ice assets, as no known values existed at the time of writing. Marine environments are also limited in their assessment due to the complexity of defining and valuing biodiversity and ecosystem services of near, mid and offshore waters. Further work is needed in this area to enhance marine natural capital appraisal, especially as governments commit to expanding marine protected areas. Second, the monetary approach employed is aligned with other Western-based scientific valuations. It does not take into consideration Indigenous world views or incorporate Indigenous knowledge. It is anticipated that this work will develop in time, involving different approaches to refine and fully develop the concept of value (Claude-Belislea et al., 2021; Sangha et al., 2018). Finally, it is acknowledged that the estimate presented here is associated with a fixed moment in time. Ecosystems are in a constant state of change as biotic and abiotic elements of the environment are cycled. The natural environment in protected and conserved areas is ever changing with the forces of nature, but also in response to other influences such as changing climate, invasive species, hyper abundant species, and to changes in uses on adjacent lands and waters. The estimates of the annual ecosystem services will evolve as the terrestrial and marine environments managed within them change over time. As a result, the estimate could serve as a base case to compare over time.

National parks and national marine conservation areas are iconic symbols of Canadian identity and the value Canadians place on protecting the environment. They support tens of thousands of jobs in communities across the country. While it is inherently understood that nature is important and is valuable, this study has provided a tangible way to demonstrate the immense value that Canada's protected areas bring to Canadian society.

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DISCLAIMER

The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the official policy or position of any agency, organisation or employer.

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RESUMEN

Cada vez se presta más atención a las áreas protegidas y a la capacidad de sus activos de capital natural para proporcionar un flujo variado y a largo plazo de beneficios a los individuos y a la sociedad en general. A menudo se anuncia que estas áreas garantizan la persistencia de los activos de capital natural, pero su valor suele limitarse al impacto económico del gasto de los visitantes y a los efectos asociados en las economías regionales y nacionales. Pocos estudios han intentado cuantificar el valor económico de los activos de capital natural en las áreas protegidas, especialmente en Canadá. Este estudio utiliza un enfoque de transferencia de beneficios para elaborar una estimación inicial del valor económico potencial de los servicios ecosistémicos y el capital natural asociados a los entornos terrestres y marinos del sistema federal de parques nacionales y áreas de conservación marina nacional de Canadá. Los resultados sugieren que el valor económico de estos activos oscila entre 156.000 y 588.000 millones de dólares canadienses anuales.

RÉSUMÉ

Les zones protégées et la capacité de leur capital naturel à fournir un flux varié et à long terme de bénéfices aux individus et à la société en général font l'objet d'une attention croissante. Ces zones sont souvent saluées pour la pérennité de leur capital naturel, mais leur valeur est souvent limitée à l'impact économique des dépenses des visiteurs et aux effets associés sur les économies régionales et nationales. Peu d'études ont tenté de quantifier la valeur économique des actifs du capital naturel dans les zones protégées, en particulier au Canada. Cette étude utilise une approche de transfert de bénéfices pour produire une première estimation de la valeur économique potentielle des services écosystémiques et du capital naturel associés aux environnements terrestres et marins du réseau fédéral de parcs nationaux et d'aires marines nationales de conservation du Canada. Les résultats suggèrent que la valeur économique de ces actifs se situe entre 156 et 588 milliards de dollars canadiens par an.

THE STATE OF UKRAINE'S PROTECTED AREAS: AN INTERIM UPDATE ON DAMAGES FROM THE FULL-SCALE INVASION

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ABSTRACT

The Russian Federation's full-scale invasion of Ukraine has become a humanitarian and political crisis. Since the very start of the invasion, it has also been an ecological disaster, with Russian troops utilising protected areas both in an attempt to access strategic Ukrainian settlements, but also as locations in which to conduct active warfare. The frontline has now crossed and retreated from many protected areas, many are still occupied and many are still the sites of active hostilities. This study found the most common damages to protected areas are: physical destruction of habitats and wildlife and wildlife behavioural changes from explosions; chemical and physical pollution from explosive materials; fires caused by shelling; damages to soil and plant cover from heavy military vehicles, equipment and defence infrastructure; and military exploitation of natural resources. Given the occupation, combat and mining with explosives, it will be years before Ukraine can account for the full extent of damage to its protected area system. This paper provides an interim assessment of the damages to protected areas so far and urges the conservation and policy communities to monitor the situation moving forward.

Key Words: conflict, war, ecology, impacts, Russia, Europe

INTRODUCTION

The Russian Federation launched the full-scale invasion (FSI) of Ukraine on 24 February 2022. Shortly after the FSI began, it became clear that this war would have significant environmental impacts (Weir, 2022). Ukrainian authorities have valued the ever-rising bill of environmental damage to the country at over US$ 46 billion (Zhao & Anthony, 2023). This includes impacts on air quality, forests and other ecosystems, soils and water, pollution from the use of weapons and military equipment and contamination from the shelling of thousands of facilities holding toxic and hazardous materials.

Ukraine's Ministry of Environmental Protection and Natural Resources (MEPNR) estimates that the first twelve months of the FSI alone generated an additional 109 million tonnes of CO_2 equivalent from missile explosions, ammunition, forest fires, burning of oil depots and settlements (de Klerk et al., 2023). There are also the future emissions that will occur during post-war reconstruction of Ukraine.

In addition to the climate costs, war and conflict can directly lead to environmental destruction. War affects all components of nature, for example, interference in the functioning of river ecosystems due to the destruction of dams, explosions in water, chemical pollution, destruction of treatment facilities, lack of access to water, air pollution by combustion products and toxic gases, destruction of soil cover and microrelief, destruction of plant and animal life due to explosions, detonations from mines, fires and flooding. Induced impacts from war can occur from a reduction in funding of environmental protection and an increase in unsustainable exploitation of natural resources and environmental crimes (Arias et al., 2020; Daskin & Pringle, 2018; Glew & Hudson, 2007; Hanson et al., 2009; Rüttinger et al., 2022).

Ukraine, whilst one of the largest countries in Europe, occupies less than six per cent of the continent's area, yet it is home to a disproportionately high 35 per cent of the continent's biodiversity (Convention on Biological Diversity, n.d.). Ukraine's 70,000 species include many

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rare, relict and endemic species, all reliant on Ukraine's network of mountain, forest, steppe, wetlands and coastal ecosystems. Ukraine also has 142 Key Biodiversity Areas (KBAs) covering 3,026,800 ha (KBA Global Dataset, 2023). Numerous migration routes and wildlife corridors connect these ecosystems, including 63,000 rivers totalling 206,000 km in length and 1.3 million ha of river and riparian protected areas (PAs; Convention on Biological Diversity, n.d.). Ukraine's wetlands extend across 4.5 million ha (Convention on Biological Diversity, n.d.) including 50 Ramsar sites of over 930,000 ha (Convention on Wetlands Secretariat, 2023). Finally, the country also has eight UNESCO biosphere reserves, four of which are cross-border sites (UNESCO, 2023).

Ukraine's Nature Reserve Fund (NRF; the MEPNR's system of PAs) lists 8,889 protected sites covering 4.6 million ha, around seven per cent of the country, including marine PAs (MEPNR, 2023a). The Emerald Network (EN) of Areas of Special Conservation Interest was created to preserve species and habitats across the European continent. Ukraine has 377 official EN sites covering an area of 8,098,200 ha and a further 162 proposed EN sites (Ukraine War Environmental Consequences Work Group, 2023). Upon joining the European Union (EU), Ukraine's EN will constitute a basis of the EU's Natura 2000 conservation network. Of particular importance at the European-level are Ukraine's steppe habitat sites; Ukraine has the largest total area of steppe habitat among countries that have ratified the Bern Convention (Ukraine War Environmental Consequences Work Group, 2023). Much of this fragile steppe habitat is situated in or near conflict zones in the south and south-east of the country.

This study aims to provide an interim update on the state of Ukraine's PAs since the start of the FSI in February 2022 and focuses on the damages to nature in these PAs. This war has also damaged the conservation sector of Ukraine; through the displacement, recruitment and even death of conservation staff and the looting and destruction of administrative buildings, vehicles and equipment. Nature protection and management is now impossible in many areas due to mining of territories with explosives, occupation of PAs, and the dangers posed by constant shelling and Russian Federation troops that may have broken through frontlines. It is recommended that further research is conducted to account for these forms of damage.

METHODOLOGY

The World Database of Protected Areas (WDPA) lists a total of 5,622 protected areas registered in Ukraine, these are not entirely aligned with Ukraine's NRF which lists 8,889 sites (MEPNR, 2023a). The Ukrainian PA system is complex and national categories do not overlap perfectly with the WDPA management category system. There are 11 NRF categories of national and local importance. Of these, four are artificial, botanical gardens for example, the remaining seven are natural areas, these include Nature Reserves (NR), Biosphere Reserves (BR), National Nature Parks (NNP), Regional Landscape Parks, Reservations, Nature Monuments, and Reserve Stows (landscapes with scientific, conservation and aesthetic values set aside to preserve natural processes, the management of which corresponds with category Ia; MEPNR, 2012).

NRs, BRs and NNPs are considered the categories of the highest national and international importance for nature. NRs are established to preserve the natural state of a landscape for research use, and economic uses are not permitted. In theory, NRs correspond to the WDPA management category Ia or Ib but in reality, NR management often appears more aligned with category IV. Like the UNESCO Biosphere Reserve programme, BRs preserve the natural state of all present ecosystems and function as models for people living in harmony with nature. BRs in Ukraine, like elsewhere, can contain a number of different management category types across the core, buffer and transition zones. NNPs are created for the conservation, restoration and effective use of nature complexes with special natural, recreational, historical, cultural, scientific, educational and aesthetic values (MEPNR, 2012). NNPs often meet the management requirements of category II PAs, however, many NNPs do not have strict management regimes and may align better with other categories (MEPNR, 2012).

To focus our analysis on the most significant of the NRF's PAs for nature conservation, we selected NNPs, BR and NRs that have come into contact with combat zones since the start of the FSI (Live UA Map, 2023). This generated a final list of 21 PAs. As the NRF names do not always match the WDPA names of PAs, WDPA identification numbers are noted in parentheses at first mention to streamline future research (see Table 1).

Whilst there are calls within the field of conflict conservation to improve scientific rigour through employing more quantitative and systematic analyses, on a practical level, this is often extremely challenging (Glew & Hudson, 2007). For example, 14 of the 21 PAs analysed remain, at least partially, occupied and are therefore particularly challenging to gather data on in any kind of systematic way. At least 16 of the PAs have been subjected to mining with explosives, rendering ecological field assessments dangerous. These ground conditions make systematic collection of comparable primary or even secondary data across all PAs difficult.

However, where possible, field trips were made to territories that are liberated and now back under Ukrainian control. Coauthors and their colleagues exercised caution in collecting field data and consulted high-risk advisors and military personnel where possible in order to avoid explosives and harmful chemicals. Damages were photographed, descriptions were compiled, soil samples were taken from explosion craters in accordance with the methodology developed jointly by ecologist Kateryna Polianska (co-author) from non-profit *Environment People Law* (EPL) and scientists from the University of Bern. Remote methods used include reviewing satellite imagery and available maps on conflict and contamination by explosive objects. Primary field research was conducted by the NGO *Ukrainian Nature Conservation Group* (UNCG) and EPL.

A systematic literature review was also conducted to increase information particularly on PAs that could not be accessed directly. This assessment has drawn on data from as many sources as possible including: the MEPNR's weekly updates on environmental damages from the war, data from the State Emergency Service of Ukraine, reports from the Ukraine War Environmental Consequences Working Group, published investigations, news from the press, reports from national and international meetings, published interviews and personal communications with employees of the NRF and those that have visited PAs on or near the frontline (Ecodozor, 2023). To avoid using misinformation, where field visits were not possible, caution was exercised by triangulating data to ensure reliability. This involved cross-comparing media and NGO reports, reports from the MEPNR and personal communications with contacts in or near those PAs.

To support a semi-quantitative assessment across the 21 PAs, reports on damages were classified into seven forms:

- Fires
- Pollution from explosive materials (including mining)
- Direct damages from shelling, missiles or active combat
- Disruption from heavy military vehicles and equipment
- Disruption from the building of combat and defence infrastructure
- Pollution from chemicals
- Other (for example, logging, hunting and other waste pollution)

Not all impacts could be comparatively and quantifiably assessed across all PAs, where possible we have provided comparable statistics and maps. However, much information is still missing. Case studies on PAs where the most information could be gathered have been provided as supplementary online material.

RESULTS AND DISCUSSION

In total, we analysed 21 PAs. These include 16 NNPs, two NRs and three BRs (Table 1 and Figure 1).

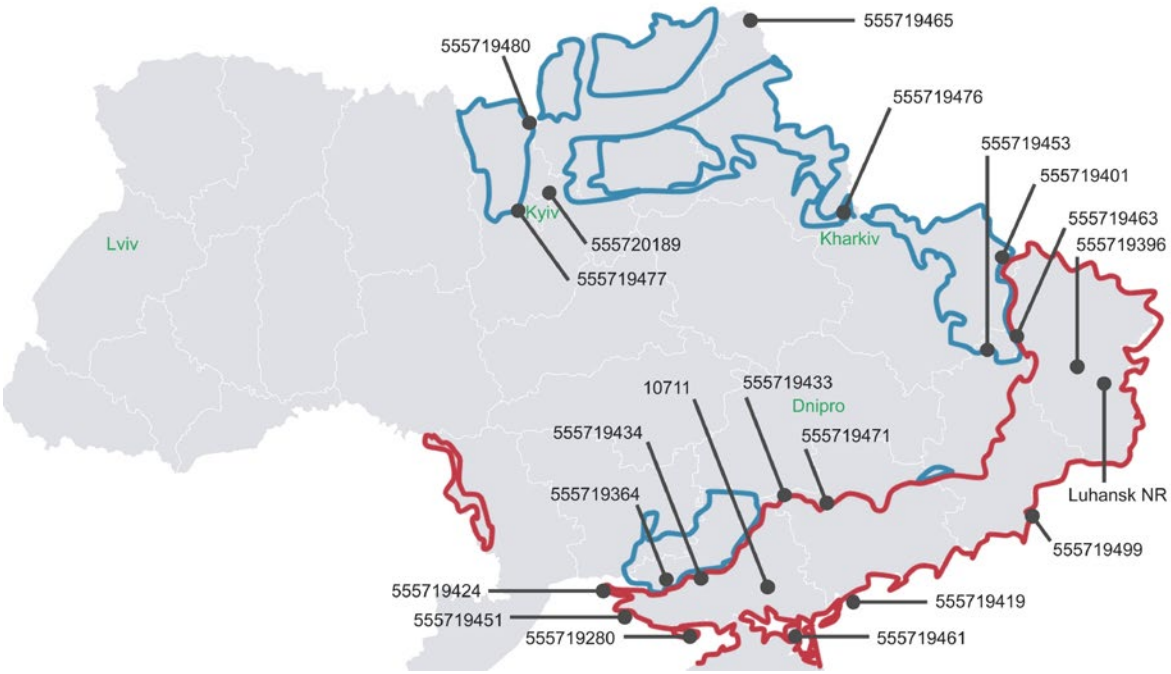

Figure 1. Locations of the 21 Protected areas assessed (numbering refers to WDPA IDs, see Table 1) in relation to the occupied (red) and liberated (blue) territories of Ukraine (based on the Live UA Map, accessed 23 August 2023).

Table 1. All protected areas analysed with major defining features

Protected area full name	WDPA ID number	WCPA category	Other overlapping designations	Area (ha)	Ecosystems present
Azovo-Syvaskyi NNP	555719461	Not reported	EN, Ramsar, KBA	51,983	Terrestrial and inland waters
Dzharylhatskyi NNP	555719280	Not reported		10,018	Marine
Oleshkivski Sands NNP	555719434	Not reported	EN	46,259	Terrestrial and inland waters
Pryazovskyi NNP	555719419	Not reported	EN, Ramsar, KBA	7,790	Marine
Velykyi Luh NNP	555719471	Not reported	EN, Ramsar	16,755	Terrestrial and inland waters
Meotyda NNP	555719499	Not reported	EN, Ramsar, KBA	22,199	Marine
Biloberezhzhia Sviatoslava NNP	555719424	Not reported	EN, Ramsar, KBA	35,242	Marine
Dvorichanskyi NNP	555719401	Not reported	EN	3,433	Terrestrial and inland waters
Kreminsky Lisy NNP	555719396	Not reported	EN, KBA	18,240	Terrestrial and inland waters
Holosiivskyi NNP	555719477	Not reported	EN	11,080	Terrestrial and inland waters
Zalissia NNP	555720189	Not reported		20,621	Terrestrial and inland waters
Sviati Hory NNP	555719463	Not reported		43,437	Terrestrial and inland waters
Hetmanskyi NNP	555719476	Not reported	EN	23,473	Terrestrial and inland waters
Desniansko-Starogutskyi NNP	555719465	Not reported	EN, Ramsar, UNESCO BR	16,223	Terrestrial and inland waters
Nyzhnodniprovskyi NNP	555719364	Not reported	EN, Ramsar	52,386	Terrestrial and inland waters
Kamianska Sich NNP	555719433	Not reported	KBA	218,119	Terrestrial and inland waters
Luhansk NR	Unavailable		EN		
Ukrainskyi Stepovyi NR	555719453	Not reported		3,355	Terrestrial and inland waters
Black Sea Biosphere Reserve	555719451	Not reported	EN	115,873	Marine
Askania-Nova Biosphere Reserve	10711	Not applicable	EN, Ramsar, UNESCO BR, KBA	33,307	Terrestrial and inland waters
Chornobylskyi Radiation and Environmental Biosphere Reserve	555719480	Not reported	EN, UNESCO BR, KBA	227,381	Terrestrial and inland waters

A note on interpretation

Of the 21 PAs analysed, 14 remain at least partially occupied by the Russian Federation, therefore retrieving reliable information about the conditions of these PAs is not only difficult, but it can put the lives of informants in danger. A further five PAs assessed have been fully liberated since the start of the FSI, the remaining two PAs were never occupied but have been damaged by active hostilities, these PAs are in varied states of damage, assessment and reporting. Data from these individual examples, along with reports from occupied PAs, can provide some interim indication of the damages so far sustained to Ukraine's PA estate. Thus all figures, photos and descriptions in the results and discussion below should be interpreted as the minimum positive confirmation of damage.

Damages will be revealed slowly, upon the liberation and de-mining of territories, the ceasing of hostilities, and once Ukrainian authorities and civil society organisations have the resources and time to safely conduct assessments. However, it is likely that the full extent of damages in Ukraine may never be accurately quantified.

Overarching information on impacts to protected areas

Preliminary assessments have been conducted on damages sustained by PAs from explosions, the movements of heavy military vehicles and equipment, the construction of military infrastructure (for example, fortifications and dugouts), fires as a result of shelling and missiles, chemical contamination of soils from explosives and other forms of pollution, waste and exploitation of natural resources. The following areas have overlapped with active hostilities and need to be assessed extensively and systematically for damages when safe to do so (Drapaliuk et al., 2023; Petrovych, 2023; Shumy et al., 2023):

- Almost 36 per cent of the total area of Ukraine's EN sites; 2.9 million ha, impacting 160 of Ukraine's 377 EN sites;
- Almost 67 per cent of the total area of Ukraine's Ramsar sites; almost 620,000 ha, impacting 16 of Ukraine's 50 Ramsar sites;
- Almost 30 per cent of the total area of Ukraine's PAs of national or local importance; 1.24 million ha, impacting 900 PAs in total.

Direct damage from shelling, missiles or active combat was the most frequently reported impact for the PAs we assessed (Table 2). Unfortunately, reports on chemical contamination remain highly localised leaving large gaps in between and a scarcity of positive confirmation. This is for a number of reasons including limited laboratory equipment and a lack of safe access to some explosion craters due to unexploded ordnance. However, soil samples were taken from explosion craters, as well as from burned equipment by our team in different PAs. These are discussed later in the paper.

Conditions of occupied protected areas

Of the PAs assessed, ten are currently fully occupied by the Russian Federation, four remain partially occupied, five have been liberated and two have not been occupied since the start of the FSI. Of the occupied PAs, the development of infrastructure and exploitation of natural resources were more frequently reported as damages to nature, for example, Pryazovskyi NNP (ID:555719419) where fortification, trenches, training grounds for heavy artillery in a strict protection zone and a shooting range have reportedly been established and industrial fishing is extracting 4.5–9 tonnes per day to feed the Russian Federation military (Petrovych, 2023). Reports on the management of occupied PAs by Russian Federation-appointed personnel are concerning, for example, staged military exercises on Meotyda NNP (ID: 555719499) Ramsar site, which reportedly included the shooting of important bird colonies for target practice (see supplementary online material for case studies).

Impacts from explosive munitions and active hostilities

Whilst the exact number of munitions being used in the current war is unknown due to operational security protocols, it has been reported that the Russian Federation is firing around 60,000 artillery shells in Ukraine on a daily basis (Khurshudyan & Sonne, 2022) and Ukraine is firing an average of 7,700 shells per day (Khurshudyan & Hrabchuk, 2023). The immediate physical impact of explosives on ecosystems is highly destructive, causing tree, plant and animal deaths and mass soil erosion (Vasyliuk, 2023).

Eighteen of the PAs reported damage from active hostilities. For example, shelling has damaged Europe's largest steppe habitat in Askania-Nova Biosphere Reserve (ID:10711; KBA); 80 per cent of Sviati Hory NNP's forests (ID:555719463; Petrovych, 2023); and 2,700 hectares of Desniansko-Starogutskyi NNP (ID:555719465; Petrovych, 2023). Holosiivskyi NNP (ID:555719477) and EN site was visited by our team who assessed first hand the significant damage done to trees and soils from shelling (see photo below). Nyzhnodniprovskyi NNP (ID:555719364), EN and Ramsar site (Petrovych, 2023) and Kamianska Sich NNP (ID:555719433; MEPNR, 2023b) reported the destruction of aquatic ecosystems from explosions inside the water column of seas and inland waters. In

Table 2. Positive confirmation (grey cells) of damages to the protected areas analysed since the start of the FSI

WDPA ID number (if available)	Impacts from explosive munitions and active hostilities	Pollution from explosive objects	Damage from fires	Disruption from heavy military vehicles and war infrastructure	Pollution from chemicals
555719461					
555719280					
555719434					
555719419					
555719471					
555719499					
555719424					
555719401					
555719396					
555719477					
555720189					
555719463					
555719476					
555719465					
555719364					
555719433					
Luhansk NR					
555719453					
555719451					
10711					
555719480					

Biloberezhzhia Sviatoslava NNP (ID:555719424; EN, Ramsar site and KBA), bomb blasts have caused bird deaths and population falls (Petrovych, 2023). Active hostilities such as shelling and artillery fire have also impacted wildlife behaviour as they seek refuge from combat zones (Grigorenko, 2023) and change migratory routes (Drapaliuk et al., 2023).

Military actors often use water as a weapon (Pacific Institute, 2023) as was the case with the Russian Federation attack on the Kakhovka hydropower plant (HPP) on 6 June 2023, the intention being to cause disruptive upstream, downstream and energy impacts (Glanz et al., 2023). The UNCG estimates that this single act of war caused more environmental damage than the combined consequences of all military operations since the beginning of the FSI (UNCG, 2023).

Upstream, the breach drained the Kakhovs'ke reservoir KBA, EN and Ramsar sites; wetlands protected by Kamianska Sich NNP and Velikiy Luh NNP (ID:555719471), causing the death of 28,000 fish (Shumy et al., 2023) and the destruction of wetland breeding grounds of tens of thousands of waterfowl (see supplementary online case studies). The breach flooded 62,000 hectares of land (UNOSAT, 2023), killing 52 people (Reuters, 2023), uprooting numerous landmines, caches of weapons and ammunition, and spilling between 150 and 450 tonnes of engine oil from the power plant's turbines into the Dnipro River (Relief Web, 2023). Nine EN sites were impacted by flooding; 90 per cent of the Nyzhnodniprovskyi NNP and Ramsar site was inundated (Moreland, 2023; Nikolaieva et al., 2023). Agricultural fertilisers, sewage, sediments and military debris were discharged into the north-western Black Sea where Ukraine, Romania and Bulgaria have numerous coastal and marine PAs (UNCG, 2023).

Pollution from explosive objects

Thirty per cent of Ukraine's territory is now potentially mined with explosives, equivalent to an area twice the size of Portugal, making it the most widely mined country in the world (Save the Children, 2023). Mines are buried

The dry basin of Kamianska Sich NNP after the Kakhovka dam explosion © Anastasiia Drapaliuk

in the sands of beaches, hidden in the vegetation of forests and grasslands and floating mines are in rivers, lakes and the Black Sea (Chernysh, 2023; The Maritime Executive, 2023). In addition to actively mined areas, unexploded munitions (missiles, bombs and shells) now litter much of Ukraine's environment. Of the 67,000 or so shells that land on Ukraine each day, the 'fail rate', that is the number of munitions that will not detonate on impact, ranges between two per cent for the modern NATO supplied shells to 30 per cent for older Soviet Union weaponry (confirmed by our team, 2023).

Unexploded munition on a tree, image taken from the road © Kateryna Polyanska

This leaves the country with a significant number of unexploded ordnance (UXO). During the first year of the FSI, Ukraine's State Emergency Service neutralised almost 314,000 explosive devices, including over 2,100 aircraft bombs, and surveyed 77,700 ha for explosives (Drapaliuk et al., 2023). UXO is lethal not only to humans, but also for wildlife which have been blown up, killed, traumatised and wounded by explosions (Polyanska, 2023). UXO also poses a threat to nature conservation by preventing conservation management activities and detering nature tourism (Hatton et al., 2001; Vasyliuk, 2023; see supplementary online case studies).

Sixteen of the PAs reported the presence of UXO. For example, in Desniansko-Starogutskyi NNP (ID:555719465) over 7,300 ha have been mined (Petrovych, 2023); over 3,500 ha of Kamianska Sich NNP (Petrovych, 2023); almost 1,400 ha in Zalissia NNP (ID:555720189; Petrovych, 2023); 1,300 ha of Velykyi Luh NNP (ID:555719471; Petrovych, 2023) and in Sviati Hory NNP only 1.5 per cent of the PA has been assessed as safe from mines so far (Petrovych, 2023; see supplementary online case studies).

Damage from fires

Combat-caused wildfires are usually collateral damage stemming from explosions of artillery, shells, missiles and rockets. Every day tens of thousands of shells explode in Ukraine, each one has the potential to start a fire. In 2022, over 10,000 fires were recorded within 60 km of the frontline, and almost 8,500 fires were recorded in occupied territories (MEPNR, 2023b). Over 100,000 ha of EN sites have burned as a result of active hostilities

The result of a forest fire caused by the invasion in Sviati Hory NNP © Kateryna Polyanska

(Ukraine War Environmental Consequences Work Group, 2023). Thirteen PAs reported damaging fires from hostilities, these include over 31,761 ha of radiation-contaminated forests and 8,695 of grasslands in the Chornobylskyi Radiation and Environmental Biosphere Reserve (ID:555719480; confirmed by our team, 2023).

The Kinburn Peninsular (site of the Black Sea Biosphere Reserve [ID:555719451] and the Biloberezhzhia Sviatoslava NNP) have lost almost 6,000 ha of vegetation (Kasyanov, 2023) in a particularly destructive series of fires, much of which is valuable rare plants and wetland habitat for birds and bats (MEPNR, 2023b; Panchenko, 2023; Petrovych, 2023). The severity of these fires worsened after occupying Russian Federation troops confiscated fire-fighting equipment (Petrovych, 2023; see supplementary online case studies).

Disruption from heavy military vehicles and war infrastructure

Numerous fortifications, barriers, trenches (Africk, 2023), dugouts, new road networks and heavy military vehicles and equipment have caused physical damage to PAs particularly in the east and south of the country. In areas where the frontline has become more static, the use of large-scale, dug-in defensive positions is analogous to the construction of a wall creating a physical barrier for terrestrial species disturbing connectivity corridors between PAs and limiting the potential for natural movement (confirmed by our team, 2023).

Such infrastructure and vehicle use destroys vegetation, disturbs and compacts soils and fragile sand and steppe habitats. Ukraine's smaller mammals are particularly vulnerable to this kind of disturbance (Rusin, 2023). Military vehicles also create habitat openings for invasive species (Pashkevich, 2023) and cause animals stress and injury. For example, military ships and equipment are suspected of causing acoustic injuries to the inner ear and chemical skin burns on cetaceans in the Black and Azov seas (Shumy et al., 2023). Mass dolphin death has been reported in these areas (Kolodezhna, 2022) and scientists are analysing samples from the bodies to provide official results for use in international courts.

Eight PAs reported damage from military vehicles and 11 from the building of combat and defence infrastructure (15 in total). These include Askania-Nova Biosphere Reserve reporting damages to fragile steppe from heavy equipment and vehicles, and trenches and low-flying jets disrupting ungulate grazing (Baturin, 2023; Petrovych, 2023); Pryazovskyi NNP reporting 672 ha of steppe, coast, delta and nesting colonies damaged by vehicles and low altitude helicopter flights, along with the building of fortification, trenches, training grounds and a shooting range for heavy artillery in the PA's strict protection zone (Petrovych, 2023); Dzharylhatskyi NNP (ID:555719280) reporting Russian Federation troops filled the channel between the island and mainland which will increase siltation and eutrophication and disrupt the hydrology of the bay (Petrovych, 2023); the Chornobylskyi Radiation Ecological Biosphere Reserve reporting six ha of fortifications and trenches (confirmed by our team, 2023; see supplementary online case studies).

Pollution from chemicals

Military activities can release dangerous toxins through emissions from fires at civil and industrial infrastructure sites, pollution from damage to water management systems, fuel and lubricant spills, rocket fuel released at unexploded rocket fall sites and abandoned and burnt-out military equipment degrading in ecosystems (Polyanska, 2023). Explosions also release heavy metals such as arsenic, copper and lead into the environment (Barker et al., 2020) which can accumulate in plants and the bodies of animals damaging internal organs and the nervous system (Polyanska, 2023).

Broadscale and systematic chemical analyses of PA soils and water systems are currently impossible given the occupation and extent of explosives pollution. However, Pryazovskyi NNP has reported fuel and other petroleum products in estuary water and soil (Petrovych, 2023), whilst Sviati Hory NNP reported soils contaminated with petroleum products and debris from military equipment (MEPNR, 2023b). Soil samples taken from missile impact sites in Kamianska Sich NNP by our team

revealed excessive concentrations of petroleum products, lead, arsenic and many other chemicals (see supplementary online case studies). Toxins like these can leach into water systems, crops, livestock, wildlife, trees and eventually humans, creating a potentially huge challenge for Ukrainian and global food and water security.

CONCLUSIONS

The damage to nature sustained so far by Ukraine's PA estate, that we know of, has been highly destructive and has the potential to be catastrophic. Indeed, the aftermath of the Kakhovskaya HPP explosion can certainly already be described as catastrophic. The frontline continues to shift, and with it the intensity of impacts to nature conservation areas. Timely monitoring of the damage caused is important. The impacts discussed in this article will not be limited to the 21 sites, instead these PAs should be interpreted as indicative of the conditions of other protected areas and important sites for biodiversity particularly in the south-east of the country.

For deeper analysis and to obtain a more complete picture of damages, the authors propose the careful assessment, recovery and restoration of the roughly three million ha of Ukraine's PAs of local, national and international importance that have come into contact with the war. Assessment should focus on the types and extent of damages in order to plan and budget for restoration costs in post-war recovery. We recognise and stress this is a huge amount of work that should bring together the efforts of conservationists in-country and internationally. Not only is this a vast area to restore but, considering the complex and varied types of damage (physical destruction, burning, chemical and heavy metal pollution and extensive mining), the process of recovery will require concerted and coordinated effort, innovation and cooperation from a variety of skillsets and expertise. For example, de-mining vast areas in an environmentally friendly way, re-designing safe ecotourism, any planning of peace parks (as per the definition in Vasilijević et al., 2015), or exploring the emerging concept of defensive rewilding (Schmidt, 2023) will all require specialist knowledge.

The repercussions for Ukraine's biodiversity and ecosystem services will be felt not just by Ukraine but by Europe and the world more broadly. It is important that conservationists and international policy makers acknowledge this war not only as a humanitarian disaster with local, regional and global effects, but also as an environmental disaster with climate, ecosystem and biodiversity effects impacting multiple geopolitical levels. Global environmental mapping and accounting systems such as WDPA, UNESCO, Ramsar, Emerald Network, KBA and Global Safety Net must also remain conscious that this is an active invasion and war for territory. As independent and neutral entities they should maintain Ukraine's official ownership of such areas until the war is over.

As a signatory to the Global Biodiversity Framework (GBF), Ukraine is committed to protecting and conserving at least 30 per cent of its terrestrial, inland water, and coastal and marine ecosystems and restoring at least 30 per cent of its degraded terrestrial, inland water, and coastal and marine ecosystems by 2030. While Ukraine's protected and conserved area estate needs to be expanded significantly to meet this target, the Russian Federation's FSI is severely hindering Ukraine's ability to effectively protect its current PA estate. Meanwhile the war has also significantly increased the extent of degraded ecosystems and further reduced their capacity to support biodiversity and ecosystem services.

This all amounts to a widening of the gap between Ukraine's current biodiversity conservation and its 2030 targets. Under Ukraine's Criminal Code, such complex, long-term and large-scale negative impacts on wildlife fall under the definition of ecocide (Polyanska, 2023). As another signatory to the GBF and other multilateral environmental agreements (MEAs), the Russian Federation could be held responsible for compromising the achievement of nature conservation goals in Ukraine, along with the goals of countries connected to and impacted by Ukraine's biodiversity. In the international legal proceedings that may follow the end of the FSI, and during the meetings of the Parties of the MEAs, the Russian Federation could be called on to take political and fiscal responsibility for this biodiversity loss and nature restoration.

Lastly, the authors acknowledge the limitations of this study and offer suggestions for future research and policy discussion. Ukraine's ecosystems will be damaged through other effects of the war, for example, the need to create special landfills for the disposal of a growing amount of rubble and military waste and the rebuilding of the irrigation system in the south of Ukraine in order to preserve agricultural land. Other damages will have been incurred through Ukraine's efforts to fight this war, such as the redirecting of financial and human resources away from conservation, the use of natural resources in the war, changes in institutional dynamics, loss of human capital and in-situ networks of environmental protection organisations that have been disbanded. Further research could focus on these impacts to provide a more holistic picture of what will be needed for post-war recovery.

During our research, we also found numerous examples of protected area management and ranger staff becoming internally displaced people or refugees, or joining the military to fight and leaving behind their positions in conservation. In some cases, staff were lost in active combat or executed as government staff by invading troops. Protected area vehicles and equipment have been destroyed or stolen, many administrative and research facilities have been looted or razed. Rebuilding Ukraine's conservation sector will require significant effort and investment that needs to be quantified.

There is also an urgent need to map out a post-war biodiversity recovery plan to get Ukraine's GBF and other MEA goals back on track. In accordance with European integration processes, the basis of this plan should be the European Union's Biodiversity Conservation Strategy, in particular drawing on the EU's future Nature Restoration Law (European Commission, 2020).

SUPPLEMENTARY ONLINE MATERIAL

Online case studies

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RESUMEN

La invasión a gran escala de Ucrania por parte de la Federación Rusa se ha convertido en una crisis humanitaria y política. Desde el comienzo de la invasión, también ha sido un desastre ecológico, ya que las tropas rusas han utilizado zonas protegidas tanto para intentar acceder a asentamientos estratégicos ucranianos como para llevar a cabo una guerra activa. La línea del frente ya ha cruzado y se ha retirado de muchas zonas protegidas, muchas siguen ocupadas y muchas siguen siendo escenario de hostilidades activas. Según este estudio, los daños más comunes en las zonas protegidas son: la destrucción física de los hábitats y la fauna y los cambios de comportamiento de la fauna a causa de las explosiones; la contaminación química y física provocada por los materiales explosivos; los incendios causados por los bombardeos; los daños en el suelo y la cubierta vegetal provocados por los vehículos militares pesados, los equipos y las infraestructuras de defensa; y la explotación militar de los recursos naturales. Dada la ocupación, los combates y la explotación con explosivos, pasarán años antes de que Ucrania pueda contabilizar el alcance total de los daños sufridos por su sistema de zonas protegidas. Este documento ofrece una evaluación provisional de los daños sufridos por las áreas protegidas hasta la fecha e insta a las comunidades conservacionistas y políticas a seguir de cerca la situación en el futuro.

RÉSUMÉ

L'invasion massive de l'Ukraine par la Fédération de Russie est devenue une crise humanitaire et politique. Depuis le début de l'invasion, c'est également un désastre écologique, les troupes russes utilisant les zones protégées à la fois pour tenter d'accéder aux implantations stratégiques ukrainiennes, mais aussi pour y mener une guerre active. La ligne de front a maintenant traversé et s'est retirée de nombreuses zones protégées, beaucoup sont encore occupées et beaucoup sont encore le théâtre d'hostilités actives. Cette étude a révélé que les dommages les plus courants causés aux zones protégées sont : la destruction physique des habitats et de la faune et les changements de comportement de la faune dus aux explosions ; la pollution chimique et physique due aux matières explosives ; les incendies causés par les bombardements ; les dommages causés au sol et à la couverture végétale par les véhicules militaires lourds, l'équipement et l'infrastructure de défense ; et l'exploitation militaire des ressources naturelles. Compte tenu de l'occupation, des combats et de l'exploitation minière à l'aide d'explosifs, il faudra des années avant que l'Ukraine puisse rendre compte de l'étendue totale des dommages subis par son système de zones protégées. Le présent document fournit une évaluation provisoire des dommages subis par les zones protégées jusqu'à présent et invite instamment les milieux de la conservation et de la politique à surveiller la situation à l'avenir.

MAPPING OIL PALM EXPANSION WITHIN THE PROTECTED LOWLAND RAINFOREST OF NIGERIA USING GOOGLE EARTH ENGINE

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ABSTRACT

Increasing demand for *Elaeis guineensis* (African Oil Palm) products both for domestic and industrial use has led to its continuous expansion. The influence of oil palm plantation establishment on the economic well-being of communities and ecosystems cannot be over-emphasised. The study focuses on the rapid expansion of oil palm plantations within all protected areas and forest reserves in the lowland rainforests of Ondo State, Nigeria using. Object-Based Image Analysis (OBIA) was used to map oil palm expansion using 10-metre resolution Sentinel-2A images for 2015 and 2020 in Google Earth Engine (GEE). We found expansion of both smallholder and commercial oil palm plantations within eight of the thirteen protected areas with three protected areas (Ipele, Onisere and Akure Ofosu) showing a significant increase in oil palm plantation establishment. The use of object-based classification techniques, which combines contextual information within the image domain to discriminate landscape features such as oil palm canopy features, was effective in delineating oil palm from the forest canopy and other crops. While Google Earth Engine, a server-based remote sensing domain with petabytes of data, is effective for monitoring large-scale tropical forests.

Key words: oil palm, satellite remote sensing, deforestation rates, Google Earth Engine.

INTRODUCTION

A protected area is a geographical location that has been defined, dedicated and managed for the long-term conservation of nature and its related ecological services and cultural values, via legal or other effective measures (Dudley & Stolton, 2007). The IUCN further defines a protected area as an area of land and/or sea dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means (DeFries et al., 2007). Protected areas include forest reserves, strict nature reserves, wilderness areas, national parks and management areas, and are important for biodiversity conservation while also contributing to livelihood through the provision of ecosystem services such as food, safe drinking water, medicines and protection from adverse climate elements.

Protected areas are at the heart of attempts to conserve nature and the services it renders, and represent a key strategy to conserve biodiversity at a small or large scale (Belote & Wilson, 2020; Hummel et al., 2019; Wang et al., 2020). Also, Ward et al. (2020) suggested that protected areas are a core tool in abating the biodiversity crisis and their importance is reflected in the new Strategic Plan for Biodiversity under the Kunming-Montreal Global Biodiversity Framework. Efforts at increasing percentages of protected areas led to the international agreement calling for the expansion of the global protected area network to cover 17 per cent of terrestrial areas and 10 per cent of marine areas by 2020 (Ward et al., 2020). Despite concerted efforts to increase the percentages of protected areas, growing human population density and land-use intensification on surrounding lands are major causes of biodiversity degradation in protected areas especially in tropical rainforests. One of the major forces of anthropogenic disturbance is the expansion of oil palm plantations into protected areas of tropical rainforest ecosystems.

10.2305/VJSB2292

Oil palm (*Elaeis* spp.) is one of the world's most rapidly expanding agricultural tree crops and is grown across more than 13.5 million ha of the tropical region (Fitzherbert et al., 2008; Yaap et al., 2010). The growing belt for oil palm is the high-rainfall zone, naturally occupied by moist tropical forests and the most biologically diverse terrestrial ecosystem on Earth (Gutiérrez-Vélez & DeFries, 2013; Miettinen et al., 2012). Oil palm is an important driver of tropical deforestation and contributes to deforestation in the following ways: a) as the primary motive for clearance of intact forests; b) by replacing forests previously degraded by logging or fire; c) as part of a combined economic enterprise, such as with timber, plywood or paper pulp, profits are used to offset the costs of plantation establishment; or (d) indirectly, through generating improved road access to previously inaccessible forest or displacing other crops into forests (Butler & Laurance, 2009).

The availability of Satellite Remote Sensing (SRS) with repeated time series has allowed for research on oil palm expansion and its implications on forest ecosystems. Oil palm mapping using satellite remote sensing data has been carried out in many studies across the tropics using various satellite remote sensing images ranging from coarse or low resolution to medium resolution and high-resolution satellite images. The Moderate Resolution Imaging Spectroradiometer (MODIS) data (a coarse low-resolution satellite image) with a pixel size of 250 m were utilised successfully to produce an oil palm map covering an area of 939,204 km² in the Amazon Forest of Brazil (Gutiérrez-Vélez & DeFries, 2013). A similar study using MODIS data was conducted in Southeast Asia; the study successfully classified a total of 13 classes together with mangrove forests, rainforests and large-scale palm plantations (Miettinen et al., 2012).

The use of medium and higher spatial resolution data for the delineation and mapping of oil palm has been successfully conducted in many studies. For instance, the impacts of oil palm on deforestation and biodiversity loss were published using 30-metre Landsat images of three epochs between 1984 and 2010 (Vijay et al., 2016). The results of the study revealed historical deforestation caused by oil palm plantations in 20 tropical countries. The above studies were carried out using the pixel-based classification method. The major disadvantages of the pixel-based method are the 'salt and pepper' effects, due to the intrinsic characteristics of the land cover elements (spectral heterogeneity) and the random variation of the sensor's response which often lead to misclassifications (Whiteside et al., 2011). Another classification procedure known as Object-based image analysis (OBIA) was preferred to solve the salt and pepper problem and improve classification accuracies.

OBIA is a robust method suitable for the classification of medium to high-resolution satellite imagery. An object is a group of pixels, and object characteristics such as mean value, standard deviation, ratio, etc., can be calculated; there are also shapes and texture features of the objects available which can be used to differentiate land cover classes with similar spectral information. In object-based techniques, contextual information such as texture, geometry and compactness are combined with spectral information of the satellite image for change detection analysis (Aguirre-Gutiérrez et al., 2012; Desclée et al., 2006). The main objective of OBIA is to improve image classification through the full exploitation of salient information within the satellite image for change detection analysis. The salient information includes texture, shape and spatial relations with neighbouring objects (Hussain et al., 2013).

OBIA uses objects produced by image segmentation and combines visual interpretations with the quantitative aspect of the pixel-based approach. It interprets images using characteristics such as spectra, texture, as well as spatial and topological characteristics (Desclée et al., 2006). These extra forms of information give OBIA the potential to produce land cover thematic maps with higher accuracies than those produced by the traditional pixel-based method. OBIA comprises two parts: 1) image segmentation and 2) classification based on objects' features in spectral and spatial domains. Image segmentation is a kind of rationalisation, which delineates objects according to certain homogeneity criteria and at the same time requires spatial contingency (Desclée et al., 2006). Although the application of OBIA was initially focused on high-resolution satellite images, it has been successfully applied using medium-resolution images. The application of OBIA in forest ecosystems includes forest cover mapping, canopy modelling, change detection studies, above-ground biomass estimations, species distribution modelling and habitat mapping (Abbas et al., 2010; Desclée et al., 2006; Duro et al., 2012; Duveiller et al., 2008; Lu & Batistella, 2005; Lu et al., 2014). For example, OBIA was used in the change detection optimisation of the mountainous forest of Mexico with a medium-resolution Landsat image (Aguirre-Gutiérrez et al., 2012). An accuracy assessment of 0.77 was obtained using the object-based classification algorithm.

Oil palm plantations have a distinct canopy cover from forest trees and other agricultural tree crops, thus the application of OBIA which uses contextual textural information to discriminate crops is well suited for mapping and discriminating oil palm in lowland rainforest. This study, therefore, aims to determine the status of protected areas in Ondo State and the extent of

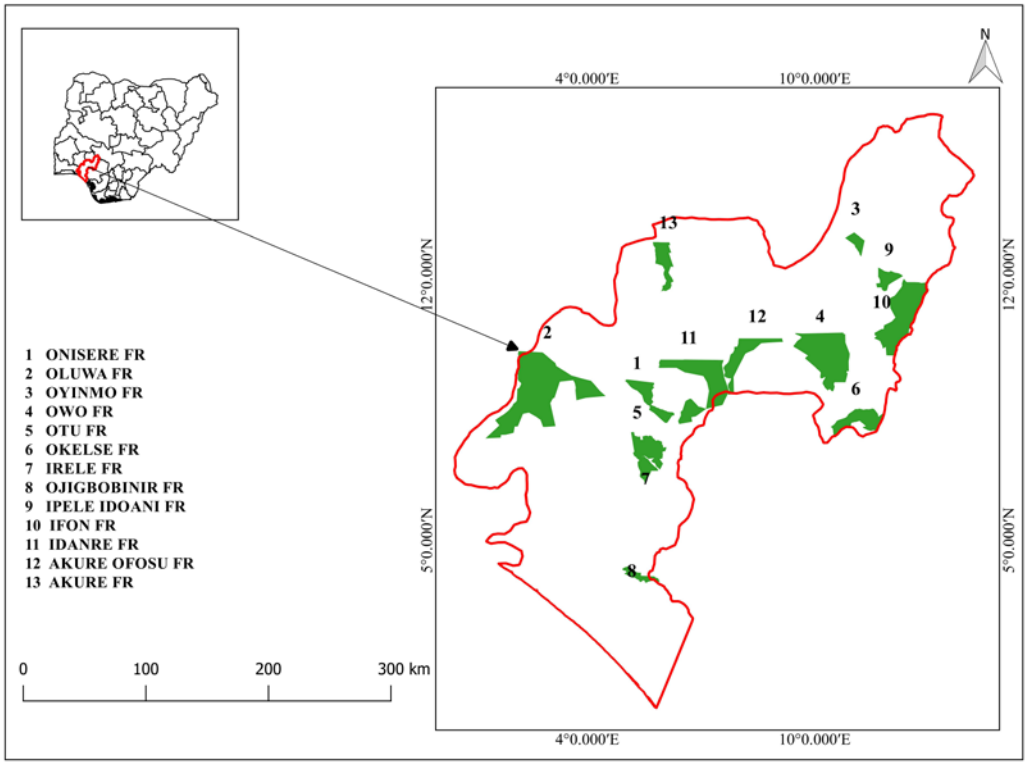

Figure 1. Protected areas of the lowland rainforest of Ondo State, Nigeria.

oil palm incursion within the protected areas using OBIA with high-resolution Sentinel-2A.

MATERIAL AND METHODS

Study areas

Ondo State is bordered to the east by Edo and Delta states, to the west by Ogun and Osun states, to the north by Ekiti and Kogi states, and to the south by the Atlantic Ocean and the Bight of Benin. The state is endowed with lowland forest cover which is highly diverse in both flora and fauna species. The study areas are the 13 forest reserves of Ondo State (Figure 1), which are highly diverse ecological niches ranging from lowland rainforest to savannah at the border with Kogi in the north. The lowland climate supports oil palm plantations because of its rainfall and rich soil.

METHODS

Digitisation of archived forest reserve maps of Ondo State

Archived maps of the protected areas were obtained from the State Forestry Department (Ondo State, Nigeria). The acquired maps dated back to the colonial eras showing the boundary and extent of each of the forest reserves. The forest maps were the original surveyed maps by the then-British colonial forestry administration. Included in the maps were the beacon numbers and the coordinate reference points for each of the forest reserves. The paper maps were scanned, georeferenced, then digitised and saved as shapefiles. The georeferencing and digitisation were to enable the maps to be imported into a remote sensing interface such as the Google Earth Engine platform. A total of 13 forest reserves were georeferenced and digitised using the QGIS (3.1.8) software.

Forest, oil palm and other land use delineation in Google Earth Engine

Google Earth Engine (GEE) is a web-based and cloud computing Remote Sensing (RS) portal that provides global time series of satellite data and other ancillary data (Lalit & Mutanga, 2019). The GEE portal provides enhanced opportunities for undertaking Earth observation studies and has the capabilities of performing raster and vector manipulations on free archival images such as Landsat, Moderate Imaging Spectroradiometer (MODIS) and the European Copernicus Earth Observation data (Sentinel-2, Sentinel-1, Sentinel-3, Sentinel-4, Sentinel-5, Sentinel-5P, Sentinel-6), etc. Embedded within GEE are petabytes of other time-series satellite images and ancillary data and several image classification and machine learning algorithms such as Support Vector Machine (SVM), Random Forest (RF), Deep Learning and Artificial Neural Network (ANN) algorithms (Kumar & Mutanga, 2018; Lalit & Mutanga, 2019).

The shapefiles from the digitised maps were imported into the GEE interface and were used to clip the dry season Sentinel-2A satellite images for the years 2015

Table 1: Statistics of annual changes between the classified maps of 2015 and 2020 and the overall accuracies of the maps

Protected area (PA)	Year	Forest	Oil palm	Farmland	Settlement	Water	Overall accuracy (%)
				Km²			
Akure Ofosu	2015	72.0813	9.6333	11.3321	6.1622	0.8379	62.07
	2020	65.4845	12.4916	13.0624	7.1268	1.9184	62.01
Changes		-6.5968	2.8583	1.7303	0.9646	1.0805	
Irele	2015	12.3014	19.9809	1.4062	0.3491	0.0523	77.78
	2020	11.1474	20.3873	2.0749	0.3886	0.0917	73.33
Changes		-1.154	0.4064	0.6687	0.0395	0.0394	
Onisere	2015	67.2543	0.3334	3.9463	0.528	0.3061	66.67
	2020	62.7333	2.7482	5.73	0.9642	0.1924	75.76
Changes		-4.521	2.4148	1.7837	0.4362	-0.1137	
Otu	2015	43.5607	33.7863	8.6923	1.7231	0.8612	66.04
	2020	37.7812	37.107	11.058	2.3358	0.3416	60.71
ChangeS		-5.7795	3.3207	2.3657	0.6127	-0.5196	
Oluwa	2015	307.38	135.526	12.5204	2.6867	1.037	64.84
	2020	264.258	164.251	22.3767	7.0135	1.2502	
Changes		-43.122	28.7257	9.8563	4.3268	0.2132	
Ipele Idoani	2015	22.4748	0.2267	15.7467	0.3183	0.043	78.38
	2020	19.7984	0.4108	18.9192	0.5781	0.103	72.97
Changes		-2.6764	0.1841	3.1725	0.2598	0.06	
Idanre	2015	200.932	10.3471	11.4362	3.3323	0.8918	75
	2020	193.459	12.1636	5.5545	5.5545	1.5697	86.77
Changes		-7.473	1.8165	-5.8817	2.2222	0.6779	
Ifon	2015	187.146	21.7715	87.8108	1.0022	NIL	58.53
	2020	153.455	23.2138	118.438	2.6241	NIL	75.61
Changes		-33.691	1.4423	30.627	1.6219	NIL	

The overall accuracy statistics range from 53.53 per cent to 78.38 per cent (OA* in Table 1).

and 2020 for each of the forest reserves using JavaScript. Atmospheric and geometric corrections were performed on the acquired Sentinel-2A images to remove noise and artefacts and the satellite digital number (DN) was subsequently converted to surface reflectance. Reference data for the classifications were obtained using high-resolution time-series Google Earth Engine Pro and in situ data (obtained during field visits). The training samples were divided into 70/30 for classification and validation. The satellite images were then classified into four major classes, namely; Forest, oil palm plantation, Agricultural land and Settlement or built-up.

Accuracy assessments

The conventional method for determining accuracy is to create an 'error matrix'. The land cover classes from the categorised image are represented by the rows and columns of this square matrix. To determine overall

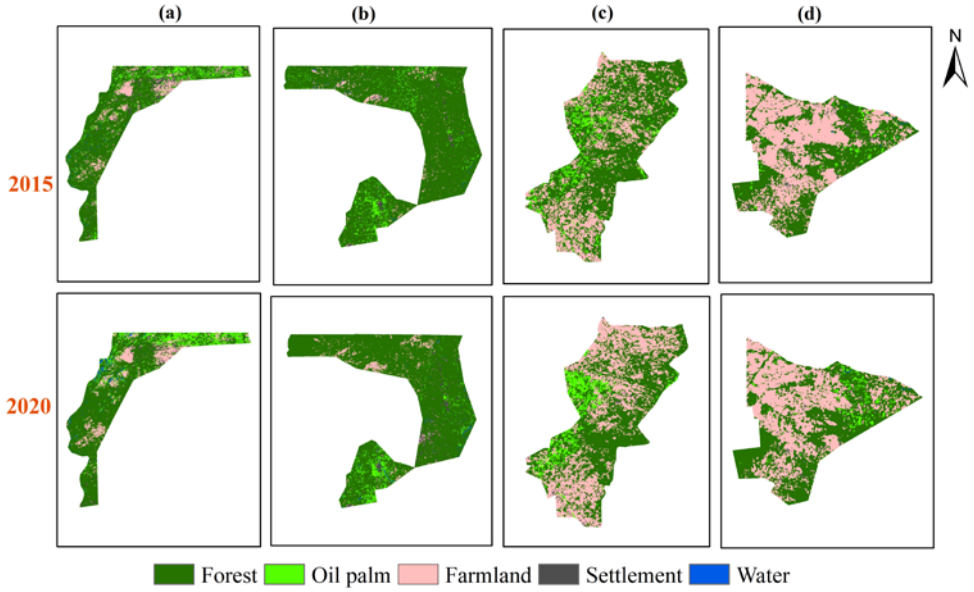

Figure 2. LULC classifications for (a) Akure Ofosu, (b) Idanre, (c) Ifon (d) Ipele Idoani

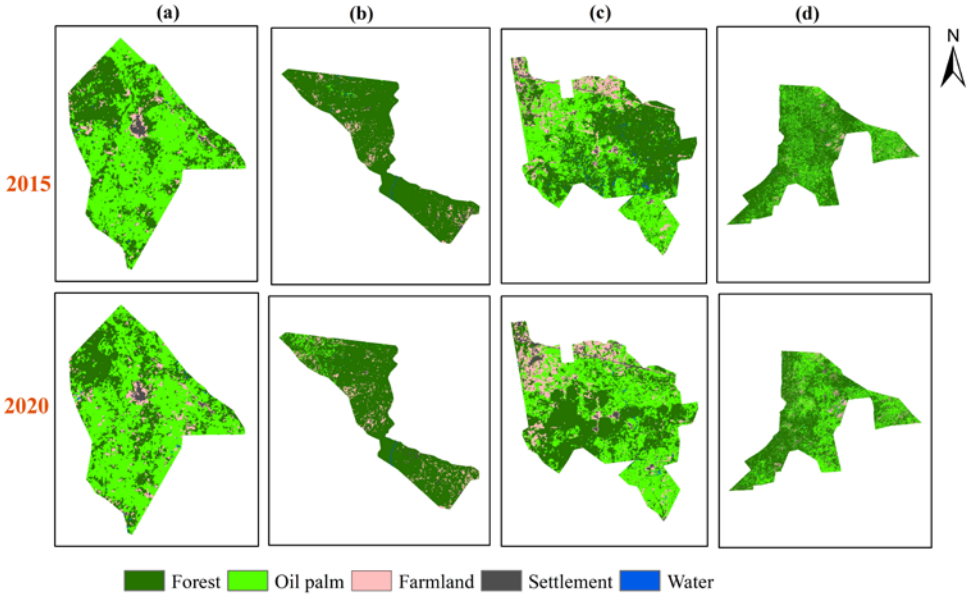

Figure 3. LULC classifications for (e) Irele, (f) Onisere, (g) Otu (h) Oluwa

accuracy, the total number of correctly classified sites is multiplied by the total number of reference sites. This can also be expressed as an error percentage, which is the complement of accuracy: error + accuracy = 100 per cent.

Also, deforestation rates were calculated for all the forest reserves / protected areas using the annual deforestation rate formula of the Food Agriculture Organization below:

$$r = \left(\left(\frac{1}{t_2 - t_1}\right) \ln \frac{A_2}{A_1}\right) \text{----------1}$$

A_1 and A_2 indicated in the formula are the areas of the forest cover mapped between time t_1 and t_2 which are 2015 and 2020 respectively.

RESULTS

The land uses land cover change analysis of the 13 digitised forest reserves with the 10-metre resolution Sentinel-2A satellite images revealed that eight of the forest reserves are currently under small-scale oil palm groves or large-scale plantations (Table 1, Figures 2 and 3). Oil palm groves are smaller hectarages of plantations, distinguishable from large commercial/industrial plantations, and are further classified as either dense, thinned or sparse providing livelihoods for small-scale farmers (Okolo et al., 2019). The oil palm groves are mainly composed of *Dura* species which have hard shells around the kernel, and are also protected plantations arising from shifting cultivations and are often scattered around the farmlands.

Table 2. Statistics on deforestation rates in the protected areas.

Forest reserve	Ipele Idoani	Irele	Onisere	Otu	Oluwa	Akure Ofosu	Idanre	Ifon
Deforestation rates	-0.55	-0.85	-0.60	-1.23	-1.32	-0.44	-0.23	-1.72

Oil palm establishment in protected areas of Ondo State ranges from 0.29 (Ipele Idoani) to 41.8 per cent (Otu Forest Reserve). Three forest reserves (Ipele, Onisere and Akure Ofosu) showed a considerable increase in oil palm plantation establishment while the annual deforestation rates within the eight forest reserves are between 0.23 and 1.32 per cent (Table 2). Changes observed from the results in Table 1 included negative changes for forest reserves which connotes forest degradation and the negative changes range from loss of forest cover -1.15 km^2 to -43.12 km^2 within the period 2015–2020. Similarly, oil palm and the other land use classes increased in the same proportion to the loss of forest cover.

DISCUSSION

The extent to which oil palm contributes to deforestation has been a subject of debate. Oil palm activities potentially contribute to deforestation, which can have serious detrimental effects on the environment, and therefore require adequate monitoring. While protected areas are at the heart of attempts to conserve biodiversity and ecosystem services, the protected areas within the lowland rainforest have been gradually eroded by the incursion of oil palm plantations. Two types of oil palm plantations were observed during the data collection phase, the 'grove' plantations and the large-scale commercial plantations, and both contributed to the loss of biodiversity within the protected areas. From observations, the grove plantations are smaller patches of oil palm plantation (not greater 1 ha). The grove plantations of oil palm are offshoots of incursions into protected areas by inhabitants farming within the boundaries of protected areas. These farmers practise shifting cultivation which in itself is destructive to biodiversity conservation. The large-scale plantations are commercial oil palm production encouraged by the government with the aim of providing employment to the growing population. However, the 10-metre resolution satellite data used in this study is limited in its ability to discriminate between grove and large-scale plantations. A higher resolution satellite image between 5 metres and 0.5 metres provided by commercial satellite providers will adequately distinguish the grove oil palms from the large-scale oil palm plantations.

While Nigeria is a signatory to several biodiversity and conservation treaties, a key question arises as to why such incursions into protected areas are occurring when it is the policy of the Government of Nigeria to make community lands available to would-be commercial farmers. The answer appears to be that the expansion of oil palm plantations into protected areas is encouraged by the state governments (Chukwu, 2022; Ekubge, 2023; Olu-Esho, 2023). Although it is an unwritten policy, the state government aims to promote employment through agricultural expansion and industrialisation (Ekubge, 2023). With the result that industrial or large oil palm plantations existing within forest reserves are mostly permitted by the state governments (Olu-Esho, 2023). This policy is, therefore, the driving force for deforestation through agricultural expansion. Oil palm demand has resulted in a massive increase in plantations in tropical rainforests hence the clearance and destruction of the ecosystem.

Implications of oil palm on lowland forest biodiversity and climate change

Structurally connected landscapes allow fundamental ecological mechanisms to operate unimpeded, such as meta-population retention and successful dispersal and migration (Ward et al., 2020). Beyond species-specific benefits, structurally connected landscapes allow for increased ecosystem function and resilience by ensuring nutrient cycling can continue unabated, as well as other important abiotic conditions, such as radiation, wind, light regimes, humidity and key hydrological regimes (Ward et al., 2020; Welborn & Langerhans, 2015). It is well known that land uses such as farming, urbanisation, mining and unsustainable forestry disrupt the connectivity of landscapes to various degrees (Ward et al., 2020). None of the protected areas are currently structurally connected; anthropogenic activities such as farming and settlement expansions were observed to have disrupted the structural connectivity of the protected areas.

Therefore, the future of the protected areas for biodiversity conservation is at risk. The protected areas of the lowland rainforests are principally designated for biodiversity conservation; however, this study has shown an increase in deforestation rates within the protected areas of the lowland rainforest of Nigeria. Deforestation is known to be the major cause of biodiversity erosion; the biodiversity of the lowland rainforests is currently in decline owing to an increase in the rate of deforestation arising from oil palm incursions into protected areas. Previous studies on the biodiversity of the tropical

An oil palm plantation devoid of biodiversity © R. Adewoye

lowland rainforest have revealed the decline due to socio-economic factors such as shifting cultivations, illegal wood harvesting and oil palm plantations, especially within protected areas (Ikemeh, 2013; Koh & Wilcove, 2008; Usman & Adefalu, 2010).

Landscape-level quantification over time

Fitzherbert et al. (2008) asserted that is difficult to quantify the extent to which oil palm contributes to deforestation because of a lack of reliable data. The availability of satellite remote sensing with high spatial resolutions and frequent temporal visits has made monitoring and quantifications of oil palm expansion and its contribution to deforestation possible. The Sentinel-2A images used in this study were sufficient to quantify the magnitude of change and the deforestation rates in the study area. The magnitude of the changes observed within the study period is an indication of the severity of the incursions of oil palm into protected areas of the lowland rainforest of Nigeria. Similarly, the conversion of forest land to oil palm and the changes in other land uses in the study areas are interrelated. The traditional farming system in West Africa is often practised whereby oil palm is cultivated with other crops such as yam, cassava and maize. By the third year, the oil palm seedlings are well established, thus a new area of land is cleared for farming and oil palm establishment. In addition, farming communities tend to settle within a short distance of existing oil palm plantations. Thus, the increase in farmlands and settlements are all secondary activities to the oil palm incursions in protected areas.

Satellite remote sensing provides a reliable means of detecting and mapping oil palm from space. The deployment of Sentinel-2A satellite images with 10-metre resolution and the use of object-based classification techniques which combine contextual information within the image domain to discriminate landscape features such as oil palm canopy features were effective in the delineation of oil palm from the forest canopy and other crops. Several studies have demonstrated the advantages of OBIA and the ability to maximise the aggregation of pixels to objects in the segmentation algorithm. This has enabled object characterisation through sub-objects thereby allowing discrimination of heterogeneous landscapes such as forest canopy and gaps, vegetation patchiness or landscape complexity (Blaschke, 2010). The advantages of the object-based approach were maximally exploited for oil palm plantation discrimination and delineation of the lowland rainforest.

The current advance in the technology of monitoring land uses through cloud computing and big data allows rapid mapping to be performed over large geographical scales. In this study, 10-metre Sentinel-2A data were processed using the GEE cloud computing platform. The GEE platform offers various options and can be tailored, especially when it comes to selecting processing techniques, algorithms and data input. It also allows users to customise the workflow for both preprocessing the satellite data and the speed of satellite data processing with maximum accuracy. The programmable platform also creates opportunities for GEE cloud computing to be combined with potent deep learning techniques.

CONCLUSION

The principal driving forces for the expansion of all agricultural activities are population increase and the need to sustain the livelihoods of the ever-increasing population which runs counter to the Kunming-Montreal Global Biodiversity Framework which aims to halt biodiversity decline and increase global biodiversity by ten-fold. The oil palm industry requires adequate management and monitoring due to its significant impact on the ecosystem, environment, and economy. Without proper oversight, unchecked oil palm activities will contribute to deforestation, which would have serious negative effects on the environment. To manage and plan the sustainable operations of oil palm plantations, a map showing the distribution of oil palm is essential. Effectively identifying and mapping oil palms is made possible by satellite remote sensing.

The object-based classification approach uses contextual information within the image domain to differentiate landscape elements such as oil palm canopy from other land features, hence was successfully used in the delineation of oil palm from the forest canopy and other crops. In this study, OBIA was successfully applied to precisely track and assess the environmental, ecological, and climate change implications of oil palm expansion on the forest ecosystem.

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RESUMEN

La creciente demanda de productos de Elaeis guineensis (palma aceitera africana) tanto para uso doméstico como industrial ha provocado su continua expansión. Nunca se insistirá lo suficiente en la influencia del establecimiento de plantaciones de palma aceitera en el bienestar económico de las comunidades y los ecosistemas. El estudio se centra en la rápida expansión de las plantaciones de palma aceitera dentro de todas las áreas protegidas y reservas forestales de los bosques húmedos de las tierras bajas del estado de Ondo, Nigeria, utilizando. Se utilizó el Análisis de Imágenes Basado en Objetos (OBIA) para cartografiar la expansión de la palma aceitera utilizando imágenes Sentinel-2A de 10 metros de resolución para 2015 y 2020 en Google Earth Engine (GEE). Encontramos expansión de plantaciones de palma aceitera tanto de pequeños agricultores como comerciales dentro de ocho de las trece áreas protegidas, con tres áreas protegidas (Ipele, Onisere y Akure Ofosu) mostrando un aumento significativo en el establecimiento de plantaciones de palma aceitera. El uso de técnicas de clasificación basadas en objetos, que combinan información contextual dentro del dominio de la imagen para discriminar características del paisaje como las del dosel de la palma aceitera, resultó eficaz para delimitar la palma aceitera del dosel del bosque y de otros cultivos. Por su parte, Google Earth Engine, un dominio de teledetección basado en servidores con petabytes de datos, resulta eficaz para supervisar bosques tropicales a gran escala.

RÉSUMÉ

La demande croissante de produits d'Elaeis guineensis (palmier à huile africain), tant pour l'usage domestique qu'industriel, a conduit à une expansion continue. On ne saurait trop insister sur l'influence de l'établissement de plantations de palmiers à huile sur le bien-être économique des communautés et des écosystèmes. L'étude se concentre sur l'expansion rapide des plantations de palmiers à huile dans toutes les zones protégées et les réserves forestières dans les forêts pluviales de basse altitude de l'État d'Ondo, au Nigeria, en utilisant. L'analyse d'images basée sur les objets (OBIA) a été utilisée pour cartographier l'expansion des palmiers à huile à l'aide d'images Sentinel-2A d'une résolution de 10 mètres pour 2015 et 2020 dans Google Earth Engine (GEE). Nous avons constaté une expansion des plantations de palmiers à huile à la fois artisanales et commerciales dans huit des treize zones protégées, trois zones protégées (Ipele, Onisere et Akure Ofosu) montrant une augmentation significative de l'établissement de plantations de palmiers à huile. L'utilisation de techniques de classification basées sur les objets, qui combinent des informations contextuelles dans le domaine de l'image pour distinguer les caractéristiques du paysage telles que les caractéristiques de la canopée du palmier à huile, s'est avérée efficace pour délimiter le palmier à huile de la canopée de la forêt et d'autres cultures. Google Earth Engine, un domaine de télédétection basé sur un serveur avec des pétaoctets de données, est efficace pour surveiller les forêts tropicales à grande échelle.

UPDATING AND ENHANCING THE PROTECTED AREAS NETWORK OF PALESTINE: A STEP TOWARDS BIODIVERSITY CONSERVATION

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ABSTRACT

The Protected Area Network (PAN) in Palestine has undergone a comprehensive evaluation and revision to ensure its effectiveness in conserving biodiversity. This re-evaluation was necessary as the previous PAN lacked clear rationale and included areas designated for non-biological reasons. The evaluation process involved analysing the 50 areas in the previous PAN, as well as conducting Marxan analysis and incorporating new data based on IUCN criteria. The evaluation process led to eliminating, combining and adjusting areas, resulting in a revised PAN consisting of 28 areas. This updated PAN represents all vegetation types and phytogeographical zones in Palestine, effectively protecting key ecoregions in the Mediterranean hotspot. The revision of the PAN has increased the total protected land mass from 9 per cent to 9.98 per cent. This expansion provides additional areas where biodiversity can thrive undisturbed, ensuring the long-term survival of species and ecosystems. The updated PAN was adopted at the highest level of government, signifying the importance and commitment to biodiversity conservation in Palestine. This achievement demonstrates the progress made by Palestine in safeguarding its natural heritage.

Key words: protected area designation, Marxan analysis, bridging science–policy–practice gaps.

INTRODUCTION

Substantial advances have been made related to Aichi Target 11, with the protected areas (PAs) estate increasing globally by 2.3 per cent on land and 5.4 per cent in the oceans between 2010 and 2018, and now covering 15 per cent of land and inland freshwater globally and 7 per cent of the oceans (UNEP-WCMC & IUCN, 2020). Yet, both within and outside PAs, biodiversity globally continues to decline. For example, over one-third of PAs have suffered increasing human pressure (Jones et al., 2018). Further, only half of the protected areas globally show connectivity (Saura et al., 2018; Ward et al., 2020). The Kunming-Montreal Global Biodiversity Framework (GBF) proposed in Target 3 that "by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, recognising indigenous and traditional territories, where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognising and respecting the rights of indigenous peoples and local communities, including over their traditional territories" (CBD, 2022). This was incorporated into the new National Biodiversity Strategy and Action Plans for Palestine (EQA, 2023).

The network of Palestinian protected areas was developed through a complex history from the 1990s when several areas were turned over to the nascent Palestinian authority. The designated 51 areas were then reduced to 50 (49 in West Bank and 1 in Gaza). Yet, due to limited capacity and political issues, there was never a real (re)evaluation of these areas or attempts at studying other potential areas worthy of conservation. As noted in the sixth national report, protected areas in Palestine and

Wadi Al-Qilt with an oasis like habitats © Palestine Institute for Biodiversity and Sustainability

areas of significant importance to them (like the Jordan Valley) are not representative of ecozones/habitats or of actual needs, as this study shows, and are not protected in practice (EQA, 2021). This problem is not only local but global: expansion of protected areas by national governments since 2010 has "had limited success in increasing the coverage across different elements of biodiversity" (Maxwell et al., 2020). An important first step in addressing this issue is to allow local communities to have control over their land and natural resources For more on this subject see Qumsiyeh and Amr (2016) and Qumsiyeh and Albardeiya (2022).

A review and update of the protected area network (PAN) for Palestine was conducted during 2021–2022 using systematic conservation planning principles, CBD protected area design criteria, and IUCN categorisation to establish a representative, efficient and climate-resilient network.

METHODS

Study area

The study area is the Palestinian Territory (hereafter Palestine) , located between the Eastern Mediterranean and west of the Jordanian River, includes 5,860 km². While we could not travel to Gaza Strip for field work, we included the protected area of Wadi Gaza and included in analysis based on available data on that area. The study included 50 'nature reserves/protected areas' listed by Israel in the area (Figure 1) in addition to eight other areas (seven identified by initial Marxan analysis and one by data collected and not included in Marxan).

Marxan analysis and GIS modelling

ArcGIS software was used to prepare the input layers and present modelling output, and Marxan Systematic Conservation Planning Software was used to perform

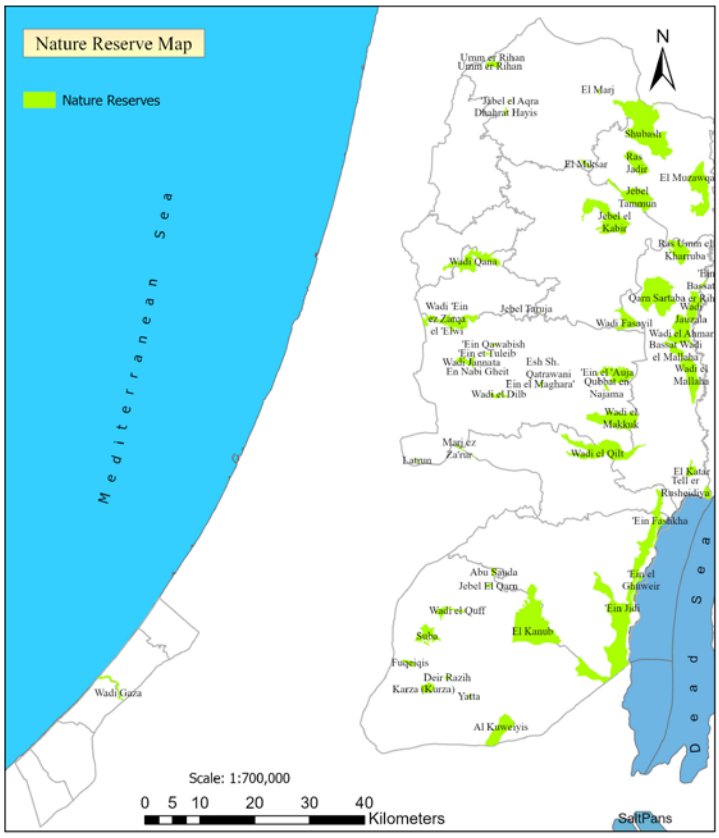

Figure 1. The study area presenting the previous PAN areas designated by Israeli occupation authorities. (Environment Quality Authority)

the conservation planning analysis (Ball & Possingham, 2000; Possingham et al., 2001), by comparing alternate solutions composed of a set of planning units using a mathematical function that assigns a value for each set of units. The value is assigned based on the cost of including the planning units in the PA network and the cost of not meeting conservation targets. Giving a value for each set of planning units, or options (solutions), for reserve networks will enable the automation of the selection of good PA networks. Marxan also allows a consideration of the fragmentation of the PA network by testing the boundary length of each alternative for the PA network. Marxan addresses these requirements by having defined targets for each identified conservation feature. These targets become design constraints and are tested against the cost of the design.

To apply Marxan analysis in this study, the following steps were taken:

1. **Preparation of planning units:** The official border map for Palestine was obtained from the Palestinian Environment Quality Authority (EQA). The area was divided into identical hexagon planning units, each with a size of 100 ha. The planning units were created using the extension 'Repeat shapes for ArcGIS 10.8' from Jenness Enterprises http://www.jennes-

Table 1. Layers used to create the Relative Biodiversity Index (RBI)

Risk element	Geometry type	Intensity value	Influence distance (m)	Distance decay
Built up areas	Polygons	100	5000	Concave
Municipal organisational boundaries (Master plan)	Polygons	100	5000	Concave
Major roads	Lines	100	5000	Convex
Minor roads	Lines	100	5000	Convex
Negative land use types	Polygons	100	5000	Concave
Construction sites	Points	100	5000	Concave

Table 2. Layers used to create the RBI: NT (not threatened), VU (vulnerable), EN (endangered), CR (critically endangered)

Layer name	Geometry type	Source
Distribution of threatened plants NT, VU, EN, CR	Points	https://www.gbif.org/ Banan Al Sheikh
Distribution of threatened fauna and avifauna NT, VU, EN, CR	Points	https://www.gbif.org/
IBAs	Polygon	BirdLife International (2017)
KBAs	Polygon	KBA Database https://www.key-biodiversityareas.org/
Existing PAs	Polygon	EQA

sent.com. The total number of resulting planning units was 5,913 planning units, which were used as the basis of analysis and for assessing environmental risk, conservation value and identifying the PA design scenarios.

2. **Identifying the environmental risk surface (ERS):** ERS for this project was created using the 'Protected Area Tools for ArcGIS' plug-in developed by the Nature Conservancy in 2008 (Schill & Raber, 2009). In order to produce a modelled risk surface, each risk element should be mapped individually, then all risk elements should be combined. A risk element could be represented by a point, line or polygon. Each risk element is then assigned values (intensity value, influence value, distance decay function) (Table 1).
3. **Relative biodiversity rareness index (RBI):** used as complementary to the Marxan analysis. The RBI analysis is used to calculate the relative uniqueness or rareness of habitats across a study area and quantify the area weighted relative contribution of each planning unit compared to the total distribution of each conservation target using the following equation as stated in Schill and Raber (2009) (see Table 2). Existing Important Bird Areas (IBAs) and Key Biodiversity Areas (KBAs) were included even though we think both need to be reevaluated based on more detailed scientific data yet to be collected. We also took into account proposed important plant areas (Radford et al., 2010).
4. **Preparation and running of Marxan:** input files from previous steps were prepared and uploaded to the software, and four different scenarios were applied to produce a proposal for the new PAN in Palestine. The four scenarios considered the conservation percentage of vegetation types (VT) and extent of occurrence (EOT) of threatened animals and plants, specifically: 1) VT 5%, EOT 5%; 2) VT 10%, EOT 10%; 3) VT 17%, EOT 20%; 4) VT 30%, EOT 20%. The four scenarios were then compared to find the areas of overlap and consolidate them into the most critical areas identified by Marxan analysis (see results).
5. **Additional data gathering and validation:** Per standard protocols (e.g. Daigle et al., 2020), key data were gathered on each area including species distribution and threats collected from fieldwork, internet available data, publications, published research papers, https://www.gbif.org/ and https://biogis.huji.ac.il/ data. Data was collected on elements needed for scoring based on the criteria. Information on suggested management of areas, including threats and opportunities, was added when not available. Buffer zones were considered, but were not necessarily added to the protected area itself, creating

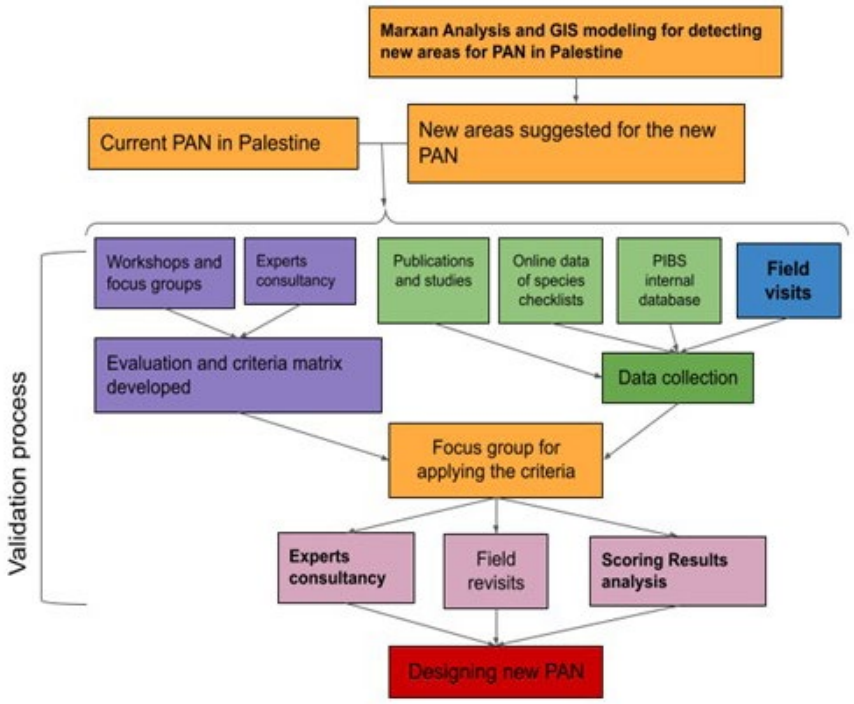

Figure 2. Methodological framework

an internal database of data for each PA. Between March 2022 and August 2022, 22 field trips were conducted by biodiversity experts from the Palestine Institute for Biodiversity and Sustainability (PIBS) and EQA, to provide an updated status of the PAs based on the criteria. Notes were taken, including on urban expansion and settlements near PAs. All protected areas were visited except Um Rihan which was annexed to the Israeli territories and inaccessible to Palestinians.

6. **Criteria development and application:** Considering IUCN guidelines and the above studies, 13 principles were adopted for the PA validation, and criteria and measures were developed with numeric values for scoring and validation of each area based on the principles and criteria listed here https://www.palestinenature.org/conservation/f3e7553fb6.pdf. The highest possible score was 53 and lowest score 15 (median 34). Scoring was done collectively by consensus and involved representatives of EQA and PIBS as well as external experts. When information was lacking in any particular category, it was scored as average to avoid biasing data. The methodological framework is summarised in Figure 2.

RESULTS

Each of the four Marxan scenarios resulted in a proposal to include planning units within the PAN that achieve the conservation targets set for each scenario. The ensemble of the four scenarios was considered the basis for the collective PAN review proposal. Overlay analysis of the solutions of each of the four Marxan scenarios

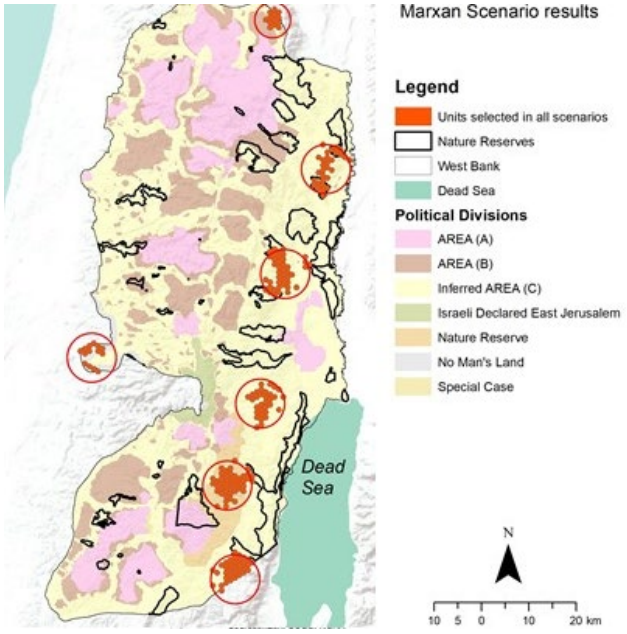

Figure 3. The Marxan scenario for protected areas in Palestine identified seven key areas and one was added later for further analysis (Environment Quality Authority)

highlighted seven areas that were common and were thus proposed for inclusion in the PAN revaluation (Figure 3). The Marxan analysis was done before data became available from an eighth area called Al-Arqoub (south Jerusalem Hills) which showed important biodiversity (see Qumsiyeh et al., 2023), so this area was also added for further evaluation.

Table 3. List of protected areas in the new PAN. The IUCN categories from I to VI are designated based on Dudley (2008) plus the intensive focus group and workshop meetings

Protected areas	Area (km^2)	Governorate/s	IUCN category	Other notes
Dead Sea	235.08	Jericho, Jerusalem, Bethlehem, Hebron	IV	The most important area with potential for designation under IUCN as Red Listed ecosystem
Ein el Auja	12.37	Ramallah and Al Bireh	II	Unchanged borders
Jerusalem Wilderness area	52.84	Jerusalem, Bethlehem, Jericho	Ib	Newly designated PA
Wadi el Qilt	28.64	Jericho, Jerusalem, Ramallah and Al Bireh	IV	Very small adjustments in borders on the western side
AlAghwar (Jordan Valley)	54.52	Jericho	II	Combining four previously adjacent areas
Wadi Fasayil	8.38	Jericho, Nablus	II	Unchanged borders
Al Kanub	29.02	Hebron	IV	Significant adjustments of borders
Al Muzawqa	28.33	Tubas	IV	Border adjustments
El Miksar	1.22	Jenin	IV	Border adjustments
Latrun	2.33	Ramallah and Al Bireh	IV	Newly designated PA
Marj ez Zarur	2.30	Jerusalem	IV	Unchanged borders
Qarn Sartaba	31.19	Jericho	IV	Border adjustments
Umm er Rihan	3.70	Jenin	IV	Border adjustments
Wadi Ein ez Zarqa el Elwi	10.53	Ramallah and Al Bireh, Salfit	IV	Border adjustments
Wadi Jannata	2.80	Ramallah and Al Bireh	II	Border adjustments
Wadi Qana	15.30	Salfit, Qalqilya	II	Border adjustments
Al Kuweiyis	12.69	Hebron	IV	Border adjustments
Ain Qawabish	0.452	Ramallah and Al Bireh	V	Border adjustments
Deir Razih	0.352	Hebron	V	Border adjustments
El Katar	3.18	Jericho	V	Unchanged borders
El Marj	0.41	Jenin	V	Significant adjustments of borders
Jabal Al-Qarn	0.533	Hebron	V	Potential national eco-garden
Ras Jadir	9.50	Tubas	IV	Significant adjustments of borders
Shubash	52.86	Tubas, Jenin	V	Potential biosphere reserve
Al Arqoub	9.10	Bethlehem	V	Potential biosphere reserve
Wadi Al Quff	3.44	Hebron	V	Potential biosphere reserve
Wadi ed Dilb	1.56	Ramallah and Al Bireh	VI	Significant adjustments of borders
Wadi Gaza	2.84	Gaza	VI	Unchanged borders

Thus, as a basis for **field validation** and for finalising the revised PAN, the following areas were validated:

- Areas that were selected in each Marxan scenario (Figure 3);
- Existing PAs that were not selected in any of the PA scenarios (except scenario 4 as it has current PAs locked in the model);
- PAs that are adjacent to each other with no clear reason for separation. This was to validate if there are practical reasons or field observations to support the decision to keep adjacent PAs separate;
- PAs that are small in size (less than 1 km^2), this was to validate these sites against the PAN design criteria and provide recommendations regarding their status.

A set of criteria was developed and assigned weights for evaluation of all 50 previously listed protected areas plus eight potential new areas (seven identified from Marxan and one from new data). Because of the tabulations of the scores, the maximum score was 48/53 and the minimum was 21/53. Raw data and scoring can be found as supplementary material (https://www.palestinenature.org/conservation/f3e7553fb6.pdf).

Table 4. Vegetation cover in the new PAN

Vegetation cover	Area of vegetation cover (km²)	Designated PAs (area within vegetation type km²)	% of vegetation type from designated PAs	KBAs (area within vegetation type) km²	% of vegetation type from KBAs
Desert savanna vegetation (15)	227	74.30	32.7	130	57.2
Desert vegetation (12)	187	97.38	52.1	81	43.3
Maquis and forest (1)	2,559	53.86	2.1	531	20.7
Oases with Sudanian trees (14)	87	9.39	10.8	28	32.1
Park forest of *Ceratonia siliqua and Pistacia lentiscus* (5)	917	59.03	6.4	185	20.1
Mediterranean Savannoid vegetation (7)	74	0.64	0.9	11	14.8
Semi-steppe batha (8)	846	123.40	14.6	333	39.3
Steppe vegetation (10)	448	153.64	34.3	167	37.2
Swamps and reed thickets (17)	5	2.51	50.2	3	60.0
Synanthropic vegetation with *Ziziphus spina-christi trees* (19b)	65	0.00	0.0	3	4.62
Synanthropic vegetation with *Ziziphus spina-christi* and *Acacia raddiana* trees (19c)	3	0.00	0.0	0	0.00
Wet salines (18)	101	21.99	21.8	60	59.4
***Ziziphus lotus* with herbaceous vegetation (6)**	135	17.73	13.1	42	31.1
Total	5,427	614	-	1,574	-

The assessment team set a cut-off value of 30 and all areas receiving a score of 30 or below were excluded, 19 of the original PAs and three of the Marxan identified areas (total 22 areas) scored 30 or less (Table 3) via the identified criteria and were eliminated from further consideration. Examples of these are very small areas like an area of less than 6,000 m² called Ash Sheikh Qatrawwani near Attara whose trees are mostly planted and around a shrine which is protected already as a town's recreational area. Many others were designated by Israel as 'nature reserves' without sufficient biological justification: Wadi Al Makkuk is used as a military training ground and Ein Al Maghara and Qubbat en Najama were already used for expanding nearby Jewish settlements (Beit El and Rimonim respectively). The remaining 36 areas that scored high based on the criteria were revisited for potential mergers, and border adjustments were made using ArcGIS software based on on-the-ground evaluations, proximity and current maps. This resulted in a final list of 28 proposed PAs covering 9.98 per cent of the landmass of Palestine (Table 3). These PAs cover all ecosystems, habitats and phytogeographical regions and aim to represent at least 10 per cent of all vegetation cover types. The original network is shown in Figure 1 and the new PAN is shown in Figure 4. In addition, the vegetation cover size is calculated within the new PAN, as shown in Table 4.

Categorisation of the new network

In collaboration with stakeholders, we looked at the new PAN and gave them designations per IUCN criteria (Dudley, 2008) (Table 3). Determining whether a site is or should be a protected area as defined by IUCN is far more difficult than giving it a categorisation. See discussion for issues of implementation.

The 28 areas identified in the new PAN for Palestine cover all vegetation classifications (Table 4), all phytogeographical zones, key habitats, and the two ecoregions identified as part of the critical biodiversity hotspots in the Eastern Mediterranean region (the Conifer-Sclerophyllous broadleaf forests and the Jordan River basin habitats, Birdlife International, 2017). If

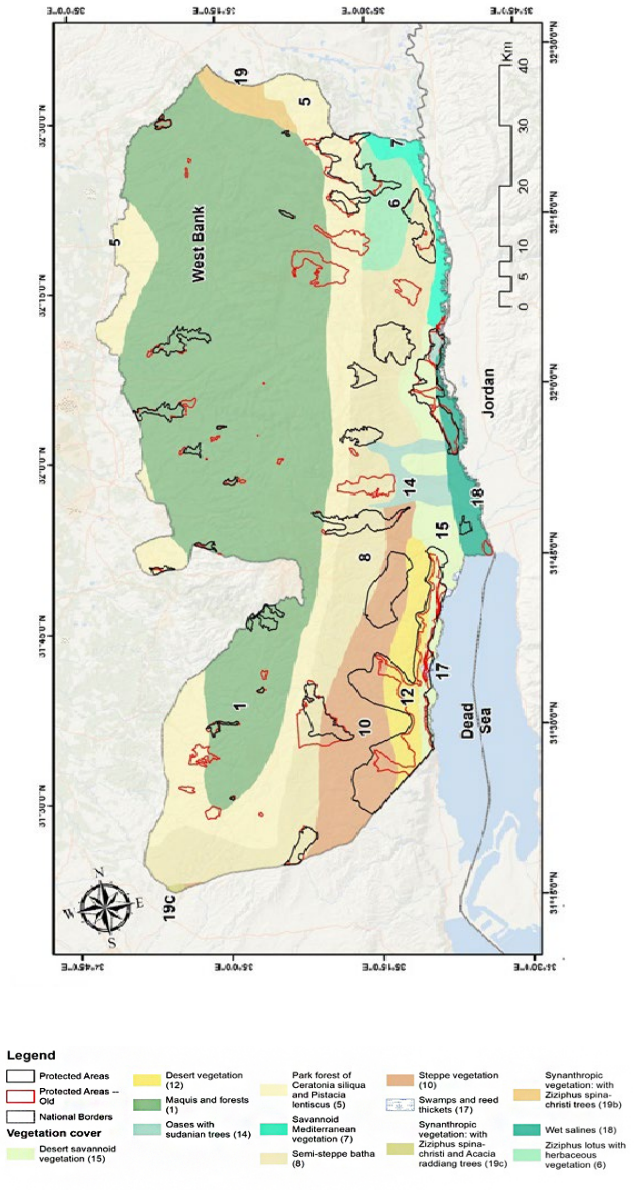

Figure 4. View of the new proposed network in relation to habitats. Here and elsewhere, red shows old borders or areas, and black shows new ones (Environment Quality Authority)

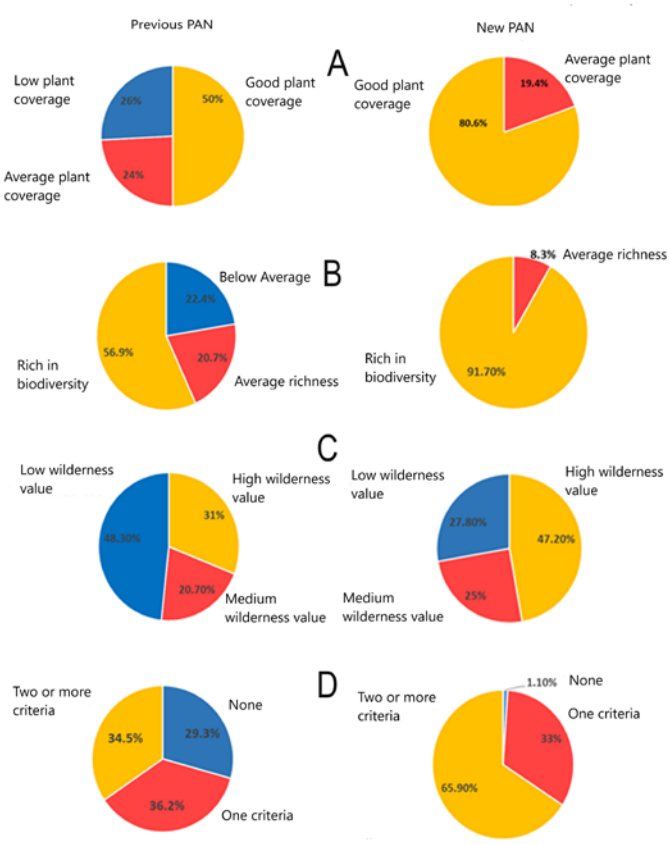

Figure 5. Selected categories for representation in the old PAN and the new PAN: (a) plant cover (b) richness in biodiversity (c) wilderness/wildness value (d) existing designation as KBA, IBA, IPA, etc. (e) land ownership

managed well, the PAN can protect the majority of known endangered and threatened species in Palestine. The PAN terrain includes:

1. Western slopes (typical Mediterranean) include coastal elements near Qalqilya like Wadi Ein Al Zarqa Al Ulwi PA). Protected areas here are relatively small by necessity as they are located close to urban developments and settlement expansions.
2. Eastern slopes: These are unique habitats with transitions from Mediterranean to Irano-Turanian to Saharo-Arabian elements.
3. Jordan Valley area: This is a semi-arid area with an oasis and penetration of Sudanese-Ethiopian elements.
4. Coastal (Wadi Gaza): With the potential to also include marine protected areas at a later date.

Figure 5 shows improvement in several areas of the new PAN over the earlier PAN.

DISCUSSION AND CONCLUSION

Earlier data are available from several sources, including BirdLife International for the important bird areas, Radford et al. (2011) for the important plant areas, Ghattas et al. (2005) for the natural forests, and Garstecki et al. (2010) for the protected areas. There was a preliminary summary (but not evaluation) of existing protected areas by Qumsiyeh and Amr (2016 also published by HSF, 2017). While significant environmental work was done earlier by the Environment Quality Authority (EQA) and stakeholders to protect the nature reserves, this remained limited because of lack of information and access. Israel controls Gaza's maritime zone and maintains a total blockade of the Gaza Strip. In the West Bank, land designated 'Area C' (the majority of land in the West Bank) is under

Al-Arqoub protected area newly designated (near Battir) © Palestine Institute for Biodiversity and Sustainability

Israeli civil and military control. This limits Palestine's ability to implement spatial planning. Most of the current reserves are located within Area C and under the control of the Israeli civil administration (Garstecki et al., 2010; Görlach et al., 2011; Qumsiyeh & Albardeiya, 2022). It is also worth noting that 36.2 per cent of the designated protected areas overlap with Israeli settlements and 39.5 per cent overlap with closed military areas and bases. Such utilisation of a protected area confirms that their declaration does not correspond to the international definition of a protected area (Dromi & Shani, 2020; Rotem & Weil, 2014). This was seen more clearly in our analysis, with details and data on each PA regarding the reasons for its earlier designation, and as our criteria have shown on some 50 per cent of studied areas with data available, the majority of earlier (Israeli) designated PAs are designated for political purposes (Alterman, 2001). Indeed our analysis shown in the results section led to eliminating many areas and consolidating and restructuring others. The new list of 28 areas increased habitat and species representation and was initially adopted by the EQA, Ministry of Agriculture, and Ministry of Local Government and then by all ministries at an official cabinet meeting. It was uploaded on https://www.protectedplanet.net/country/PSE. This is done in line with national and global targets and strategies.

Achieving the Global Biodiversity Framework (GBF) requires urgent and intensive actions and PANs are a key component of this (CBD, 2022; Leadley et al., 2020). The 28 areas that were designated as a result of this work represent those with high scores based on the criteria identified and those areas ended up being representative of vegetation types and phytogeographical zones. They range in size from 0.352 to 235.08 km^2. While some small areas were excluded, some were kept because they added value and richness to the PAN (Riva & Fahrig, 2022). The largest designated area combined and expanded a previous one and is now called the Dead Sea PA (category Ia). This work represents the state-of-the-art knowledge regarding PAN. Much more work is needed especially to complete detailed studies of the areas that were not surveyed (for fauna and flora) and to develop management plans for each PA (currently management plans are available for 6 of the 28 areas). The baseline data generated also opens avenues of research in other areas like representation and effectiveness (see examples in Pliscoff & Fuentes-Castillo, 2011; Pressey et al., 2021). Finally, it is recommended that a protected area management agency be established at the central government level, supported by good data underlying policy, which will eventually facilitate an integrated management system for the PAN. It is also suggested that local management be delegated to local entities under the supervision of this authority. The science of area conservation continues to evolve to meet the GBF targets and goals (CBD, 2022; Nicholson et al., 2021). It is recommended that scientific knowledge and flexibility be maintained in Palestine to enable the protection of the few remaining habitats and ecosystems in the country. This can be achieved through transparency, science-based decision-making, democratic participation and local involvement.

A number of gaps and challenges are revealed in the analysis and generation of the new PAN, including a

lack of systematic documentation, weak stakeholder engagement in the planning and designation process, unclear governance and management of protected areas, and unsystematic planning and designation based on natural values. It is evident that there is a need to set clear targets for the conservation of critical habitats and species within the network. Furthermore, current research programmes are not covering protected areas in a systematic manner. There is a need to update and strengthen the current conservation legislation in Palestine in order to comply with international treaties and obligations. To do this, detailed guidance must be provided on how the EQA should fulfil its duties as outlined in Article 40 of the law. Additionally, scientific data must be collected on all protected areas and potential protected areas using the best available methods for geography, geology, hydrology, fauna and flora. This data can then be used to identify biodiversity hotspots for conservation priorities. Furthermore, management plans should be developed that take into account social, cultural and economic factors as well as an ecosystem approach. By doing so, Palestine can ensure that its conservation efforts are effective and in line with international standards. In order to ensure the proper planning and designation of protected areas in Palestine, a clear reference vegetation map must be used. The current review process for protected areas has identified reference vegetation that can be used as a basis for reviewing and updating the PAs network. This reference vegetation map should provide detailed information on the various vegetation types present in Palestine, including their distribution, composition and structure. This will enable decision-makers to make informed decisions about prioritising protected areas.

The fragmented nature of the landscape in Palestine poses a challenge. Tabarelli and Gascon (2005) recommend dealing with such issues by: 1) incorporating protection measures as part of development projects; 2) protecting large areas and preventing the fragmentation of currently contiguous patches of forest; 3) managing forest edges when creating forest patches; 4) protecting gallery forests along waterways to connect isolated forest patches; 5) controlling the use of fire and the introduction of exotic plant species, and limiting the use of toxic chemicals in areas near forest patches; and 6) promoting reforestation and forest cover in critical areas of the landscape.

Another major challenge for the PAN in Palestine is the lack of baseline studies that cover rich biodiversity areas, their location, distribution and what they contain. Some of this work was already done focused on threats (Alhirsh et. Al. 2016; Al-Sheikh & Qumsiyeh, 2022; Qumsiyeh & Abusarhan, 2021; Qumsiyeh et al., 2016) and even

Habitat in Wadi Qana Protected area © Palestine Institute for Biodiversity and Sustainability

a new designation of a threatened "microreserve" was recently done (Qumsiyeh et al., 2022). Yet, significant data must be collected inside and outside the PAN (Cox & Underwood, 2011; Levin & Shmida, 2007). Finally, while we are satisfied that the results of the new PAN are representative, the onus is on the responsible authorities to ensure local participation to conserve these areas and other areas (Beltrán, 2000; Borrini-Feyerabend et al., 2013; Chape et al., 2008) and perhaps even designate some areas as biosphere reserves to ensure adequate valorisation of ecosystem services (Bridgewater, 2016; Ferreira et al., 2018) and integration into the landscape design (Ervin et al., 2010). As the new PAN was adopted by the highest national government authorities (Ministerial Cabinet), it is obligatory on all ministers to implement the relevant portions in their ministries' sectoral plans. Further, the new PAN was incorporated in the new National Spatial Plan which impacts local and national planning, especially land use, thus bridging the science–policy gap. There remains of course a need to bridge the policy–practice gap. To this end, the National Biodiversity Strategy and Action Plan 2023–2050 articulated specific actions to be achieved. This is all contingent on the Israeli occupation allowing such actions especially in parts of the West Bank (60 per cent of the land called 'area C').

An example of this issue is that the management plan for one of the newly designated protected areas was produced ('Al-Arqoub' in South Jerusalem Hills and Valleys) and the local communities with stakeholders engaged in actual activities on the ground to protect it (Qumsiyeh et al., 2023; Qumsiyeh et al., submitted). However, a large part of the natural area was designated for the expansion of existing Jewish colonial settlements. Better protection can be afforded if the local people are not excluded from planning by the authorities, or better yet if the local people are given control of their natural resources as enshrined in UN resolutions and international law. It would also be worthwhile to study many species for potential Red Listing, which aids conservation, and study the areas identified here for potential inclusion on the IUCN Red List of Ecosystems (Hockings et al., 2019; Keith et al., 2015). Especially interesting areas are the areas around the Dead Sea (the lowest point on Earth, part of the Great Rift Valley).

Finally, we note that the methodology for the new PAN articulated here and its inclusion in workshops and focus groups in ways that bridge science–policy–practice gaps will be applicable to many developing countries, especially those facing difficult geopolitical situations. The main point to remember is that local people can and should implement protection despite the challenges they face.

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RESUMEN

La Red de Áreas Protegidas (RAP) de Palestina ha sido objeto de una evaluación y revisión exhaustivas para garantizar su eficacia en la conservación de la biodiversidad. Esta reevaluación era necesaria ya que la anterior RAP carecía de una justificación clara e incluía zonas designadas por razones no biológicas. El proceso de evaluación implicó el análisis de las 50 áreas del PAN anterior, así como la realización de un análisis de Marxan y la incorporación de nuevos datos basados en los criterios de la UICN. El proceso de evaluación llevó a eliminar, combinar y ajustar áreas, lo que dio como resultado un PAN revisado compuesto por 28 áreas. Esta PAN actualizada representa todos los tipos de vegetación y zonas fitogeográficas de Palestina, protegiendo eficazmente las ecorregiones clave del punto caliente mediterráneo. La revisión del PAN ha aumentado la masa terrestre total protegida del 9% al 9,98%. Esta ampliación proporciona zonas adicionales donde la biodiversidad puede prosperar sin perturbaciones, garantizando la supervivencia a largo plazo de especies y ecosistemas. El PAN actualizado fue aprobado al más alto nivel gubernamental, lo que significa la importancia y el compromiso con la conservación de la biodiversidad en Palestina. Este logro demuestra los progresos realizados por Palestina en la salvaguarda de su patrimonio natural.

RÉSUMÉ

Le réseau de zones protégées (PAN) en Palestine a fait l'objet d'une évaluation et d'une révision complètes afin de garantir son efficacité en matière de conservation de la biodiversité. Cette réévaluation était nécessaire car le PAN précédent manquait de logique claire et incluait des zones désignées pour des raisons non biologiques. Le processus d'évaluation a consisté à analyser les 50 zones du PAN précédent, à effectuer une analyse de Marxan et à intégrer de nouvelles données basées sur les critères de l'UICN. Le processus d'évaluation a permis d'éliminer, de combiner et d'ajuster des zones, ce qui a abouti à un PAN révisé composé de 28 zones. Ce PAN actualisé représente tous les types de végétation et toutes les zones phytogéographiques de Palestine, protégeant ainsi efficacement les écorégions clés du hotspot méditerranéen. La révision du PAN a permis d'augmenter la masse terrestre protégée totale de 9 % à 9,98 %. Cette expansion fournit des zones supplémentaires où la biodiversité peut se développer sans être perturbée, assurant ainsi la survie à long terme des espèces et des écosystèmes. Le PAN actualisé a été adopté au plus haut niveau du gouvernement, ce qui témoigne de l'importance de la conservation de la biodiversité en Palestine et de l'engagement pris à cet égard. Cette réalisation démontre les progrès accomplis par la Palestine dans la sauvegarde de son patrimoine naturel.

SOCIAL MEDIA AS A CONTRIBUTOR TO CONFLICTS IN PROTECTED AREAS: EXPERIENCES, PROBLEMS AND POTENTIAL SOLUTIONS

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ABSTRACT

Within two decades, social media has profoundly changed modern society. The various effects of this rapid development are increasingly the subject of interdisciplinary research. For protected areas, the focus has so far been on the possibilities of social media as a means of visitor communication and monitoring. This is an exploratory study identifying case studies of protected areas where visitors' use of social media has contributed to negative environmental effects. Furthermore, potential measures to address these challenges are provided. Data collection was conducted with a selective review of academic and non-academic literature using a global research framework and EU-wide qualitative email interviews with staff from 44 national parks. The research results were structured using the DPSIR framework of the European Environment Agency. Social media trend-driven mass tourism and dissemination of nature-damaging behaviour via social media appear to be the most pressing issues. To implement conservation measures successfully and ensure long-term conservation goals, protected area management must consider the potential negative effects of social media. As digitisation progresses, the urgency of corresponding studies and measures increases. The enhancement of digital skills and digital visitor guidance by nature conservation actors may help to counteract future negative environmental effects.

Keywords: national park, mass tourism, nature-damaging behaviour, DPSIR model, Leave No Trace

INTRODUCTION

Since 2005, social media have become an elementary part of modern life with a growing influence on information flows and opinion making (Fuchs, 2021). 'Social media' is a collective term for a wide range of internet-based applications, whose conceptual framework is yet to be conclusively defined. The term generally refers to individuals and groups creating profiles for websites or apps that are designed and maintained by the respective social media service (Obar & Wildman, 2015). By connecting these profiles, social media facilitates the development of online social networks (ibid.). Thereby, social media services allow their users to make information of all kinds available to others (Taddicken & Schmidt, 2017). This user-generated content (UGC) is the key feature of social media (Obar & Wildman, 2015) and is characterised by being persistent, replicable and searchable (Taddicken & Schmidt, 2017).

In recent years, interest in the role of social media in nature conservation has increased. Researchers have discussed social media as a means to communicate nature conservation concerns to the public (Miller & Heiland, 2021; Šmelhausová et al., 2022), and for gathering data (such as georeferenced UGC) about visitors' locations and activities in protected areas (Ghermandi, 2022; Teles da Mota & Pickering, 2020; Wilkins et al., 2021).

However, headlines regarding the adverse impacts of social media on the protected environment contrast their benefits for nature conservation practice. Newspaper headlines from *The New York Times* (Holson, 2018) or *The Guardian* (Simmonds et al., 2018) have drawn the public's attention to the alarming increase in visitor numbers to US-protected areas. Social media platform Instagram is cited as the main cause of nature-destroying crowds (ibid.). Geotagged photos allow social media

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users to easily find (protected) locations (Holson, 2018). On-site, outdoor apps with maps and user-generated route suggestions empower visitors to move independently of existing infrastructure and traditional visitor guidance (Job et al., 2016). This challenges the prediction of development trends in protected areas and consequently their management (Øian et al., 2018).

With increasing user numbers worldwide (Dixon, 2023), the influence of social media is growing. Therefore, nature conservation actors will have to address the potential environmental effects social media exerts on protected areas. This paper explores visitors' use of social media and resulting conflicts in protected areas, providing a first systematic overview of potential cause-effect relationships. Conflict experiences from various protected areas are compiled and analysed to identify problems and solutions.

METHODS

An exploratory research approach was adopted to identify case studies of protected areas exemplifying the conflict potential of visitors' use of social media. Given the lack of scientific literature on this topic, a selective review of both academic and non-academic literature was initially conducted and supplemented by qualitative email interviews.

Selective review of academic and non-academic literature

The review scope of scientific and non-scientific literature was broadly defined to include case studies from protected areas of all categories and geographic locations and social media services. The literature search was conducted using Google Scholar and Google search engines with English and German keywords. In the first research phase, a search entry contained a conservation-related term ('protected area', 'national park' or 'nature conservation'), a social media term ('social media', 'Instagram' or 'YouTube') and the term 'problem' or 'conflict'. A search result was considered as a case study if a described conflict occurred in a protected area with explicit links to visitors using social media. The latter applied if either a specific social media service or social media in general were suggested as a contributing cause. In the second phase, a more targeted search of information about the case studies identified in the first phase aimed at a deeper understanding of the individual situation. In the third phase, references to other potential case studies in the identified search results were reviewed for relevant information. When identifying a new case study, the second phase was carried out again. This approach did not allow for a complete review of relevant literature but provided an initial overview of relevant case studies.

Box 1. Interview questions

Does the use of social media have an impact on the number and behaviour of visitors in your national park? If this is the case:

1 What are the positive and negative impacts in your national park?

2 Have measures already been taken or are they planned in your national park to counteract negative impacts? Which measures are involved?

3 If (2) applies: Can conclusions already be made about the effect or success of these measures?

Qualitative email interviews

EU-wide, semi-structured, qualitative email interviews were conducted to gather experiences from national park staff on local conflicts related to social media. The research scope was limited to national parks classified as IUCN management category II in EU member states with an additional geographical boundary of continental Europe. Based on the World Database on Protected Areas (WDPA), relevant national parks were identified. With the defined scope and restrictions due to missing and incomplete WDPA data, 229 national parks were compiled. An internet search was used to collect the email addresses of the respective national park employees. Email interview requests were ultimately sent to the administrations of 177 national parks.

The interview request followed the 'Guidelines for Conducting Effective E-Mail Interviews' by Meho (2006) and directly integrated the interview questions (see Box 1). The recipients were asked to describe their experiences of possible effects of social media in their respective national parks and to be open to potential follow-up questions. To protect the anonymity of the interviewee, complete interview responses are not disclosed.

The interview data were evaluated using thematic analysis (Braun & Clarke, 2012), combining a deductive and inductive approach. The pre-structuring of the data complies with the DPSIR framework developed by the European Environment Agency (EEA) (1999) addressing the components: Driving forces, Pressures, States, Impacts and Responses. The elements were derived from the literature search results. In the following analysis of the interview data, the email interviews were divided into thematic response sections (direct quotes) and further assigned to thematically matching elements.

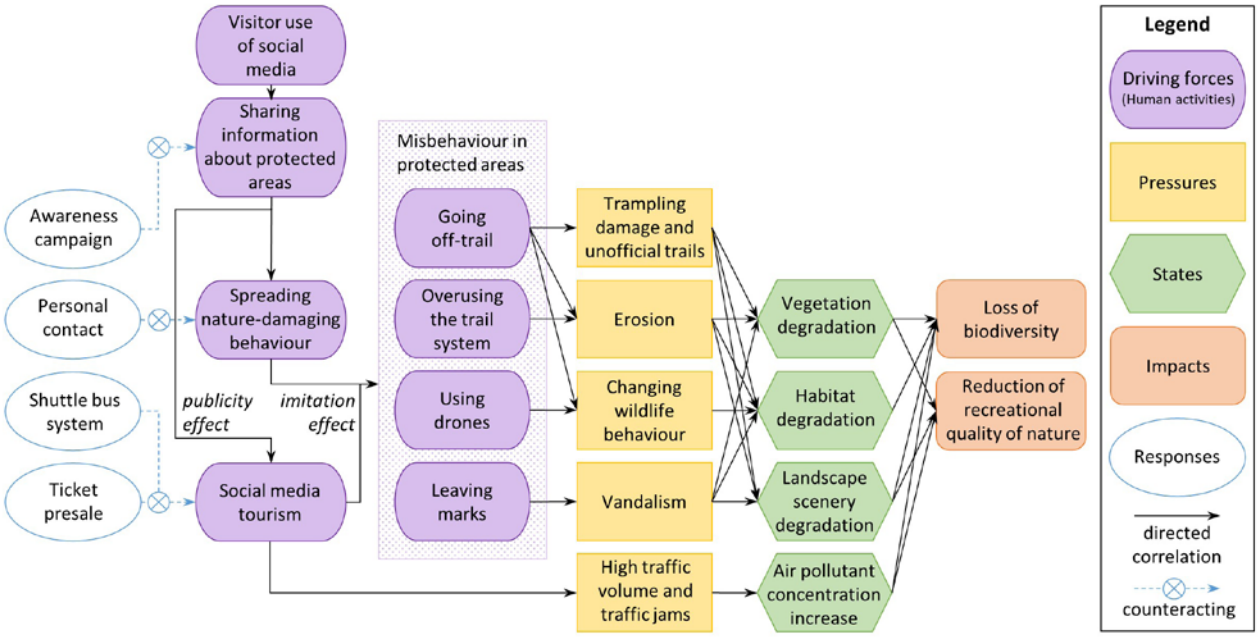

Figure 1. DPSIR model illustrating potential relationships between visitors' use of social media and environmental effects in protected areas, including counter-measures

RESULTS

Conflict perception of interviewed national park staff

Out of 177 email interview requests, 44 were answered (response rate of 25 per cent). For a complete list of national parks providing interview responses, see Table 1 (supplementary online material). In 15 national parks, the interviewees reported conflicts that they (partly) attributed to social media. They refer to content seen on social media showing misbehaviour or observed behaviour on-site (e.g. crowding) believed to be related to social media activities. A further 16 respondents assume such conflicts, presumably because descriptions of conflicts are not directly linked to social media or are accompanied by uncertainties or a lack of specific data. The other 13 interviewees are unaware of social media-related conflicts in their respective national parks or report that no conclusive studies have been conducted on the subject so far.

Case studies and the DPSIR model

The results comprise a total of 57 case studies. The review of academic and non-academic literature identified 26 case studies, with a strong emphasis on non-scientific sources (see discussion). A complete overview of these case studies is listed in Table 2 (supplementary online material). Another 31 case studies originated from the email interviews describing conflicts (presumably) related to visitors using social media. Based on the case studies, a DPSIR model was developed to explain correlations between visitors' use of social media and negative environmental impacts in protected areas, including potential responses. Figure 1 gives a visual overview of the potential causal relationships. Each text field represents an element of the DPSIR model. The colour codes indicate the affiliation to the components of the DPSIR framework. The elements are connected by directed relationships shown by black arrows, illustrating the potential cause-effect relationships.

In the following, I present central aspects of the DPSIR model focusing on the driving forces directly related to social media: spreading nature-damaging behaviour and social media tourism (Figure 1, column 2). In addition, I address specific misbehaviour in protected areas (column 3) and name the associated pressures, states and impacts (columns 4–6). When illustrating interrelationships using selected case studies, elements of the DPSIR model are indicated by quotation marks in parentheses. Finally, I outline potential responses (column 1) that are intended to counteract (blue dashed arrows) the initial driving forces and are therefore placed before the driving forces in Figure 1.

Spreading nature-damaging behaviour via social media

Social media as a source of information and inspiration for visiting protected areas can become problematic when they provide access to content that is non-compliant with protected area regulations and rules (according to 19 interviewees). Since any social media user can create (almost) uncontrolled and uncensored content, social media can contribute to a vigorous sharing of individual and non-compliant behaviour in

Demonstrating potential nature-damaging behaviour – a visitor to Joshua Tree National Park posing on a protected Joshua tree
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protected areas. By spreading such content, other social media users are inspired to imitate the misbehaviour (imitation effect). Three interviewees emphasised the lack of critical reflection on information in social media probably adding significantly to the problem.

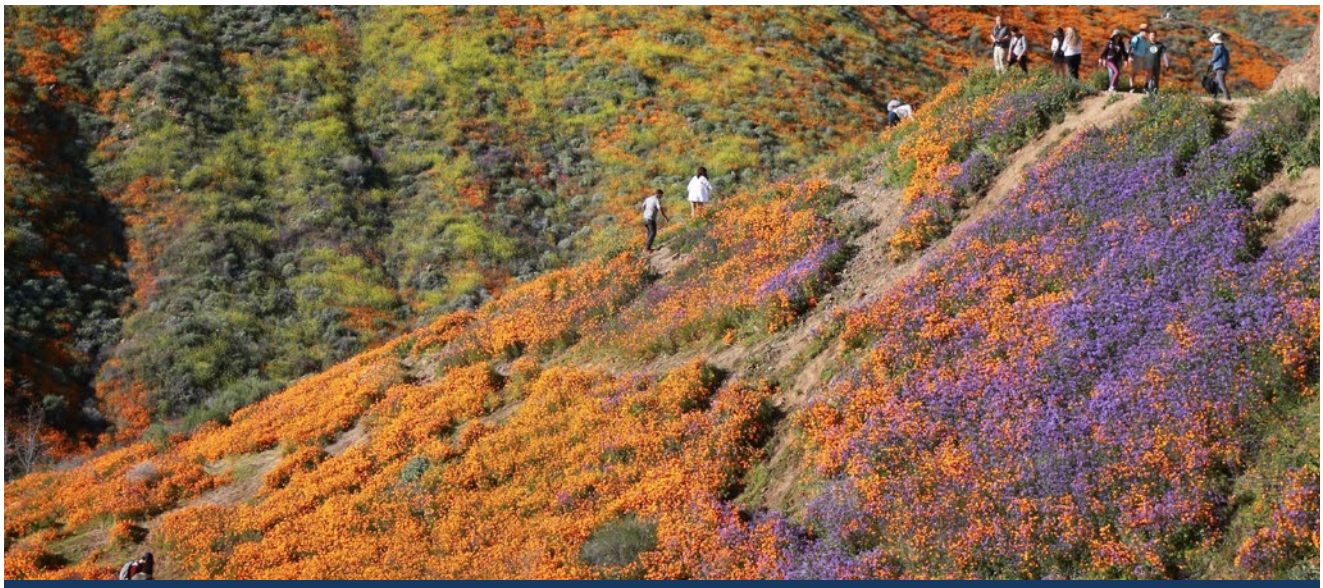
Such an imitation effect is demonstrated, for example, in Joshua Tree National Park (California, US) through selfies with Joshua trees (*Yucca brevifolia*) on Instagram (Clarke, 2017a). The photos show people sitting, standing and lying on the trunks of Joshua trees, striking yoga poses and stretching hammocks between them ('Driving force'). Joshua trees are mainly native to the Mojave Desert and are highly threatened by climate change (Sweet et al., 2019). Their root system is shallow, and adding weight puts extra stress on the Joshua trees, making them vulnerable to breakage or collapse (Joshua Tree National Park, 2016). Posting such photos gives people the impression that such behaviour is acceptable.

In Acadia National Park (Maine, US), the removal of nearly 3,500 rock stacks in 2016 and 2017 demonstrates another example of social media-driven hype, according to the public affairs specialist (Haigney, 2018). Rock stacking is a form of self-expression, and sharing on social media serves as a way to show the world that one has been 'here', inspiring new rock stackers to imitate ('Driving force') (ibid.). Also, one interviewee suggested the visual appeal of rock stacks against natural sceneries may explain the popularity on social media. However, moving geological material and leaving such individual marks is not desired in national parks ('Driving force'). Zion National Park (2018) (Utah, US) refers to rock stacking as an act of vandalism ('Pressure'), affecting protected landscape scenery negatively ('State') and, therefore, visitors' experience of solitude and wilderness ('Impact'). Moving a considerable number of stones can result in wildlife habitat degradation ('State'), and eventually impact biodiversity conservation ('Impact') (ibid.). The case study illustrates how (pre-existing) human behaviour, rather harmless in isolation, can be popularised through social media reaching a level of environmental degradation (Haigney, 2018).

Social media tourism

Sharing information about protected areas on social media creates a certain publicity effect, potentially leading to an increase in popularity and consequently to rising visitor numbers in protected areas (according to 20 interviewees). Once visitor numbers overburden existing infrastructure and staff capacities are no longer able to cope, a phenomenon occurs that the media refers to as 'Instagram tourism', 'selfie tourism', 'mass tourism' and 'overtourism'. In the following, this phenomenon will be summarised under the term 'social media tourism'.

Social media tourism potentially alters visitors' motivation and, therefore, the type of visitor behaviour in protected areas. According to one interviewee, social media attracts visitors who seem to have little affinity for nature and are more event and adventure-oriented. They presumably know little about nature itself and the environmental effect of certain behaviours. Moreover, they obtain their information from sources that usually do not provide information about the need for environmental protection and conservation-oriented behaviour.



Unofficial trails – remnants after visitors posed for photos in Walker Canyon's sea of wildflowers during the Superbloom 2019
© Angelica Reyn / Pexels

The phenomenon of social media tourism was observed during the spring bloom of wildflowers in desert regions in southern California in 2019 (BBC, 2019; Reyes-Velarde, 2019). 'Superbloom' years can lead to an influx of thousands, even hundreds of thousands, of visitors within a few weeks (Winkler & Brooks, 2020). Social media plays a contributing role in publicising these events (ibid.), for example, when Instagram influencers with numerous followers post selfies in the sea of flowers ('Driving force') (Pollack, 2019). Near Walker Canyon Ecological Reserve, the city administration of Lake Elsinore reported approximately 50,000 visitors on one weekend in March 2019, leading to traffic jams on Interstate 15 with cars backing up to 32 km at times ('Pressure') (BBC, 2019; Reyes-Velarde, 2019). To take photos of the sea of blossoms, visitors often go off-trail ('Driving force'), creating unofficial trails ('Pressure') that leave lifeless patches (State of California, 2023) and damage vegetation and landscape ('States'), eventually reducing biodiversity and the recreational quality of nature ('Impacts').

However, the occurrence of mass tourism always relates to the visitor capacities of a given location (Moczek et al., 2020; Øian et al., 2018). This particularly applies to wilderness areas and core zones of national parks. In Grand Teton National Park (Wyoming, US), postings by social media influencers from Delta Lake led to increased visitor numbers from one or two per day to around 145 hikers daily ('Driving forces') (Holson, 2018). Less known paths became heavily frequented ('Driving force') leading to partial erosion ('Pressure') (ibid.). Similarly, at Conundrum Hot Springs in the Maroon Bells-Snowmass Wilderness (Colorado, US), preserving wilderness has become increasingly difficult due to growing visitor interest and nature-damaging behaviour, driven partly by social media content (Worby, 2017). The management of wilderness areas presents a paradox, as wilderness refers to an area (almost) without human intervention. Balancing the protection and experience of wilderness may be the greatest management challenge in modern times (ibid.).

Misbehaviour in protected areas and its environmental effects

Spreading nature-damaging behaviour via social media and social media tourism potentially contribute to misbehaviour in protected areas. In some circumstances, this misbehaviour applies pressure on the environment, potentially leading to changes in the environmental state and ultimately leading to adverse impacts. This study identifies at least (but is not necessarily limited to) four types of misbehaviour on-site in the context of visitors' use of social media: "Going off-trail", "Overusing the trail system", "Using drones" and "Leaving marks" (Figure 1).

In the Berchtesgaden National Park (Germany), a hidden natural pool lies in the Königsbach waterfall. The popularity of the off-trail pool has increased massively after influencers with large followings started posting selfies and drone videos from the pool ('Driving forces') (Barth, 2020; Nationalpark Berchtesgaden, 2020). Geotagged pictures and directions disseminated on social media ('Driving force') encouraged new visitors to ignore warning signs and go off-trail ('Driving force') (NDR, 2021). In the visitor survey by Moczek et al. (2020), 62 per cent stated that they had learned about the Königsbach waterfall through social media. As a

result, a network of trampling damage and unofficial trails of at least three kilometres covering an area of about 10 hectares formed around the natural pool ('Pressure') (Nationalparkverwaltung Berchtesgaden, 2021), leading to massively degraded vegetation ('State'). Going off-trail also severely contributed to soil erosion ('Pressure') (ibid.) and the human presence disturbed wildlife ('Pressure'), likely resulting in habitat degradation of protected bird species ('State') (Moczek et al., 2020). Furthermore, the presence of drones (for creating social media content ('Driving force')) may be perceived as predatory by wildlife (Rebolo-Ifrán et al., 2019), potentially affecting wildlife behaviour ('Pressure') and contributing to habitat degradation ('State'). The addressed disruptive factors may contribute to biodiversity loss and reduced recreational quality of the national park ('Impacts').

Counter-measures

Environmental education is one approach addressing nature-damaging behaviour. An example of norms for environmentally responsible behaviour is 'The Seven Principles of Leave No Trace' (2021) (see Box 2). Such principles are characterised by being formulated concisely to be memorable and with a high recognition value. Protected area management can adopt such principles for their environmental communication.

However, environmental education should also include raising awareness about environmentally friendly behaviour on social media. Therefore, Schreiner (2018) proposes digital behaviour principles for human-nature interactions, which were also adopted by Leave No Trace (2020) as social media guidance, reading as follows:

- "Use Conscientious Tagging" (Schreiner, 2018);
- "Be Mindful of What You're Showing" (ibid.); or
- "Encourage and Inspire Leave No Trace in Social Media Posts" (Leave No Trace, 2020).

Such digital behaviour principles can be communicated through awareness campaigns. Such campaigns may have a catchy name or slogan to promote them on and off social media, like the campaign and simultaneous geotag "Tag Responsibly, Keep Jackson Hole Wild" (Holson, 2018). Similarly, the Nationalpark Berchtesgaden (2021) published a series of animated videos on its Instagram account, including one titled "Think before you post", addressing geo-referenced UGC on social media and its environmental effects.

To make visitors aware of their social media posts showing nature-damaging behaviour, protected area management can comment on such content (public) or directly message the creators (private) (as indicated by 13 interviewees). The users may be asked to delete the post or to modify it in a way that points out the misbehaviour. Additional staff capacity may be needed to monitor social media activity around the protected area (digital rangers), using protected area-related hashtags, geotags and search terms.

Box 2. The Seven Principles of Leave No Trace

1 Plan Ahead & Prepare
2 Travel & Camp on Durable Surfaces
3 Dispose of Waste Properly
4 Leave What You Find
5 Minimize Campfire Impacts
6 Respect Wildlife
7 Be Considerate of Other Visitors

(Leave No Trace, 2021)

Increasing numbers and misbehaviour of visitors may challenge the management capacities of protected areas. Restricting access can be considered as a last resort when other measures have failed. One way of reducing crowds in protected areas to a nature-compatible number of visitors is to pre-sell a limited number of entrance tickets, similar to the reservation system of Spring Creek Canyon Wilderness Study Area (Utah, US) with a limit of 150 tickets per day (Kanarra Falls, 2023). However, this measure requires strict entrance control and, consequently, additional staff. Another option might be the implementation of a shuttle bus system. For instance, a limited bus service with an online booking system and a daily car ban of several hours during the main visitor season was introduced for the Lago di Braies in the Fanes-Sennes-Prags Nature Park (Italy) (Radiotelevisione Italiana, 2020).

DISCUSSION AND CONCLUSION

The research results heavily rely on non-academic literature, mostly reports about conflict situations in protected areas from regional to international newspapers as well as outdoor and travel magazines. Here, interviewees from protected area and municipal administrations mention (among others) social media as a critical conflict driver. In the interviews with national park staff, 22 of 44 respondents explicitly mentioned uncertainties in the conflict assessment due to a lack of empirical data making it difficult to answer the interview questions. The lack of academic literature and objective data on this topic urges caution in evaluating the study results. This exploratory work represents a first approach to disclose the complex cause-effect relationships

of social media and their contribution to negative environmental effects in protected areas.

This study emphasises the need for further research regarding the conflict potential of social media for protected areas. Comprehensive visitor surveys would allow for more precise statements about the influence of social media on visitor behaviour, as demonstrated in the visitor observations and surveys conducted by Moczek et al. (2020) for Berchtesgaden National Park. Studies show how geo-referenced UGC on social media can provide information on the location and activities of visitors in protected areas (Teles da Mota & Pickering, 2020). Future studies could specifically focus on undesirable behaviour and rule violations as shown, for example, by Norman and Pickering (2017) in detecting off-trail use in Mount Barney National Park (Australia). Furthermore, correlations could be analysed between observed increasing visitor crowding or misbehaviour at a particular site in the protected area and increased social media activity related to that site.

Besides social media, other factors have strongly contributed to and still contribute to the presented conflicts. Concerning the development of mass tourism, US national parks have been struggling with high visitor flows for years (Duncan, 2016) with a major increase in visitation (Statista, 2022). Also, a significant rise in visitor numbers to European national parks was observed during the pandemic (McGinlay et al., 2020). Which factors further favour mass tourism and its adverse effects in protected areas cannot be conclusively determined by this study. However, the dominance of the US case studies in the literature search results suggests that an already existing high visitor pressure is a determining factor. In future studies, relationships between mass tourism associated with social media coverage in protected areas and their popularity, uniqueness and accessibility could be analysed.

Regarding nature-damaging behaviour, the lack of environmental awareness and education of visitors have to be considered (Solomon, 2022). Social media seems to contribute to this general problem by attracting people with low environmental awareness to a protected area for the first time, usually without providing the necessary background knowledge. Several case studies indirectly link visitors' use of social media to increased misbehaviour like leaving rubbish, leaving dogs unleashed, wild camping and lighting prohibited campfires (Burkitt, 2017; Nationalpark Berchtesgaden, 2020; Worby, 2017). Such misbehaviour is shared on social media (Clarke, 2017a, 2017b; Solomon, 2022) and may contribute to further misbehaviour, although possible links need to be explored further. However, potential new visitor groups to protected areas also bring opportunities for reaching more people through environmental education measures.

As digitisation progresses and the number of users of social media services grows, the influence of social media on protected areas and their management is likely to increase. The results of this study can be understood as a recommendation to further strengthen digital skills in protected area management and to improve digital visitor guidance.

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SUPPLEMENTARY ONLINE MATERIAL

Table 1. Overview of national parks (IUCN Management Category II) with email interview responses.

Table 2. Overview of case studies from the selective review of academic and non-academic literature

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RESUMEN

En dos décadas, las redes sociales han cambiado profundamente la sociedad moderna. Los diversos efectos de este rápido desarrollo son cada vez más objeto de investigación interdisciplinar. En el caso de las áreas protegidas, la atención se ha centrado hasta ahora en las posibilidades de las redes sociales como medio de comunicación y seguimiento de los visitantes. Se trata de un estudio exploratorio en el que se identifican estudios de casos de áreas protegidas en las que el uso de los medios sociales por parte de los visitantes ha contribuido a provocar efectos medioambientales negativos. Además, se ofrecen posibles medidas para hacer frente a estos problemas. La recopilación de datos se llevó a cabo con una revisión selectiva de la literatura académica y no académica utilizando un marco de investigación global y entrevistas cualitativas por correo electrónico en toda la UE con personal de 44 parques nacionales. Los resultados de la investigación se estructuraron utilizando el marco DPSIR de la Agencia Europea de Medio Ambiente. El turismo de masas impulsado por las tendencias de las redes sociales y la difusión de comportamientos perjudiciales para la naturaleza a través de las redes sociales parecen ser los problemas más acuciantes. Para aplicar con éxito las medidas de conservación y garantizar los objetivos de conservación a largo plazo, la gestión de las áreas protegidas debe tener en cuenta los posibles efectos negativos de los medios sociales. A medida que avanza la digitalización, aumenta la urgencia de los estudios y medidas correspondientes. La mejora de las competencias digitales y de la orientación digital de los visitantes por parte de los agentes de la conservación de la naturaleza puede contribuir a contrarrestar futuros efectos ambientales negativos.

RÉSUMÉ

En l'espace de deux décennies, les médias sociaux ont profondément modifié la société moderne. Les différents effets de ce développement rapide font de plus en plus l'objet de recherches interdisciplinaires. Pour les zones protégées, l'accent a été mis jusqu'à présent sur les possibilités des médias sociaux en tant que moyen de communication et de suivi des visiteurs. Il s'agit d'une étude exploratoire qui identifie des études de cas de zones protégées où l'utilisation des médias sociaux par les visiteurs a contribué à des effets négatifs sur l'environnement. En outre, des mesures potentielles pour relever ces défis sont proposées. La collecte des données a été réalisée à l'aide d'un examen sélectif de la littérature académique et non académique en utilisant un cadre de recherche global et des entretiens qualitatifs par courriel à l'échelle de l'UE avec le personnel de 44 parcs nationaux. Les résultats de la recherche ont été structurés à l'aide du cadre DPSIR de l'Agence européenne pour l'environnement. Le tourisme de masse induit par les médias sociaux et la diffusion de comportements nuisibles à la nature par le biais des médias sociaux semblent être les problèmes les plus urgents. Pour mettre en œuvre avec succès les mesures de conservation et garantir les objectifs de conservation à long terme, la gestion des zones protégées doit prendre en compte les effets négatifs potentiels des médias sociaux. À mesure que la numérisation progresse, l'urgence des études et des mesures correspondantes augmente. Le renforcement des compétences numériques et l'orientation numérique des visiteurs par les acteurs de la conservation de la nature peuvent contribuer à contrecarrer les futurs effets négatifs sur l'environnement.

STRENGTHENING A RESILIENT PROTECTED AREA WORKFORCE TO ADVANCE THE 30X30 GOAL: THE CASE OF MADAGASCAR

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ABSTRACT

Protected areas depend on a reliable and strong workforce to achieve biodiversity conservation goals. The Kunming-Montreal Global Biodiversity Framework adopted a target to protect at least 30 per cent of the planet's land and seas by 2030, also known as '30x30'. To reach and maintain this ambitious goal, an expanded conservation workforce is indispensable. Despite this, most protected areas are currently critically understaffed. This study examines staffing in shared governance protected areas in Madagascar – a biodiversity hotspot that has significantly expanded its protected area network since 2015. We explore factors that attract and retain protected area workers in order to suggest recommendations for workforce development. We employ a qualitative approach utilising face-to-face interviews and a survey of protected area staff and local communities in Madagascar. We obtained data from 62 individuals across 10 protected areas, under IUCN management categories II, V and VI. Findings indicate that understaffing is a dynamic rather than a static phenomenon. A key motivation for working in the protected area sector is place attachment. Non-monetary work practices including place-based empowerment of community groups and gender-inclusive approaches can improve organisational culture to meet growing human resource needs in protected areas. By charting a new path for workforce development, protected areas may be able to address long-standing human resources issues and contribute to community empowerment and sustainable livelihoods.

Keywords: protected area management, biodiversity conservation, staffing

INTRODUCTION

No industry can thrive if it is unable to attract and retain workers (Eversole et al., 2012). Effective workforce development requires awareness of employee needs and an understanding of the sector's demands on human resources. Throughout the world, protected areas severely lack human resources: staffing is only about a third of what is needed for effective protected area management (Appleton et al., 2022; Waldron et al., 2020). Concerns about staffing adequacy have been raised in light of the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) that aims to conserve land and seas on 30 per cent of the planet by 2030, the '30x30' goal (Appleton et al., 2022; Rakotobe & Stevens, 2023). Attracting and retaining workers will be vital to the success of the '30x30' goal. These staff capacities are essential to reduce the risk of having established yet ineffective protected areas or 'paper parks'.

Research on the issue of protected area understaffing is limited and focuses on a narrow subset of staffing aspects. From a quantitative perspective, a major global study has updated data on paid protected area staff numbers, decades after the last census was published (Appleton et al., 2022; James et al., 1999). Although significant, these studies do not capture contributions from civil society and private organisations, a significant segment of the actual and potential protected area workforce. At the site level, studies based on management effectiveness evaluations conclude that a majority of protected areas lack necessary human resources (Coad et al., 2019; Geldmann et al., 2018; Gill et al., 2017). Again, these studies capture numbers

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of formal employees within a given public, private or non-governmental organisation, but not contributors that provide labour and capacity outside the formally paid organisational structure (Parr et al., 2013; Waithaka et al., 2012). Fewer studies have attempted to calculate external workforce service contributions to protected area management (Rakotobe & Stevens, 2023; VIPP, 2021). Indeed, although formal staffing can be insufficient, the external workforce can often complement skills and tasks, closing staffing gaps and creating greater presence on the ground (Rakotobe & Stevens, 2023). In state governed and shared governance protected areas, local community members often contribute to patrolling, biodiversity monitoring, ecological restoration and other tasks as contingent workers hired on a per-project or activity basis (Lotter & Clark, 2014; Singh et al., 2021a). In Indigenous, community-led protected areas, local people self-organise and engage in management without monetary compensation, as part of a broader system of locally sustainable livelihoods (Tran et al., 2020; Worboys & Trzyna, 2015).

From a qualitative perspective, an understanding of the factors influencing the sector's long-term workforce remains fragmentary. Since most protected areas lack personnel, it is essential to know how understaffing is experienced by current workers and what attracts, motivates and retains the protected area workforce. This is critical, both for the contractual and non-contractual (external) workforce, as it determines rewards or outcomes that are valued by current and potential members of the workforce, with possible variations across sites and groups (Eversole et al., 2012). Studies on frontline rangers have revealed profound issues pertaining to their work conditions, capacities, well-being and security and have increased recognition of the critical importance of looking beyond numbers of protected area staff (Belecky et al., 2019; Singh et al., 2021a). Site-specific studies have demonstrated that factors motivating staff participation in protected area management are not necessarily linked to financial rewards, number of employees or even training and qualifications, rather, they are linked to a favourable work environment and personal attitudes (Ayivor et al., 2020; Elisée et al., 2021). Reasons that local communities engage in conservation efforts were categorised as both heteronomous motivations (engaging in a behaviour to obtain social and economic rewards) and autonomous motivations (self-endorsed behaviour from an intrinsic value such as love of nature) (Nilsson et al., 2016). During the Covid-19 pandemic, less studied qualitative aspects in the protected area workforce emerged such as increased anxiety and stress among staff and exacerbated negative effect of chronic understaffing (Powlen et al., 2023), the roles of rangers in providing health service (Singh et al., 2021b; Stolton et al., 2023) and continued maintenance of conservation activities through on-the-ground presence (Eklund et al., 2022).

This study examines the protected area understaffing phenomenon and investigates factors that attract and retain full-time paid staff and an external non-contractual workforce. Our goal is to promote a more inclusive protected area workforce development strategy that is sensitive to the workforce population's diversity, needs and motivations.

METHODS

Study area: Madagascar

Our study employs a qualitative case-study approach to examine protected areas in Madagascar, one of the world's biodiversity hotspots with key biodiversity conservation significance (Mittermeier et al., 2011; Ralimanana et al., 2022). The country has increased its protected area coverage from 6 per cent of the nation's territory in 2003 to about 11 per cent in 2015 through the Durban Vision, an ambitious plan to extend Madagascar's system of protected areas, locally termed SAPM (Gardner et al., 2018). Such extension has required additional management efforts. The parastatal association (Madagascar National Parks, or MNP) retains management of 43 protected area sites – mostly of IUCN management category II (national parks). Management authority for the 80 new protected areas was delegated to a collection of 20 non-governmental, community-based and private organisations. Most of these were in new management categories V (protected landscape or seascape) and VI (protected area with sustainable use of natural resources) featuring socio-economic objectives and close management collaboration with local communities – attributes that had not previously characterised Madagascar's protected area system. The latter are often engaged through local groups called CLP (in French, Comité Local du Parc, or local park committee) by MNP or through VOI (in Malagasy, Vondron'Olona Ifotony, or community-based groups).

Sustainability and resilience of the extended SAPM presents significant challenges in a country characterised by 77 per cent of its population living in extreme poverty (Crespo Cuaresma et al., 2018), 28 per cent lacking access to formal education (Instat, 2021), and a road density index of 11 per cent – among the lowest globally – meaning 17 million Malagasy inhabitants (65 per cent of the total) remain isolated from primary infrastructure

A scenic view of Isalo National Park, south of Madagascar
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(World Bank, 2023). Rural areas, where protected areas are located, face more extreme challenges than do urban settings.

Overall, Madagascar's protected areas are severely understaffed, particularly the newly designated sites (Rakotobe & Stevens, 2023). A key feature of SAPM is increased collaboration with local community-based organisations for biodiversity monitoring, law enforcement and socio-economic projects. Local communities, via CLPs or VOIs, provide significant in-service hours to protected areas, either voluntarily or in exchange for minimal compensation (Rakotobe & Stevens, 2023). In this study, we document motivations among both full-time paid staff members and external workforce contributors such as CLP and VOI members that assist with tasks on an unpaid or temporary basis for protected area management.

Data collection

We conducted face-to-face semi-structured interviews with on-site protected area staff and local community participants in July 2022 and April 2023 using convenience sampling (Patton, 2002). Participants are from shared governance protected areas, which vary in size (from 4.02 km² to 3,104.1 km²) and management categories (II, V, VI) (Figure 1, Table 1). All participants were informed about the scope and goals of the research, and they granted permission to record the interviews. Each interview was conducted individually, in the local language (Malagasy), permitting effective and informative interactions with study participants. In April 2023, a protected area director who was interested in the study's outcomes made it possible for the study team to evaluate motivations of her entire staff (21) through a paper-based questionnaire (see Supplementary Online Material). That survey was anonymous, with responses collected by a staff member and passed in full to the primary investigator.

In total, we received responses from 62 people, 44 male and 18 female, representing 10 sites: 44 staff members and 18 members of CLP and VOI supporting protected area management. Interview transcripts were coded using an inductive approach and a coding process following Williams and Moser (2019) with similar responses aggregated into categories for analysis and discussion.

Research limitations

Certain study limitations restrict the generalisability of our findings. For example, we chose to focus on protected areas under the shared-governance model, with an employer-employee structure. Additional insights may be gained through deeper study of other protected area governance models. In addition, our choice of protected area sites for this study was based on accessibility, hence more remote and hard-to-access sites were not included. Rich opportunities exist to survey motivations and retention factors for staff and external workforce in remote protected areas.

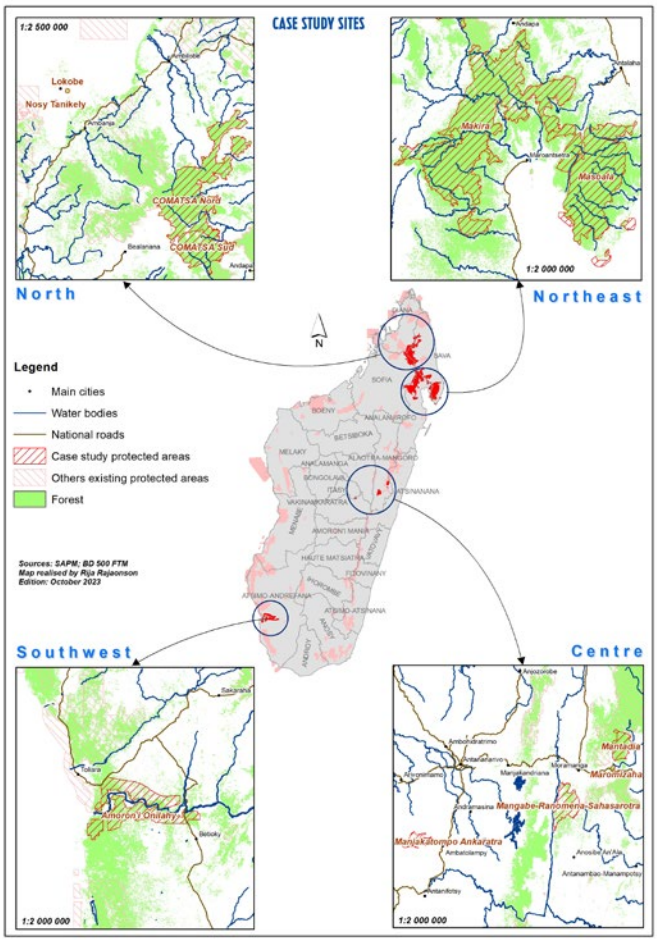

Figure 1. Map of the study area

Table 1. Site and study participants.

Zone	Protected areas and management categories	Surface (km²)	Managing institutions
Centre	1. Manjakatompo Ankaratra (VI)	81.3	Tafo Mihaavo
	2. Maromizaha (VI)	15.8	GERP
	3. Analamazaotra-Mantadia (II)	163.27	MNP
	4. Ranomena-Mangabe-Sahasarotra (VI)	271.34	MV
North	5. Corridor Marojejy- Anjanaharibe Sud-Tsaratanana COMATSA (V and VI)	3104.1	WWF
	6. Lokobe (II)	15.1	MNP
	7. Nosy Tanihely (II)	4.02	MNP
Northeast	8. Makira (II)	7224.9	WCS
	9. Masoala (II)	3100.95	MNP
Southwest	10. Amoron'Onilahy (VI)	1020.71	WWF
National			MNP, Tafo Mihaavo

GERP: Groupe d'Etude et de Recherche sur les Primates | MNP: Madagascar National Parks | MV: Madagasikara Voakajy | WWF: World Wildlife Fund | WCS: Wildlife Conservation Society

RESULTS

We organised our results into four themes based on the empirical data: 1) how understaffing is experienced and its consequences, 2) sense of place as a major motivation, 3) importance of equity and respect, and 4) local community members' work expectations relating to protected areas.

Understaffing and its consequences

Interviews with staff offer nuanced insights into protected area understaffing. A key finding of this study is that understaffing is a dynamic rather than a static phenomenon. Staffing is adequate in some settings (e.g. in offices but not in field locations, in some departments but not others). Understaffing often reflects specific skills gaps rather than an insufficiency in overall personnel numbers. In some cases, teams based in the organisation's headquarters may complement competency gaps for activities such as communication or capacity building. Staffing shortages also vary over time. When field agents are sick or on leave, and during times with high influx of visitors, severe temporary understaffing is experienced. Also, the number of rangers, locally termed 'field agents', may become insufficient with workload changes over time, or as seasoned field staff develop physical limitations (e.g. with age) and become unable to keep pace with previous expectations. Availability of staff can also change with new projects. On the positive side, an influx of project funds may alleviate staffing shortages by temporarily enabling the hiring of new staff. Conversely, new projects can also become burdensome when the budget covers project activities only with no resources to support additional staff.

A staff member handling an injured lemur brought to the Ivoloina park © Domoina Rakotobe

One main consequence of staffing insufficiency is a delay in reporting illegal activities. When field agents are readily available, they can immediately contact their supervisor as soon as serious offences are observed, and immediate measures can be taken. Failure to respond

Community rangers patrolling in Itremo protected area, center of Madagascar © Rhayo | Forum Lafa WCS Madagascar

quickly can severely impact biodiversity (e.g. the spread of fire or deforestation). Insufficient numbers of field agents can also result in complete lack of enforcement in areas that are difficult to monitor. Offenders know that rangers often cannot reach remote areas, making them prime targets for illegal activities. Lack of field enforcement results in persistent destruction, and unaddressed illegal activities create a negative image of park staff. Understaffing frequently requires performing tasks outside the job description on a daily basis, diminishing the ability to achieve desired results. Chronic understaffing creates an unsustainably heavy workload for existing employees. From our staff survey, those who reported negative impacts on their family life were all women, as longer work hours reduced their time to fulfil family roles such as tutoring their children.

Major motivation: A sense of place

Responses varied as to why staff and local communities choose to work in protected areas. A love of the beauty of nature and the desire to preserve natural spaces are vividly expressed by local community members and also by staff members in two popular protected areas that are highly frequented by tourists. Our interviewees from local communities cited love of nature and desire to protect the environment as top motivations for engaging with protected areas. Some reported that they enjoy exploring the forest, seeing wildlife, and getting fresh air. Community members reported that they enjoy higher air quality in and around the protected area, compared to other places like nearby small cities.

But love of place is not just about the beauty of the landscape or its ecological attributes (fresh air, presence of charismatic species, etc.). It was also at times more personal. Protected area staff reported that they engage in this work in their region of origin, filling them with pride, a sense of belonging and contribution to a greater purpose. Even office-based employees, such as one young female staff member, the mother of a toddler, felt fortunate to work near where her family lives. A park director shared that he accepted transfer to a more challenging park setting because of its location within his native region, where his elderly parents still reside.

Equity and respect in the workplace

Protected area staff mentioned a number of effective, motivating, on-the-job practices. With specific considerations for women, they included more flexible hours and improved field work conditions. In particular, early career professionals aspire to have opportunities for training and capacity growth. Recommendations by protected area staff and external workforce from local communities are summarised in Table 2, detailing employer–employee and peer-to-peer relationships and collaborations. A park director with 20 years of experience noted that "*Building team spirit is exceedingly important for site-based employees, because they are far from their own family and our stressful work requires strong bonds among staff.*" Many protected area staff cite small practices that make a difference in creating long-term positive working environments for the external workforce (Table 2).

Local community members expressed similar feelings. Members stressed the importance of work organisation being sufficiently flexible in response to an individual's needs, as VOI members are not a uniform group that will follow strict rules of participation as would formal employees. Indeed, some members may be disproportionally impacted by required workloads, on a seasonal or regular basis. For example, those without family members find it hard to share subsistence farming tasks. One woman explains that she is unmarried with children and works as a day labourer in other people's fields, hence it is harder for her to perform VOI duties than for members with additional caregivers/ farm workers. In addition, authoritarian attitudes and harsh language can easily demotivate local community members from joining a VOI, performing activities and complying with rules.

VOI leaders explain that the best way to improve relationships among protected area managers and VOIs is to strengthen local agency and ownership of protected area sites. This approach is important long-term, establishing the local community as first line decision-makers and conflict resolution experts in their territory. Individual VOI organisations also appreciate praise and recognition for achieving positive results, in a way that highlights individuality. Long-term protection depends on VOIs taking ownership of decision-making mechanisms related to their lands. One leader from the national platform of VOIs indicated that having an outside institution paying VOI members to patrol undermines local ownership of a given protected area and reinforces donor dependency, all unsustainable in the long-term. In fairness, people must receive compensation for time spent on habitat monitoring, but he suggests developing a stable locally organised income-generating activity, such as a cooperative that would pay for surveillance and patrols. A protected area chief, drawn from the local communities, supports the notion of self-funding VOIs. He would like to establish a potato farming cooperative, leveraging the region's flagship product to pay salaries for park management and community rangers. Another respondent shared that a similar approach is already in place in the Corridor Marojejy- Anjanaharibe Sud-Tsaratanana (COMATSA) protected area, featuring well-run and profitable vanilla cooperatives that have afforded local communities greater financial autonomy.

Local community members' expectations

Many VOI and CLP members considered that having an additional income apart from their traditional farming activities was a tangible benefit of working for a protected area. Generally, each VOI or CLP member patrols for an average of one day per week or four days per month, conducting biodiversity monitoring and recording evidence of any illegal activities. Payment systems vary across sites, with two common payment types. One is by direct payment to the community member for each day of patrolling at a rate of 5,000 Ariary (1.16 USD), equivalent to a workday in the fields. Alternatively, a community organisation may receive a monthly lump sum payment for all protected area activities undertaken. The amount varies among protected area managing institutions, ranging between 120,000 Ariary (27.30 USD) and 250,000 Ariary (57.80 USD). Some community organisations elect to keep one-fifth for management fees, distributing four-fifths to the participants in that month's activities. Others retain the entire amount for community activities (e.g. supporting local schools or organising member trainings). In one protected area, the withdrawal of the official managing institution led to the cessation of payments to VOIs. This change generated complaints among the former beneficiaries and the new management institution struggled to sustain a financial mechanism for VOIs. Even minimal supplemental income is meaningful to families in impoverished rural areas.

Most community rangers suggest that higher payments would increase practical motivation. A former CLP member explained that he stopped being a CLP member because reduced workdays made payments less attractive. Indeed, with additional members and no increase in total workdays, MNP redistributed the workload among CLP members, resulting in fewer working days per person. Similarly, VOI members from central Madagascar expect a revision of the current payment scheme, generally insufficient to allow the VOI to undertake major community projects. Particularly for one site, support mechanisms do not result in an increase in the number of participants simply because all funds are split among active members. Consequently, when more people participate in the activities, each receives a lower share.

Many others expect that continuing to work for protected areas will bring eventual socio-economic rewards. Some said they would continue to do the work with the hope that some protected area partners will provide service projects to local communities, such as building schools or

Table 2. Recommendations from protected area staff and local communities on non-monetary practices to motivate and retain protected area workforce.

For staff and full-time employees		For external workforce from local communities (CLPs and VOIs)
Increase visibility and understanding of protected area mission: communicate, train staff, and repeat mission frequently		Avoid top-down interactions (from protected area team to community members)
Delegate full authority to local staff on matters concerning the site, not being overshadowed by HQ in Antananarivo		Trust communities to be responsible decision-makers and to resolve conflicts in and about their territory
Create adequate balance between field and desk activities	Common	Grant autonomy for participants to manage their own tasks
Develop clear work instructions	Create opportunities for all to increase capacity/responsibility	Create social engagement with protected area team
Create opportunities for inter-generational learning: early-career professionals to learn from longer term staff	Allow possibility to exchange ideas and discuss tasks	
Engage/train director with strong positive communication skills, equity and leadership	Treat everyone equally and implement non-discrimination policies	Ensure equitable share of tasks among community members
Reinforce communication among staff	Offer opportunities for exchanges of ideas and discussions	
Identify and alleviate stress and pressure	Use encouraging and respectful (not offensive) language	Praise and recognise individual VOI organisations (VOIs are not all the same)
Hire locally whenever possible	Avoid authoritarian attitudes and harsh language	
Create flexibility for remote work, Adapt adequate logistical conditions in field settings, Consider and develop resources for family support		Permit flexibility in response to each individual's needs to promote diversity and inclusion

providing trainings for farmers. One member indicated that he would continue to be a VOI member because he expects some future returns, or '*valim-babena*[1]', either for himself or his children. Another one hopes to become a permanent park agent one day because she has been a CLP for six years and, apart from the park, work opportunities in the area are very rare.

Other motivations derive from the joy of the work itself. The president of the local guides' association estimates that he will continue to work if researchers need him because he retains unique local ecological knowledge of the area. A local guide has been proud to contribute to research on birds for 15 years. One woman, who had never attended high school, enjoys doing research with students because she is learning too.

DISCUSSION

Our results indicate that the local communities surveyed appear to exhibit a strong desire to work in protected areas, offering the System of Protected Areas of Madagascar (SAPM) a vast potential pool of collaborators and/or workers. Local stakeholders may be motivated by place-based connections and appreciation for nature, wanting to benefit their surroundings. Scarcity of other employment opportunities in rural areas, together with key opportunities for people lacking formal education, make engagement with protected areas a comparatively attractive sector. Our work relates to discussions on heteronomous and autonomous motivations for local communities involved in nature protection (Lliso et al., 2022; Nilsson et al., 2016). Although some studies have documented that direct payment can generate positive outcomes (Jones et al., 2018), others point out a reversal of behaviour should payment be inconsistent or discontinued, with particularly detrimental effects on intrinsic motivation

(Rode et al., 2015). It is still unclear whether salary-based participation by local community members would decrease or eliminate intrinsic motivation. As autonomous motivations create sustainable pro-conservation behaviour, shifting focus from predominantly heteronomous motivation to an approach with additional non-financial incentives to motivate community participation such as conservation stewardship, easements, and performance-based payments for communities may help to mitigate staffing shortages and benefit conservation in the long term (Nilsson et al., 2016). However, ethical implications for low-or-no pay work in areas experiencing food insecurity and lower access to resources are of paramount concern. Local CLP and VOIs remain sensitive to non-monetary rewards based on healthy work relationships, attachment to place, celebration of achievements, citizen science and capacity development. With similar aspirations to formal paid employees, the local external workforce appears to be motivated and perseverant, offering strong potential for retention and long-term stability in protected area staffing.

The work environment itself is another key motivation for staff. In contrast with Elisée (2021), our study found that not only senior-level protected area managers, but importantly, local community members aspire to stronger professional relationships and advancement. On the one hand, insufficient work opportunities – apart from farming – in remote rural areas explain why local workers seek permanent careers in the protected area sector. On the other hand, protected areas would benefit from greater sensitivity to human resource management, not simply in terms of recruitment, but also for retention and growth. Our findings align with best practice suggestions for working with local communities outlined by the Universal Ranger Support Alliance (Stolton et al., 2022), which include for example that they should feel valued and offered life opportunities. Loffeld et al. (2022) also found that positive psychological states associated with fairness and recognition of achievement for work are determinant factors for perseverance among conservation professionals. Taken together, these data raise the call for conservation organisations to address motivation and empowerment for long-term community protected area management.

Notably, some female participants in this study expressed gender-specific workplace considerations as either a motivator/deterrent to participation in the protected area sector, namely the importance of proximity to family network, scheduling flexibility for childcare, and logistical conditions during fieldwork. These findings suggest that, as in many other professions, actions to ensure gender equity in the conservation workplace are needed to advance more diverse, inclusive, empowering and appealing employment opportunities to enable long-term protected area staffing success (Jones & Solomon, 2019; Woodhouse et al., 2022).

CONCLUSION

Long-standing issues in protected area management can be addressed by community empowerment and espousing a renewed collaborative philosophy. Such a place-based strategy will help attract and retain a local workforce. In-office staff, field-based employees and members of the external workforce all report a desire for a more inclusive and equitable workplace. Key issues include family considerations, pride of place and recognition of individuality and strengths for local groups (e.g. women as knowledge holders). New pandemic induced work relationships, the Kunming-Montreal Global Biodiversity Framework and lessons learned from the 'Durban vision' provide opportunities for governmental (such as SAPM) and non-governmental organisations to promote critical discussions around human resource issues.

This study lifts the veil on sensitive questions, including: What systemic changes are needed to empower local communities to engage in management of existing protected areas? What changes in work practices are needed among current protected area managing organisations? How can the protected area sector become more inclusive by taking into consideration the needs of women and especially single mothers in the workforce? How can we address the needs of distance-separated families, and young professionals? What financial mechanisms can reduce donor-dependency and sustain community workers? Does success depend on changing the mandates and roles of protected area managing institutions (both governmental and non-governmental)? How can donors, international aid agencies and other protected area stakeholders (universities, tourism actors, etc.) shift to a more inclusive, equitable, mature, internal and external workforce management practice?

Embracing these questions is a turning point for the SAPM. It is a pivotal opportunity to help restore agency to communities and avoid the mistakes made in the past by depriving local and Indigenous peoples of decision-making about their lands and seas. Avoiding change runs the risk of merely generating paper parks, and threatens to perpetuate top-down and neo-colonial systems of power. Now is the time for an honest paradigm shift restoring human rights and recognising protected area human resources as an important dimension of human capital in the global conservation effort.

"Polisin'ala" members of local communities in charge of surveillance and patrolling of Maromizaha protected area, Madagascar
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ENDNOTE

[1] Valim-babena: an expression used to say that the duty of grown children is to help their parents in the future in recognition of what they have done.

SUPPLEMENTAREY ONLINE MATERIAL

Questionnaire used in study

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RESUMEN

Las áreas protegidas dependen de una mano de obra fiable y sólida para alcanzar los objetivos de conservación de la biodiversidad. El Marco Mundial para la Biodiversidad de Kunming-Montreal adoptó el objetivo de proteger al menos el 30% de las tierras y mares del planeta para 2030, también conocido como "30x30". Para alcanzar y mantener este ambicioso objetivo, es indispensable ampliar la mano de obra dedicada a la conservación. A pesar de ello, la mayoría de las áreas protegidas carecen actualmente de personal suficiente. Este estudio examina la dotación de personal en las áreas protegidas de gobernanza compartida en Madagascar, un punto caliente de biodiversidad que ha ampliado significativamente su red de áreas protegidas desde 2015. Exploramos los factores que atraen y retienen a los trabajadores de las áreas protegidas con el fin de sugerir recomendaciones para el desarrollo de la fuerza laboral. Empleamos un enfoque cualitativo mediante entrevistas personales y una encuesta al personal de las áreas protegidas y las comunidades locales de Madagascar. Obtuvimos datos de 62 personas de 10 áreas protegidas de las categorías de gestión II, V y VI de la UICN. Los resultados indican que la escasez de personal es un fenómeno dinámico y no estático. Una motivación clave para trabajar en el sector de las áreas protegidas es el apego al lugar. Las prácticas laborales no monetarias, como el empoderamiento de los grupos comunitarios basado en el lugar y los enfoques inclusivos de género, pueden mejorar la cultura organizativa para satisfacer las crecientes necesidades de recursos humanos en las áreas protegidas. Al trazar un nuevo camino para el desarrollo de la mano de obra, las áreas protegidas pueden ser capaces de abordar problemas de recursos humanos de larga data y contribuir al empoderamiento de la comunidad y a medios de vida sostenibles.

RÉSUMÉ

Les aires protégées dépendent d'une main-d'œuvre fiable et solide pour atteindre les objectifs de conservation de la biodiversité. Le cadre mondial pour la biodiversité de Kunming-Montréal a adopté un objectif de protection d'au moins 30 % des terres et des mers de la planète d'ici 2030, également connu sous le nom de "30x30". Pour atteindre et maintenir cet objectif ambitieux, il est indispensable de disposer d'une main-d'œuvre plus nombreuse dans le domaine de la conservation. Malgré cela, la plupart des aires protégées manquent cruellement de personnel. Cette étude examine la dotation en personnel dans les aires protégées à gouvernance partagée à Madagascar - un hotspot de biodiversité qui a considérablement étendu son réseau d'aires protégées depuis 2015. Nous explorons les facteurs qui attirent et retiennent les travailleurs des aires protégées afin de suggérer des recommandations pour le développement de la main-d'œuvre. Nous employons une approche qualitative en utilisant des entretiens en face à face et une enquête auprès du personnel des aires protégées et des communautés locales à Madagascar. Nous avons obtenu des données de 62 personnes dans 10 aires protégées, dans les catégories de gestion II, V et VI de l'UICN. Les résultats indiquent que le manque de personnel est un phénomène dynamique plutôt que statique. L'une des principales motivations pour travailler dans le secteur des aires protégées est l'attachement au lieu. Les pratiques de travail non monétaires, y compris l'autonomisation des groupes communautaires basée sur le lieu et les approches intégrant le genre, peuvent améliorer la culture organisationnelle afin de répondre aux besoins croissants en ressources humaines dans les aires protégées. En traçant une nouvelle voie pour le développement de la main-d'œuvre, les aires protégées peuvent être en mesure de résoudre des problèmes de longue date en matière de ressources humaines et de contribuer à l'autonomisation des communautés et aux moyens de subsistance durables.

CHARACTERISATION OF VISITATION OF THE REMOTE CONCEPTION ISLAND NATIONAL PARK USING DAILY SATELLITE IMAGERY

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ABSTRACT

Conception Island is a remote island bank in the central Bahamas, the entirety of which is encompassed within the Conception Island National Park. Conception Island is of vital importance to numerous threatened and critically endangered wildlife species, but tracking visitation is considered challenging as there is no warden and not all vessels follow registration rules. To augment understanding of park visitation, we obtained daily satellite imagery from Dove CubeSat® satellites managed by the company Planet® to characterise diurnal marine vessel traffic around Conception Island between 2016 and 2021. We obtained a total of 888 observable days, which yielded 1,197 vessel detections. Using these remote observations, we were able to geolocate vessels that visited Conception Island National Park over this period, as well as estimate the length overall of each vessel to within 10 m. We found that peak visitation to the National Park occurs in the spring, a time that corresponds to when migrating songbirds arrive at the island, when the critically endangered Silver Boa is mating, when White-tailed Tropicbirds are using the island for mating, and when Green Turtles are starting to lay eggs. This study provides the first analysis of marine vessel visitation to Conception Island National Park and we believe that these data show that the park is visited far more frequently than was appreciated.

Key words: birds, boa, Caribbean, *Chilabothrus*, endangered species, protected area management, Bahamas National Trust

INTRODUCTION

Conception Island National Park (CINP) is one of 32 national parks in the Bahamas managed by the Bahamas National Trust (BNT), a non-governmental, non-profit organisation. The BNT is funded in part by the Commonwealth of the Bahamas (about 33 per cent of operating expenses; Bahamas National Trust, 2018) as well as support from individuals, members and corporate partners (Bahamas National Trust, 2020). The Bahamas National Trust oversees these 32 parks and 2.2 million acres via the legal authority vested in it by the Commonwealth of the Bahamas through an act of Parliament (Bahamas National Trust Act of 1959). Nevertheless, given the vast territory and distances of the parks from Nassau, several of these parks and protected areas (including CINP) have lacked sufficient resources for patrol, wardens or monitoring and some have been considered 'paper parks' (e.g. Knapp et al., 2011) meaning that little enforcement is possible. Such a characterisation might not be appropriate, however, as park protection and conservation enforcement are complicated and multifaceted in the Bahamas (e.g. Wise, 2014). Nevertheless, a lack of data makes conservation decision making more challenging (Chiappone & Sealey, 2000).

Established in 1978 and expanded in 2009, CINP encompasses Conception Island, Booby Cay and the South Rocks as well as the oceanic platform surrounding these islands extending out to the 100-fathom line (Figure 1). Conception Island National Park is one of only a few National Parks in the Commonwealth that encompasses an entire island bank free from development pressures. Conception Island is one of the most remote national parks in the BNT system and is of critical importance to regional wildlife. It is home to 68

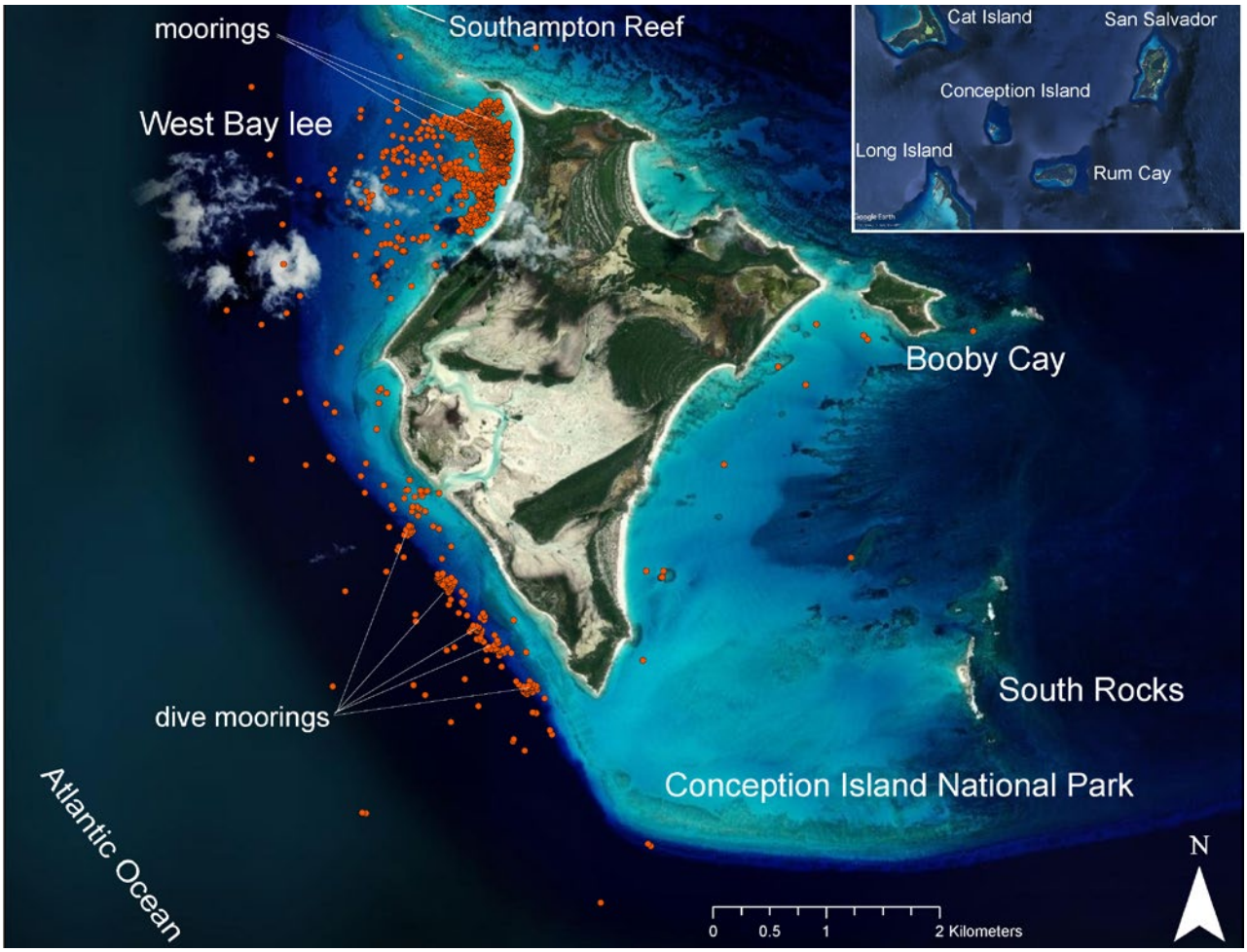


Figure 1. Map of Conception Island National Park, located in the central Bahamas Archipelago (inset). The Conception Bank is visible as the lighter blue areas, the darker blue is open ocean. Conception Island National Park extends across the bank to the 100-fathom line in all directions, which corresponds approximately to the darkest blue in the image. All 1,197 vessel locations obtained during the study are mapped, where each orange dot represents one vessel. Note that the majority, over 900 of the observations, are in the West Bay lee anchorage area. Another large proportion are moored along the dive mooring buoys along the western margin of the bank. Inset map from Google Earth, main image from ArcGIS Pro®

bird species, and hosts regionally important seabird nesting areas for species such as Audubon's Shearwater (*Puffinus lherminieri*), which might have as many as 250–500 breeding pairs present in the park (Mackin, 2007, 2015; Reynolds & Buckner, 2022; Sprunt, 1984). Conception Island is thought to have the largest White-tailed Tropicbird (*Phaethon lepturus*) nesting colony in the Bahamas, one of the largest Sooty Tern (*Onychoprion fuscatus*) colonies, and one of the largest Brown Noddy (*Anous stolidus*) colonies in the Bahamas (White, 1998). Three of the eight range-restricted bird species in the Bahamas Endemic Bird Area (BEBA) are documented from CINP (Reynolds & Buckner, 2022). White-crowned Pigeons (*Patagioenas leucocephala)* are common in CINP and are listed as Near Threatened on the IUCN Red List (BirdLife International, 2020). Because there are so many species of birds, several of which are species of concern that have robust breeding colonies, the bank is of tremendous importance to avifauna conservation. Further, CINP is home to the only population of the endemic Conception Island Bank Silver Boa (*Chilabothrus argentum*), which is listed as Critically Endangered on the IUCN Red List (Reynolds, 2017) and consists of fewer than 200 adults (Reynolds et al., 2020, 2022). Finally, CINP hosts crucial mangrove habitats which serve as nurseries for Green Turtles (*Chelonia mydas)* as well as economically important fishery species (Bjorndal et al., 2003; Serafy et al., 2003). Despite its protection as a national park, Green Turtles were previously harvested (Bjorndal et al., 2003), as are lobster, Queen Conch (*Aliger gigas*) and finfish (R. G. Reynolds, pers. obs.). Shotgun shells were found on Booby Cay in the 1990s, likely from bird hunting (Franz & Buckner, 1998; Reynolds & Buckner, 2022), and at least six used signalling flares were found in 2017, which pose a fire hazard (Reynolds et al., 2020, 2022).

Conception Island has long been a destination for sailors, with West Bay lee (Figure 1) providing the only protected harbour on the bank, and only in relatively calm sea conditions with prevailing winds. Three mooring buoys were installed in West Bay lee in 2014, one of which can accommodate ships of at least 60 m length overall (LOA; Figure 1). Visitors to the park are expected to first register their vessel with the BNT and to follow posted rules about park use (see Figure 2). Visitors are permitted to come ashore on Conception Island, but only on the beaches and never with pets (although this latter rule is frequently disregarded, R. G. Reynolds, pers. obs.). Visitors are not allowed on Booby Cay nor South Rocks, owing to their importance to bird nesting. Previously, large signs with visitation rules were deployed at strategic points along Conception Island and Booby Cay, warning visitors not to disturb wildlife. Those signs were destroyed by Hurricane Joaquin in 2015 and were subsequently replaced through a partnership between the North Carolina Zoo, the BNT and the first author RGR (Figure 2; Reynolds et al., 2020). Beyond West Bay lee, the rest of the bank can be treacherous to navigate owing to coral reef heads, sand bars and lee shores. Indeed, a famous double shipwreck of the Southampton and the Vixen in 1812, on what is now known as Southampton Reef (Figure 1), stranded 300 sailors on the island until they were rescued by a ship bound for Port Royal, Jamaica (One of the Vixen's crew, 1813). Additional private mooring buoys are located along the southern edge of the Conception Bank, the second most popular destination in CINP behind West Bay lee, owing to the excellent scuba diving available there.

Though CINP is managed by the BNT, the island is hard to oversee for several reasons: CINP has no cell phone signal, has poor marine radio signal and is rarely visited by BNT park rangers or wardens. With these disadvantages and given that vessels do not always register their visits to CINP, the BNT has not had an easy way to monitor visitation to the park, to assess visitor numbers or where visitors are going, and limited knowledge of what time of year most visitation occurs. This study sought to determine whether the use of remote sensing data obtained from satellite imagery could be used to provide a base-level understanding of CINP visitation to assist the BNT in making future management decisions, such as whether to implement more permanent and comprehensive monitoring. Specifically, some commercial companies use satellites to image portions of the Earth daily at high-resolution, a relatively new resource for non-governmental or non-corporate entities. One of these is the company Planet® (Planet Labs Inc.). Planet Labs was founded in 2010 and has more than 200 operational satellites. Planet® offers multiple services, including high-resolution real-time monitoring, high frequency mosaic base maps and high-resolution image tasking. While their image access is largely intended for corporate customers, a researcher and education access grant was available and was used for the present study.

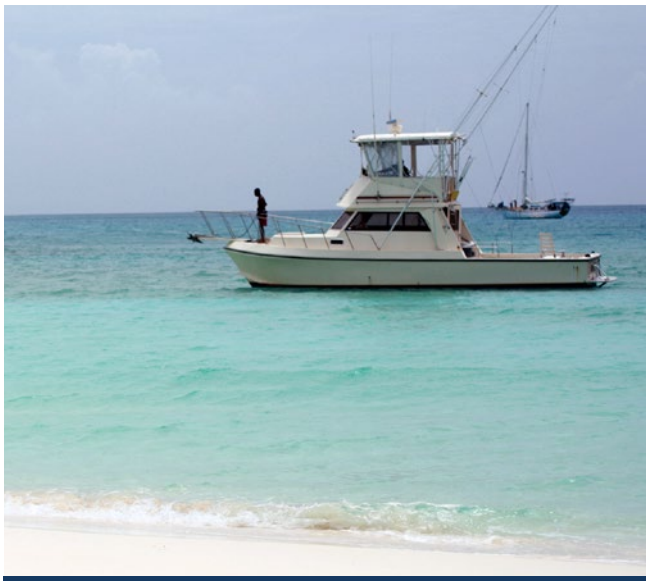
This study is an attempt to characterise visitation and use of a remote national park in the Lucayan Archipelago using satellite imagery. Such studies could provide valuable data to assist with decision making regarding park monitoring as part of a comprehensive plan for well-managed and well-protected natural assets.

METHODOLOGY

Site description

Conception Island National Park encompasses the entirety of the Conception Island Bank, which is a partially submerged carbonate platform occupying about 102 km² and surrounded by water > 2,000 m deep on all sides. The bank is located within an imaginary polygon bounded by the larger Bahamian Islands of Cat Island to the northwest, Long Island to the southwest, Rum Cay to the southeast and San Salvador to the northeast. Conception Island Bank is dominated by Conception Island, which is 820 ha with a maximum elevation of 24 m (Lands and Surveys Department, Bahamas Government, 1972). Booby Cay (20 ha) is 250 m east of Conception Island, and the South Rocks (2.5 ha) are 2.6 km to the southeast of Conception Island. Numerous smaller emergent islets and rocks dot the bank, and the Southampton Reef projects north ~7.5 km from Conception Island then curves to the east.

Figure 2. Laws governing visitor use at Conception Island National Park. These are new signs that were installed at various locations throughout the park in 2021.



Two vessels located in West Bay lee, Conception Island National Park, Bahamas July 2015. In the foreground is a dive boat from Long Island that has made a day trip, in the background is a sailing vessel at anchor. Both vessels are in the 10—20 m LOA class © R. Graham Reynolds.

Imagery and analysis

We accessed near-daily satellite imagery of CINP from the company Planet®, granted via an Education and Research Program award. Planet uses Dove CubeSat® satellites to take images up to 3.7 m resolution in four multispectral bands (RGB and near infrared). These images are aggregated in Planet's online database, and images are interactively searchable using a map of satellite image areas (Planet Team, 2017). We searched all available imagery for the Conception Island Bank (bounded between approximately 23.8625° and 23.7910° north latitude and -75.1390° and -75.0710° west longitude) and logged daily photos from 1 January 2016, to 31 December 2021. We made note of, but excluded, days when CINP was at least 50 per cent obscured by clouds. Because we did not use satellite imagery tasking, we relied on preplanned satellite imaging sweeps and hence satellites do not make a direct overhead pass of CINP every day. So, days that did not have imagery of CINP were also noted but excluded. All retained near-daily images were downloaded in full colour at the highest resolution available within Planet's proprietary visualisation interface (Planet Team, 2017).

For each retained image, CINP was visually scanned for marine vessels starting at the northeast corner of the bank and then around the bank in a counter-clockwise pattern. Vessel locations were recorded as latitude and longitude in decimal degrees provided by Planet's pinpoint tool (Planet Team, 2017). The pinpoint was placed at the centre of each vessel observed. Length overall (LOA) in metres was obtained by measuring from bow to stern with Planet's distance measuring tool. The measuring tool's smallest increment was 10 m, so all vessels smaller than the smallest increment were marked in the 10 m category, and LOA is approximated to within 10 m. Depending on the tide and sea conditions, exposed sandbars and reefs can give the appearance of a vessel, in these cases, the area was compared to known visible sand bars and reefs on the bank (known from other images being assessed as well as previous ground truthing expeditions in 2015–2017; Reynolds & Buckner, 2022; Reynolds et al., 2022). Smaller vessels that were obviously ship tenders were not counted if they appeared to be nearly in contact with a larger vessel. Objects appearing to be vessels located in areas where vessel traffic would be unlikely (i.e. on top of very shallow reef heads) were not included. Similarly, windy days can produce whitecaps that resemble vessels. To reduce the possibility of mistaking waves for vessels, we crossed-referenced days when whitecaps appeared to be present against a database of historical wind speeds for the area using timeanddate.com. If wind speeds suggested that whitecaps would be present (generally, sustained winds >30 kts), and if the wind direction corresponded to the expected location (aspect relative to Conception Island) of whitecaps, then ambiguous observations were not counted as vessels.

Table 1. Description of the dataset used in the study, with explanations for how data were included or excluded from the study. A total of 1,304 days were excluded, and 888 days were included in the final dataset, out of a possible 2,192 days during the study.

Days Excluded: 1,304
2,192 possible days (1 Jan. 2016 to 31 Dec. 2021)
282 days without any imagery data
941 without a direct satellite pass or missing large areas
81 days with >50 per cent cloud cover
Total: 1,304 days excluded
Total: 888 days included
Days Included: 888
499 days with no vessels detected
78 days with some clouds and no vessels
91 days with some missing imagery and no vessels
330 days with no visibility impediments
389 days with at least one vessel
133 days with some clouds and vessels
104 days with some missing imagery and vessels
152 days with no visibility impediments

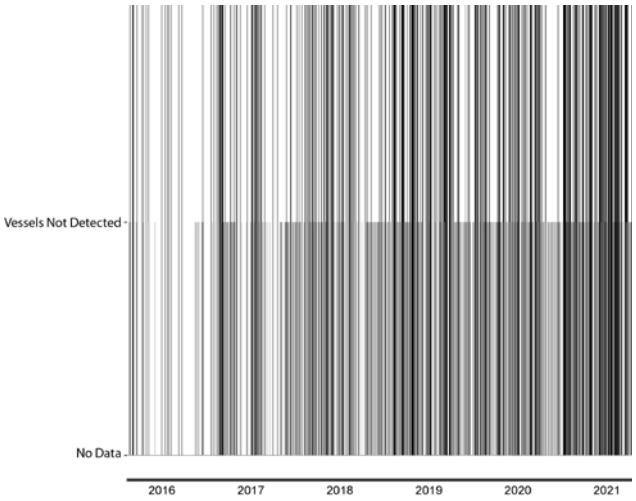


Figure 3. Distribution of imagery availability and vessel detection over the study period. White bars represent days without any imagery data (1,304), bars reaching halfway represent days when vessels were not detected (499), and bars reaching full height represent days when at least one vessel was detected (389). All bars with either imagery data, vessel data, or both are grey colored, the appearance of darker bar colors simply indicates more days are stacked closer together. Note that fewer imagery days were available towards the beginning of the study.

After parsing all images, we mapped each vessel observation onto a satellite image of CINP using ArcGIS Pro® with the '*import x,y coordinates*' tool and adjusted the size of the points. We then imported our data matrix into R v4.3.0 (R Core Team, 2023) and plotted a histogram of vessel sizes using RStudio v2023.03.1. We created a bar plot of vessel frequency per month of the year, aggregating across the six years of the study to determine when visitor numbers were highest, as well as characterise seasonal visitation patterns. We also created a boxplot comparing the LOA of vessels through each month of the year and tested for a relationship between LOA and month using a 1-way ANOVA test using the function *aov*() in R.

RESULTS

Our study period from 1 January 2016 to 31 December 2021 spans a total of 2,192 days. Of that potential period, we excluded a total of 1,304 days (Table 1; Figure 3) as 282 days did not have imagery data loaded into Planet's database, 941 days did not have a satellite pass over CINP, and 81 days were too cloudy (>50 per cent cloud cover over CINP). This left a total of 888 observable days, or 40.5 per cent of the total days of the study period. We did not detect vessels on 499 of 888 observable days (56.2 per cent; Figure 3). Of the observable days without vessels, 78 had some cloud cover, 91 had partial missing imagery and 330 had no imagery issues (Table 1). During these 888 observable days, we recorded at least one vessel present on 389 of the days (43.8 per cent; Figure 3) and documented a total of 1,197 vessels. Of the days in which vessels were detected, 133 had at least some cloud cover, 104 days had some missing satellite imagery, and 152 days had no imagery issues (Table 1).

The average vessel LOA was 17.7 m (range 10–100 m), which suggests a mean vessel size capable of open ocean travel in calm water. But the most frequent vessel observed was in the range of 10 m or less LOA (mode

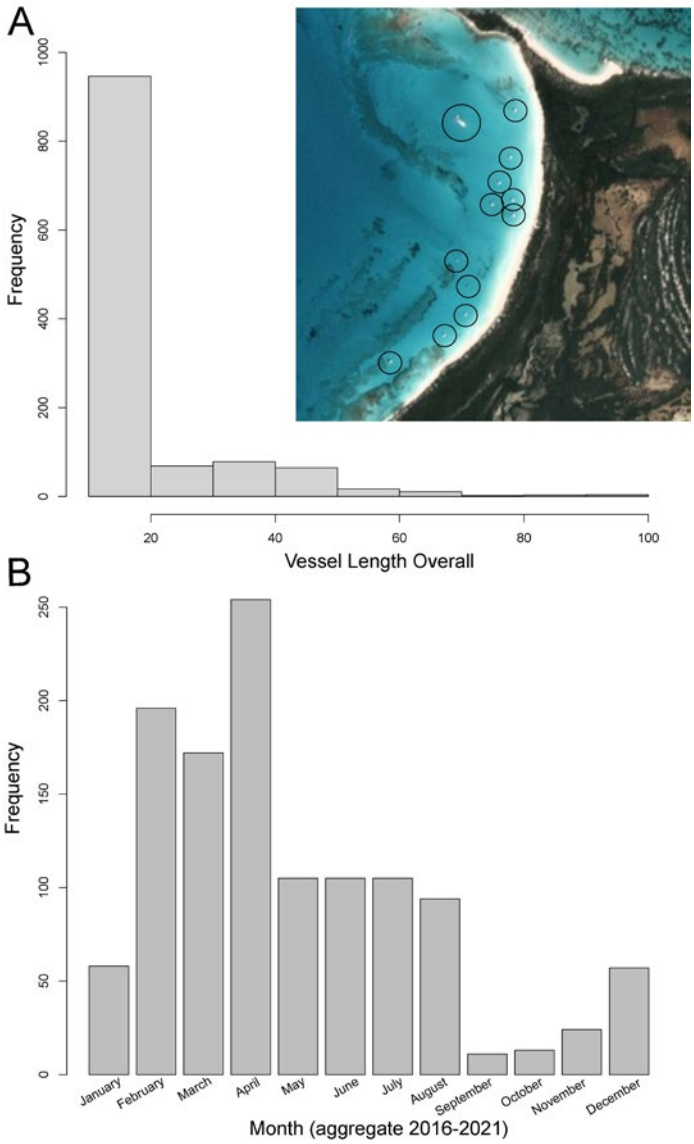


Figure 4. A) Histogram showing the frequency of vessels given their size (LOA) visiting Conception Island National Park. The inset shows relative vessel size comparisons. It is an image from Planet® from 7 February 2021 with black circles around a 40 m LOA ship at a mooring buoy in West Bay lee and 11 vessels of the 10 m LOA size class scattered in West Bay. B) Bar plot of aggregate monthly visitation to Conception Island National Park 2016–2021. Note that September and October are the peak hurricane season in the Bahamas, hence visitor numbers are expected to be low (but they are not zero).

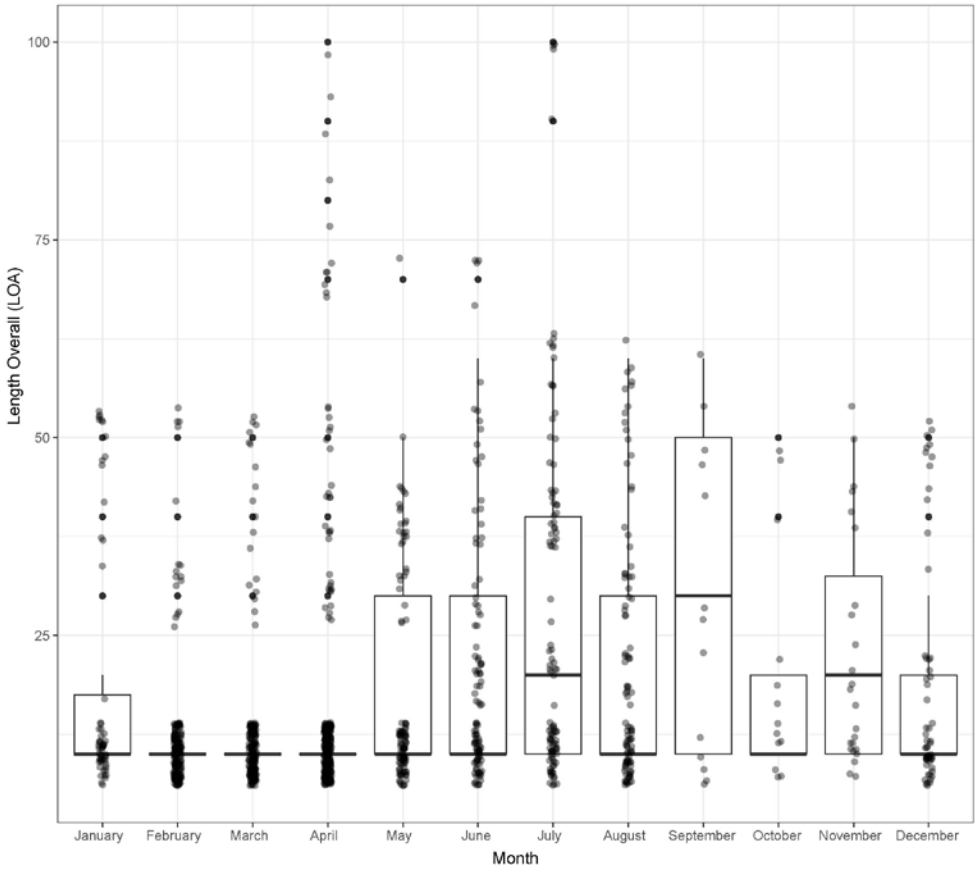


Figure 5. Box-and-whisker plot of vessel sizes (LOA) by month for Conception Island National Park. Note that the points are offset and differently coloured relative to one another to allow visualisation ('jittered').

LOA = 10 m, median LOA = 10 m; Figure 4), which represents what would be regarded as a relatively small vessel for making a trip to CINP.

Vessel detection was highest in the spring, particularly between February and April (Figure 4). Visitation to CINP was lowest during September and October, which is peak hurricane season for the area (Figure 4). Vessel LOA varied by month, with the summer months generally hosting larger vessel LOA (ANOVA = 10.9, P <0.001; Figure 5). We detected a maximum of 16 vessels in one day (18 April 2021).

Most vessels detected in CINP were observed in two core areas: in the West Bay lee of Conception Island or at the dive wall mooring buoys at the southern edge of Conception Island Bank (Figure 1). All vessels detected on the eastern side of Conception Island and near Booby Cay or South Rocks were vessels <20m LOA.

DISCUSSION

The foremost goal of this study was to characterise marine vessel traffic in Conception Island National Park to gather baseline data on visitation to the park, something that has not previously existed. This is particularly important as remote national parks, including CINP, are home to numerous threatened and endangered species (Carey et al., 2001; Reynolds & Buckner, 2022; Reynolds et al., 2022). Conception Island National Park is understudied (relative to the Exuma Cays Land and Sea Park; Chiappone & Sealey, 2000; Dahlgren, 2004) given its significance to regional wildlife, both in the Commonwealth of the Bahamas as well as the greater Lucayan Archipelago. This is starting to change with increased attention to the island bank, and new studies continue to emphasise the biodiversity significance of the park (e.g. Reynolds et al., 2016; Reynolds & Buckner, 2022). Of concern are visitor activities and visitation rates that could disrupt ecologically sensitive species that do not nest in areas with frequent human activity, such as White-tailed Tropicbirds (Walsh-McGehee, 2000). Nevertheless, CINP has and will continue to remain a treasured destination for visitors, and it is known that ecotourism, when properly managed, can be beneficial to local economies and to attitudes towards biodiversity conservation (Walpole et al., 2001; Walpole & Leader-Williams, 2002). Thus, additional signage might help to reduce visitor impacts on ecologically sensitive parts of the island, such as the north cliffs where the tropicbirds nest. Further, there could be additional mooring buoys deployed to accommodate the traffic, which we found can be over a dozen vessels a day.

Despite not having the ability to task satellites, we obtained an observation rate of 40.5 per cent, being the percentage of days in the study for which we obtained an image of the CINP that was less than 50 per cent obscured by clouds (Table 1). Of these 888 observable days, 482 (54.3 per cent) had no imagery missing and minimal cloud cover, while 406 had some cloud cover and some missing imagery. Clouds can certainly obscure vessels, and some of these observable days had partial missing imagery, which means that a satellite did not pass completely over CINP, or a section of the image was missing. Therefore, it is likely that our approach is conservative, in that we have almost certainly undercounted vessels in CINP.

Our data showed a surprisingly high level of marine vessel visitation to CINP. Dozens of vessels visit the island every month, and an average of 240 vessels per year are mooring on the bank. Further, most visitation occurs in the spring, a season when migratory songbirds arrive to the island and White-tailed Tropicbirds are mating. Visitation drops off during the peak of the hurricane season, as expected, but surprisingly does not fall to zero. This concurs with observations by RGR, who observed one sailing vessel in CINP in October 2015 just one week after the passage of Hurricane Joaquin, a category 4 major hurricane. The most frequent vessel observed was in the range of 10–20 m LOA (mode LOA = 10 m, median LOA = 10 m), which represents what would be regarded as a relatively small vessel for making a trip to this region. This category (10 m LOA) most likely includes a combination of small sailing vessels, outboard-powered fishing and pleasure boats, and small craft known as vessel tenders used to make trips back and forth from a larger ship. Outboard-powered centre-console boats can easily reach CINP from Long Island or Cat Island in less than two hours in calm seas, and many sailing vessels that cruise in the Bahamas are in the range of 20 m LOA (R. G. Reynolds, pers. obs.). Given the imagery available, a precise determination of vessel LOA is challenging, although we note that a difference between a vessel 5 m LOA and 15 m LOA is a significant difference with regard to offshore seaworthiness. This limitation means that we are not fully able to determine vessel types at LOA of 10 m or less. But smaller vessels probably overestimate actual visitor numbers, as it is likely that the presence of both large and small LOA vessels on a given day represents both a mothership and its tender(s). Indeed, on 8 February 2021, we documented a mothership with at least 12 skiffs or small sailing craft operating in West Bay lee (Figure 4). Hence, we expect that we are overcounting vessels relative to independent operators, but there is no way to consistently parse between a mothership and its tender with the resolution offered in the Planet images unless the vessels appear to be moored together. We also documented several ships up to 100 m LOA, which is the size of a superyacht or small cruise ship that can carry dozens of guests and crew. The first author RGR has visually observed one such vessel in July 2017, a superyacht carrying a helicopter that moored for 24 hours in West Bay lee.

All vessels detected on the eastern side of Conception Island and near Booby Cay or South Rocks were vessels <20 m LOA. This is a shallow water and treacherous operating area, but also happens to be a good area for marine recreation activities and bird watching. Vessels would not be expected to moor there, as the prevailing winds (SSE to NNW) make the island a dangerous lee shore (R. G. Reynolds, pers. obs.). Nevertheless, smaller craft such as vessel tenders could navigate this side of the bank. Most vessels were observed near the mooring buoys in West Bay lee and the dive wall (Figure 1). These are the safest anchorages, but also provide ready access to recreational opportunities such as scuba diving, snorkelling and access to the island itself. Anecdotal reports suggest that fishing and lobstering also take place in these areas, even though it is illegal to do so. Given these data, a fruitful path might be the extension of a recreational plan for CINP, similar to what has been accomplished elsewhere in the Bahamas such as the Exuma Cays Land and Sea Park and Abaco National Park (Eadens et al., 2009).

We noted a few areas that could be improved in future studies. The measuring tool within Planet's software gives a rough approximation of vessel LOA but is probably only accurate to within 5–10 m and there is no consistent way to verify these distances against known landmarks with enough precision to improve estimates of LOA. Another weakness is that images are limited to one photo per day, hence vessels that arrive or depart from CINP outside of the imaging time are not detectable. Finally, it is known that some vessels visit during the nighttime, presumably to conduct illicit activity (Reynolds et al., 2020). Hence, other technologies such as shore-based radar or underwater sound traps could provide a more comprehensive approach to park monitoring. Despite the limitations of the satellite imagery we used, we found that the use of Planet's imagery database can provide a highly useful estimate of remote park visitation.

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RESUMEN

Conception Island es un remoto banco insular de las Bahamas centrales, cuya totalidad está incluida en el Parque Nacional de Conception Island. La isla Concepción es de vital importancia para numerosas especies de fauna amenazadas y en peligro crítico de extinción, pero el seguimiento de las visitas se considera un reto, ya que no hay guardas y no todas las embarcaciones siguen las normas de registro. Para aumentar la comprensión de las visitas al parque, obtuvimos imágenes satelitales diarias de los satélites Dove CubeSat® gestionados por la empresa Planet® para caracterizar el tráfico diurno de embarcaciones marinas alrededor de la isla Concepción entre 2016 y 2021. Obtuvimos un total de 888 días observables, que arrojaron 1.197 detecciones de embarcaciones. Gracias a estas observaciones remotas, pudimos geolocalizar las embarcaciones que visitaron el Parque Nacional de la Isla de la Concepción durante este periodo, así como estimar la eslora total de cada embarcación con una precisión de 10 m. Descubrimos que el pico de visitas al Parque Nacional se produce en primavera, una época que coincide con la llegada a la isla de las aves cantoras migratorias, el apareamiento de la boa plateada, una especie en peligro crítico de extinción, el apareamiento de los pájaros tropicales de cola blanca y el inicio de la puesta de huevos de las tortugas verdes. Este estudio proporciona el primer análisis de las visitas de embarcaciones marinas al Parque Nacional de la Isla de la Concepción y creemos que estos datos demuestran que el parque es visitado con mucha más frecuencia de lo que se apreciaba.

RÉSUMÉ

L'île de la Conception est un banc d'îles isolé au centre des Bahamas, dont la totalité est comprise dans le parc national de l'île de la Conception. L'île de la Conception est d'une importance vitale pour de nombreuses espèces sauvages menacées et en danger critique d'extinction, mais le suivi de la fréquentation est considéré comme difficile car il n'y a pas de gardien et tous les navires ne respectent pas les règles d'enregistrement. Pour mieux comprendre la fréquentation du parc, nous avons obtenu des images satellites quotidiennes des satellites Dove CubeSat® gérés par la société Planet® pour caractériser le trafic maritime diurne autour de l'île de la Conception entre 2016 et 2021. Nous avons obtenu un total de 888 jours observables, qui ont donné lieu à 1 197 détections de navires. Grâce à ces observations à distance, nous avons pu géolocaliser les navires qui ont visité le parc national de l'île de la Conception au cours de cette période, ainsi qu'estimer la longueur totale de chaque navire à 10 m près. Nous avons constaté que le pic de fréquentation du parc national a lieu au printemps, une période qui correspond à l'arrivée des oiseaux chanteurs migrateurs sur l'île, à l'accouplement du boa argenté, une espèce en danger critique d'extinction, à l'utilisation de l'île par le carouge à queue blanche pour s'accoupler et au début de la ponte des tortues vertes. Cette étude fournit la première analyse de la fréquentation du parc national de l'île de la Conception par les navires et nous pensons que ces données montrent que le parc est visité bien plus fréquemment qu'on ne le pensait.

SHORT COMMUNICATION: CAUSES OF SECONDARY FOREST LOSS IN A LOWLAND RAINFOREST OF NIGERIA

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ABSTRACT

The increasing human population which promotes the conversion of secondary forests into other land use types has resulted in the decrease of forest areas in Nigeria. This study examined the causes of secondary forest loss in Osho Forest Reserve, Nigeria. Changes in Land Use Land Cover (LULC) were assessed using Landsat 5 TM and Landsat 8 OLI/TC images for four timelines over a period of 38 years (1984, 2013, 2017 and 2022). Results showed an increase in area of plantations, bare land and farmland, leading to a decrease in secondary forest cover. Farmland increased from 731 ha to 859 ha at the rate of 3.7 ha yr^{-1}, bare land increased from 314 ha to 523 ha at 5.5 ha yr^{-1}, plantations increased from 1,105 ha to 1,495 ha at 10.3 ha yr^{-1}, while secondary forest drastically reduced from 1,132 ha to 405 ha at 19.1 ha yr^{-1}. At this rate, secondary forest is estimated to be lost in the study area by 2050.. Osho Forest Reserve requires immediate management interventions driven by updated laws and policies, silvicultural treatment, community engagement and ecosystem rehabilitation. In addition, implementation of sustainable forest management would enhance secondary forest recovery.

Key words: Osho Forest Reserve, remote sensing, plantation, sustainable forest management, silvicultural intervention

INTRODUCTION

In Nigeria, the forest reservation system was officially created in 1937, when approximately 20–25 per cent of the rainforest was placed under reservation and protected by enactment of gazettes. The aims were to maintain biological diversity, enhance hydrological processes, improve nutrient cycling, control soil erosion, conserve wildlife and improve air and water quality (Olajuyigbe, 2018). These forest reserves are governed by various laws and regulations which include the National Forest Policy, the Forestry Act of 1956 and state-specific forest laws (Edet et al., 2011). These legal frameworks establish rules for activities within forest reserves, emphasising conservation, sustainable management and restricted land use (Enuoh & Bisong, 2015). Forest reserves also contribute to socioeconomic growth and development, providing timber and non-timber forest products (NTFPs).

However, overexploitation of forest resources and land use change have resulted in deforestation and degradation of the reserves. The situation has been exacerbated by weak and outdated forest laws and policies, increased urbanisation and infrastructural development, and population growth. Hence, it is estimated that over 60 per cent of the country's forest estate has been lost to anthropogenic factors (Akpan-Ebe, 2017; Ancha et al., 2021; DeFries et al., 2010). Most forest reserves have become secondary regrowth which are further threatened by pressures from farmland encroachment, urbanisation and tree crop plantation establishment. The loss of secondary forests in the rainforest region of Nigeria would have devastating consequences on flora, fauna and socioeconomic activities of local communities (Fagariba et al., 2018).

Secondary forests, which represent approximately 90 per cent of the tropical forests in West Africa, are natural vegetation, which are recovering mainly through

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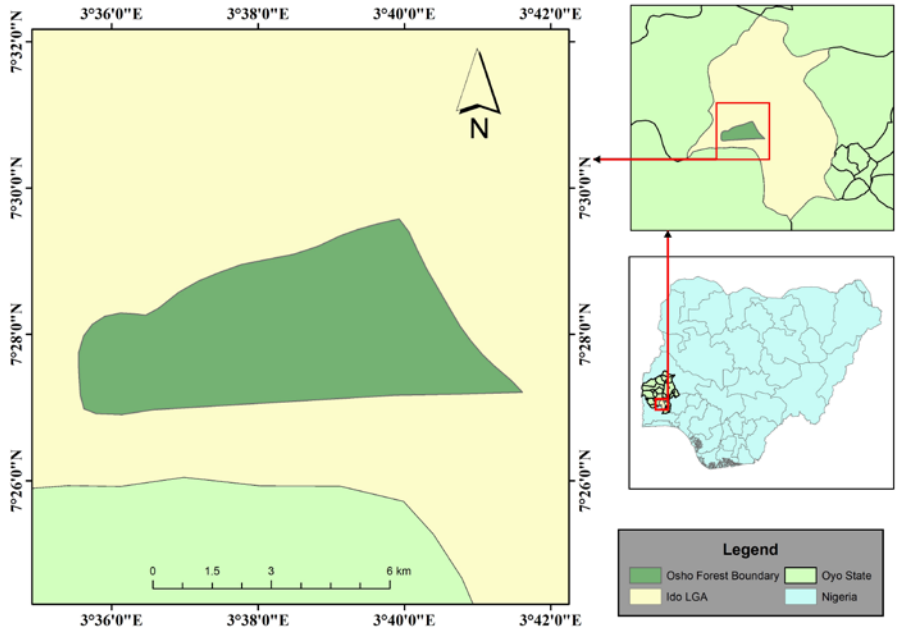

Figure 1. Map of Osho Forest Reserve (inset: maps of Nigeria, Oyo state and Ido local government area)

natural processes, after serious anthropogenic and/or natural disturbances (Chokkalingam & de Jong 2001; Schroeder et al., 2010). Secondary forests provide habitats for plant and animal species, some of which are threatened and endangered. Loss of secondary forest increases the risk of soil erosion, flooding, decreased water quality, and increased sedimentation in rivers and streams (Schroeder et al., 2010; Zeraatpishe et al., 2013). Nevertheless, the conversion of secondary forests to other land uses, such as monoculture plantations and farmlands, is usually seen as a more profitable option than leaving the land in its natural state (Wineman et al., 2021). Hence, large areas of secondary forest are being cleared for non-forest use in the lowland rainforest of Nigeria (Oluwajuwon et al., 2021). This is due to factors such as changes in government policies to promote agricultural expansion, land tenure issues, and lack of enforcement of environmental regulations. In addition, the rapid population growth has increased the pressure on land resources, resulting in increased plantation establishment and encroachment of farmlands into forest reserves (Oyetunji et al., 2020).

Previous studies have shown the increasing levels of conversion of natural forests to other land use types in different parts of the world. For instance, tropical forests were the primary source of new agricultural lands in the 1980s and 1990s, when more than 80 per cent of farmlands were established in the forests (Gibbs et al., 2010). Sanara et al. (2014) showed that farmland expansion was responsible for severe forest loss in Ratanakiri Province, Cambodia. Plantation establishment promoted plant invasions and hindered the survival of endemics in Central Chile and Chilean Patagonia (Andreas et al., 2017) and plantation establishment caused substantial loss of natural forests between 2000 and 2016 in South Central Chile (Altamirano et al., 2020).

Empirical information on the loss of secondary forest cover in comparison to the expansion of other land use types would assist in the development of strategies necessary for their long-term protection and sustainability in Nigeria. In this study, satellite images were used to assess the drivers of secondary forest loss in Osho Forest Reserve, southwest Nigeria.

MATERIALS AND METHODS

Study area

Osho Forest Reserve is one of the major reserves in southwest Nigeria. It is located in Ido Local Government Area of Oyo State, Nigeria (Figure 1). It covers an area of 3,500 ha which was reduced from 5,180 ha, by a 1951 Amendment Order (Azeez et al., 2017; Olayode, 2019). The climate is characterised by two distinct wet seasons, which occur from May to July and September to November, and a major dry season between December and March. The forest contains important indigenous trees such as *Terminalia* spp, *Treculia africana* and *Triplochiton scleroxylon* and exotic species such as *Tectona grandis* and *Gmelina arborea*.

Table 1. Satellite images used in the study

SN	Landsat type	Date	Spatial resolution (m)	Path/row
1	Landsat 5 (TM)	1984	30	191/55
2	Landsat 8 (OLI/TC)	2013	30	191/55
3	Landsat 8 (OLI/TC)	2017	30	191/55
4	Landsat 8 (OLI/TC)	2022	30	191/55

Table 2. Land Use Land Cover classes in Osho Forest Reserve, southwest Nigeria

LULC classes	Description
Secondary forest	Land with vegetation such as trees and shrubs re-growing after natural or anthropogenic disturbances
Plantation	Land dominated by tree stands raised artificially. These include *Tectona grandis, Gmelina arborea, Anogeissus leiocarpus and Tetrapleura tetraptera*
Farmland	Land used for agricultural production including arable crops, permanent crops, pastures and heterogeneous agricultural areas
Bare land	Land not under agricultural use and with no vegetation such as degraded land, bare ground, rocks and quarry-despoiled lands

Table 3. Land Use Land Cover area and rate of change in Osho Forest Reserve, southwest Nigeria (1984–2022)

	1984		2013		2017		2022		
LULC	**Area (ha)**	**(%)**	**Area (ha)**	**(%)**	**Area (ha)**	**(%)**	**Area (ha)**	**(%)**	**Rate (ha yr-1) 1984–2022**
Farmland	731	22.3	987	30.1	1062	32.3	859	26.2	+3.7
Bare land	314	9.8	329	10.0	404	12.3	523	15.9	+5.5
Secondary forest	1132	34.4	1053	32.1	795	24.3	405	12.4	-19.1
Plantation	1105	33.6	914	27.8	1021	31.2	1495	45.5	+10.3

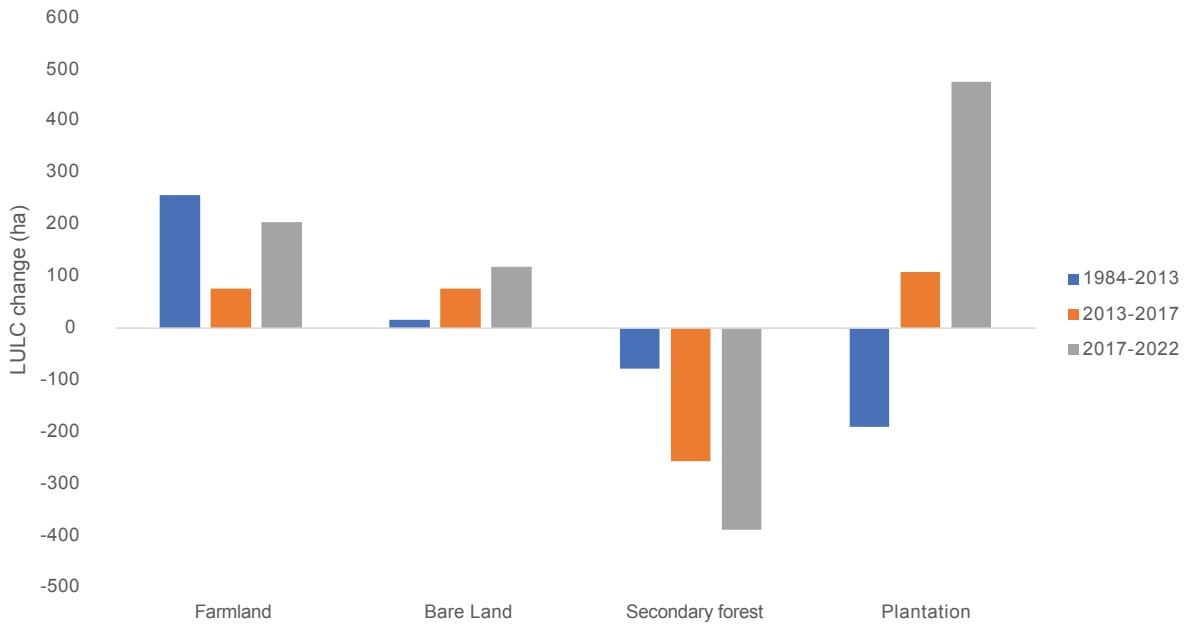

Figure 2. Land Use Land Cover Change between 1984 and 2022 in Osho Forest Reserve, Southwest Nigeria

Satellite imagery

Landsat 5 TM and Landsat 8 OLI/TC were acquired and processed to determine the land use and land-cover changes in Osho Forest Reserve at four timelines over 38 years (1984, 2013, 2017 and 2022) (Table 1).

Trend analysis

The Land Use Land Cover (LULC) was determined using equation1.

$$\Delta LULC = L_2 - L_1 \quad (1)$$

Where L_2 (ha) = Land Use/Land Cover (final year); L_1 (ha) = Land Use/Land Cover (initial year)

Rate of change

The rate of change in LULC was calculated using equation 2.

$$R_{t=}[(L_2 - L_1) \times 1/t)] \times 100 \quad (2)$$

Where L_2 (ha) = Land Use/Land Cover (final year); L_1 (ha) = Land Use/Land Cover (initial year) and t (year) = periodic interval.

Land Use Land Cover classification

Based on the description of Anderson (1976), the LULC classes identified in the study area were secondary forest, plantation, farmland and bare land (Table 2).

RESULTS

The extent and rate of change of LULC classes between 1984 and 2022 are shown in Table 3 and Figure 2. In 1984, farmland covered 731.7 ha (22.3 per cent), bare land covered 314.5 ha (9.6 per cent), plantation covered 1,105.3 ha (33.7 per cent), while secondary forest covered 1,132.2 ha (34.5 per cent). By 2013, farmland had increased to 987.4 ha (30.1 per cent), bare land increased to 329 ha (10 per cent), while secondary forest (1053.3 ha or 32.1 per cent) and plantation (914.0 ha or 27.8 per cent) were reduced in the reserve. However, by 2017, plantation cover increased (1021.7 ha or 31.1 per cent), alongside farmland area (1062.0 ha or 32.3 per cent) and bare land (404.7 ha or 12.3 per cent); while secondary forest (795.2 ha or 24.2 per cent) continued to decline. By 2022, the extent of farmland, bare land and plantation were 859.2 ha (26.2 per cent), 523.1 ha (15.9 per cent) and 1495.5 ha (45.5 per cent), respectively. On the other hand, secondary forest cover had reduced to 405.8 ha (12.4 per cent). Over the 38-year period, farmland, bare land and plantation increased by 3.4 ha yr^{-1}, 5.5 ha yr^{-1} and 10.3 ha yr^{-1}, respectively, while secondary forest decreased by 19.1 ha yr^{-1} (Table 3). Although, there was an initial decrease in plantation area (1984 to 2013), it had the highest positive rate of increase. Secondary forest would be lost entirely by 2050 and largely replaced with plantation forest if the current trend persists.

DISCUSSION

Anthropogenic factors were observed to have severely shifted the reserve from its pristine state, with the LULC classes indicating a disturbed forest ecosystem. Plantation establishment was a primary driver of secondary forest loss. Olajuyigbe (2018) indicated that natural vegetation was being replaced with exotic tree species plantations in an effort to replant the country's degraded rainforest landscape. Similarly, Adeyemi and Ibrahim (2020) found that plantation crops were being established to support timber production, while some forest reserves had become grazing grounds for livestock. This appears to also be the case in Osho Forest Reserve with close to half of the land area presently covered with monocultures of exotic species like *Tectona grandis* and *Gmelina arborea*, and patches of indigenous species plantations of *Anogeissus leiocarpus* and *Tetrapleura tetraptera*. Furthermore, the forest reserve shares boundaries with eight rural communities that depend on forest land for farming activities, wood extraction and charcoal production. The situation is further worsened by obsolete forest laws and policies, inadequate monitoring, and weak technical capacity among forest managers (Olayode, 2019).

Agricultural expansion continues to be implicated as a cause of secondary forest loss in the lowland rainforest region of Nigeria. For example, an increase in farmland area with a corresponding decrease in secondary forest has been reported across southwest Nigeria in Shasha Forest Reserve (Adeyemi & Oyeleye, 2021); Ogbese Forest Reserve (Oluwajuwon et al., 2021); Gambari Forest Reserve (Adedeji et al., 2015); Ijaiye Forest Reserve (Phillips & Ceesay, 2020); Okeluse Forest Reserve (Adeyemi & Olowo, 2022) and Oba Hills Forest Reserve (Adeyemi & Ayinde, 2022). Oyo State is one of the leading agrarian states in Nigeria with approximately 400,000 smallholder farmers (Atser et al., 2019). Hence, the high demand for farmland has led to increased encroachment of forest reserves in the state (Azeez et al., 2017; Haastrup et al., 2020; Oladoye, 2019). In addition, the renewed interest of the state government in agriculture production has led to the degazettment and conversion of parts of forest reserves to large-scale commercial farms.

The expansion of bare lands has serious ecological implications, including habitat loss, land vulnerability to erosion, loss of ecosystem resilience, and decreased ecosystem service provision. The advancement of bare land area threatens the ecological health of the Osho

Farmland Cultivated for Yam in Osho Forest Reserve © Farhan Jimba Moshood

Forest Reserve, as it was observed to increase in size by about 5.5 ha, annually. Bare land expansion has also been observed in forests of the Zurgurma Sector of Kainji Lake National Park (Adeyemi & Ibrahim, 2020) and Andoni LGA, Rivers State Nigeria (Eludoyin et al., 2019).

The future LULC estimates revealed a continuous decline in secondary forest with increases in other land uses, especially plantations. By 2050, secondary forest would have been completely replaced by plantations and other land use types. Similar trends have been reported for other secondary forests in the region. For instance, Phillips and Ceesay (2020) noted that trees in Ijaiye Forest Reserve may last for only 15 years, while Adeyemi and Olowo (2022) estimated that secondary forests in Okeluse Forest Reserve would be completely lost before 2026. Also, Adeyemi and Ayinde (2022) noted that the secondary forests in Oba Hills Forest Reserve may be completely degraded before 2040.

Artificial regeneration through direct tree planting and the taungya agroforestry system are viable alternatives for rehabilitation of forest reserves. Taungya is a system which involves growing annual crops temporarily with trees, during the early phase of plantation establishment. It has been successfully implemented in various reforestation efforts (Appiah et al., 2020; Chamshama et al., 1992). Some of the indigenous and exotic tree species presently in Osho Forest Reserve were established through the taungya system. Azeez et al. (2017) examined the performance of the taungya system in the reserve and affirmed that it contributed positively to the promotion of forest conservation. However, constraints such as lack of technical support, inadequate funding and lack of credit facilities were major impediments to its successful implementation. If these constraints are adequately addressed, assisted natural regeneration and other agroforestry practices may potentially be used to enhance indigenous tree species recovery in Osho Forest Reserve.

The challenges related to ineffective forest management strategies and conflicts between custodians of government forest reserves and farmers have to be addressed. Hence, legal constraints such as limitations on land clearing, farming and commercial activities within and around forest reserves have to be strategically resolved. Interventions such as enhanced law enforcement, community engagement, reforestation and rehabilitation projects, policy reforms, and education and awareness campaigns would be beneficial in achieving ecosystem recovery (Azeez et al., 2010; Phalan & Hajjar, 2007).

The use of remotely sensed data is essential for monitoring trends in LULC change and when combined with sociocultural information helps to identify the drivers of forest cover loss. This information is critical in tropical countries like Nigeria, where deforestation rates are high and secondary forest recovery is vital in initiatives such as landscape restoration and biodiversity conservation (Altamirano et al., 2020).

Teak Plantation in Osho Forest Reserve © Farhan Jimba Moshood

CONCLUSION AND RECOMMENDATION

The forest reserve requires immediate management interventions (such as assisted natural regeneration, enhanced law enforcement, community engagement and rehabilitation) to restore its ecological processes and functions. It is essential to improve land tenure security as this will allow small-scale farmers to practise sustainable land management. In addition, it is essential to build the capacity of forestry officials and communities in strategies that would promote natural forest regeneration as a favourable alternative to plantation establishment in the lowland rainforest of Nigeria.

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RESUMEN

El aumento de la población humana, que promueve la conversión de los bosques secundarios en otros tipos de uso del suelo, ha provocado la disminución de las zonas forestales en Nigeria. Este estudio examinó las causas de la pérdida de bosques secundarios en la Reserva Forestal de Osho, Nigeria. Los cambios en el uso del suelo y la cubierta vegetal (LULC) se evaluaron utilizando imágenes Landsat 5 TM y Landsat 8 OLI/TC en cuatro ocasiones durante un período de 38 años (1984, 2013, 2017 y 2022). Los resultados mostraron un aumento de la superficie de plantaciones, terrenos baldíos y tierras de cultivo, lo que llevó a una disminución de la cubierta forestal secundaria. Las tierras de labranza aumentaron de 731 ha a 859 ha a un ritmo de 3,7 ha/año-1, las tierras desnudas aumentaron de 314 ha a 523 ha a 5,5 ha/año-1, las plantaciones aumentaron de 1.105 ha a 1.495 ha a 10,3 ha/año-1, mientras que el bosque secundario se redujo drásticamente de 1.132 ha a 405 ha a 19,1 ha/año-1. A este ritmo de pérdida, el bosque secundario se habrá perdido en la zona de estudio en 2050. La Reserva Forestal de Osho requiere intervenciones inmediatas de gestión impulsadas por leyes y políticas actualizadas, tratamiento silvícola, compromiso comunitario y rehabilitación del ecosistema. Además, la aplicación de una gestión forestal sostenible mejoraría la recuperación del bosque secundario.

RÉSUMÉ

L'augmentation de la population humaine, qui favorise la conversion des forêts secondaires en d'autres types d'utilisation des sols, a entraîné une diminution des zones forestières au Nigeria. Cette étude a examiné les causes de la disparition des forêts secondaires dans la réserve forestière d'Osho, au Nigeria. Les changements dans l'utilisation des terres (LULC) ont été évalués à l'aide des images Landsat 5 TM et Landsat 8 OLI/TC à quatre reprises sur une période de 38 ans (1984, 2013, 2017 et 2022). Les résultats ont montré une augmentation de la superficie des plantations, des terres nues et des terres agricoles, entraînant une diminution de la couverture forestière secondaire. Les terres agricoles sont passées de 731 ha à 859 ha au rythme de 3,7 ha par an, les terres nues de 314 ha à 523 ha au rythme de 5,5 ha par an, les plantations de 1 105 ha à 1 495 ha au rythme de 10,3 ha par an, tandis que la forêt secondaire a considérablement diminué, passant de 1 132 ha à 405 ha au rythme de 19,1 ha par an. À ce rythme, la forêt secondaire aura disparu de la zone d'étude d'ici 2050. La réserve forestière d'Osho nécessite des interventions de gestion immédiates basées sur des lois et des politiques actualisées, des traitements sylvicoles, l'engagement de la communauté et la réhabilitation de l'écosystème. En outre, la mise en œuvre d'une gestion durable des forêts favoriserait la reconstitution de la forêt secondaire.

SHORT COMMUNICATION: SAFEGUARDING THE RIGHTS AND WELL-BEING OF RANGERS

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ABSTRACT

Rangers are on the frontline of conservation, providing a crucial service to nature – and humanity. Many of them face difficult and dangerous situations on a regular basis. They may encounter poachers and other criminal and potentially armed groups while on patrol, support rescue missions, fight fires or prevent wildlife from damaging crops, thus risking and sometimes even losing their lives. Despite these dangers and hardships, the provisions in place to safeguard their interests and safety often fall short of providing meaningful response and protection and they lack the same acknowledgement other frontline workers receive. The 'Principles for Safeguarding the Rights and Well-being of Rangers' were developed in an effort to contribute towards the improvement of the situation rangers face around the world and to provide clear standards for practitioners and decision-makers to guide policy and action. Guidance and tools for the implementation of the principles were also developed to help close the gap between theory and practice.

Key words: safeguards, protected and conserved areas, human rights

INTRODUCTION

Rangers play a crucial role as nature's first responders. They are known by different titles and are defined by the International Ranger Federation (IRF) as individuals or groups of individuals working in protected and conserved areas and wider land- and seascapes that are responsible for safeguarding nature and cultural and historical heritage as well as for protecting the rights and well-being of present and future generations (IRF, 2021).

The ranger profession demands a multitude of skills and an extensive understanding of the environmental and socio-cultural landscape in which they operate. At the same time, ranger jobs can be dangerous, and death in the line of duty is not rare within the ranger workforce: between 2006 and 2021, an estimated 1,535 rangers have lost their lives (Galliers et al., 2022). All too often rangers lack adequate equipment, support and recognition, and do not have the means to ensure their rights and well-being are respected (e.g. Anagnostou et al., 2022; Belecky et al., 2019; Singh et al., 2020; WWF, 2022).

Misconduct by rangers towards communities or individuals has been an issue of considerable concern that has damaged the reputation of the workforce and undermined the overall approaches adopted by conservation projects and protected area authorities (e.g. Duffy et al., 2019; Tauli-Corpuz et al., 2020). However, while a lot of attention is paid to such cases and there has been a strong international response, including the creation of a 'Code of Conduct' (CoC) by the IRF, the perilous situation of rangers themselves often gets overlooked and they find themselves lacking the appropriate working conditions and respect that other essential frontline workers, such as police officers and firefighters, receive (Galliers et al., 2022; Stolton et al., 2023; WWF, 2016, 2019).

In light of this, there is a need to ensure that the rights of rangers are also safeguarded. Social safeguards are a set of standards, policies, mechanisms and compliance systems that aim to prevent and mitigate harm to people and their environment and to offer compensation to those affected by conservation activities and other development interventions. The 'Principles

for Safeguarding the Rights and Well-being of Rangers' and accompanying guidance were designed to be part of this broader social safeguards umbrella, providing a framework for and connecting existing efforts to improve the lives of rangers and ensure that they are, and feel, safe and supported.

To understand the gaps that needed to be filled by the principles and accompanying guidance, an initial literature review was conducted. Based on this review, two scoping workshops were held in March and May 2022 by Asesoramiento Ambiental Estratégico (AAE) and the Universal Ranger Support Alliance (URSA) to shed further light on the needs in safeguarding provisions for rangers. The workshops included practitioners working with and supporting rangers, such as experts in environmental and social (E&S) safeguards and human rights and employees from the ranger workforce itself. The insights gained during this process informed the development of the principles and guidance (Barrueco et al., 2023; Iraola et al., 2023).

THE PRINCIPLES FOR SAFEGUARDING THE RIGHTS AND WELL-BEING OF RANGERS

The following ten principles (see Figure 1) seek to achieve the aim of creating a motivated ranger workforce that places human rights at the heart of their operations and fosters trust with vulnerable individuals and groups they come into contact with. The human rights approach on which the principles are based involves: 1) proactively preventing or, if not possible, minimising situations where the safety of rangers or those they interact with could be compromised, and 2) reactively addressing instances in which rangers or people they interact with did not feel safeguarded.

It is important to recognise that no one principle alone will achieve this aim. Instead, these principles are interconnected, with each one offering contributions that collectively support their realisation. While rangers, whether officially employed or working as volunteers, are the focus of the principles, this aim can only be achieved with the support of all stakeholders, including governments, organisations employing or supporting rangers, local communities and the general public.

Ensuring rangers have a clear mandate and role

Rangers can find themselves in situations where lives are potentially at stake and therefore need clarity on how to identify their responsibilities and respond during emergencies. Lack of clarity on mandate (authority to act in a particular way) and role (position or purpose of an employee) as well as lack of adequate training can have

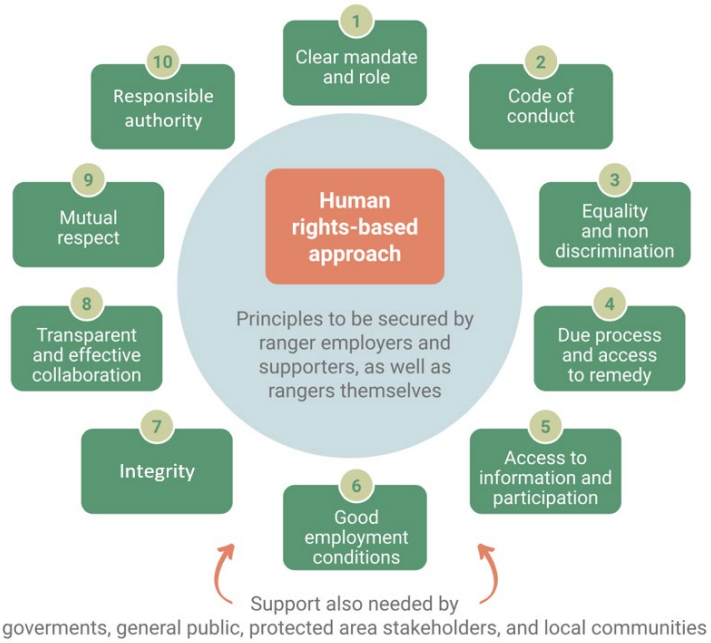

Figure 1. The Principles for Safeguarding the Rights and Well-being of Rangers, with a human rights-based approach at the centre (Source: Iraola et al., 2023).

severe consequences (i.e. result in injuries or even death if they suffer accidents or attacks, or in civil and criminal proceedings and/or penalties if they act wrongfully or negligently).

Organisations employing or supporting rangers can ensure a clear mandate and role through a combination of measures, including conducting a conflict sensitivity analysis, determining the necessary competencies for the job (see, for example, IRF and URSA, 2023), and developing training and education plans according to the specific circumstances of each area. Many rangers face difficult challenges when they are threatened, for example, with violence by poachers or other armed groups, and therefore, adequate training, as well as having clarity on their mandate and role, become essential to ensure they are well prepared to face such challenges. Where rangers are expected to carry firearms (e.g. in areas where poachers might be present), psychological and technical assessment checks for job suitability and comprehensive training in the use of weapons ought to be implemented.

Acting within and respecting the Code of Conduct

A well-developed Code of Conduct (CoC) encourages a disciplined and empowered workforce that maintains high standards of practice and ethics. It also provides valuable guidance to rangers, ranger employers and conservation organisations supporting rangers to make better work decisions and promotes the implementation of globally accepted best practices.

Salome Idoidze, the first female ranger in Georgia (Tusheti Protected Areas). © Paata Vardanashvili

Employers and organisations should first analyse the need for a CoC, and if one has already been developed, assess and benchmark it against IRF's CoC to ensure that the highest standards are met. Effective communication and awareness-raising of the need for a CoC is also very important to ensure buy-in, as is making the necessary adjustments to meet specific practical and institutional needs and requirements.

Securing equality and non-discrimination

Discrimination and unequal treatment are unfortunately not uncommon within the ranger workforce. Apart from suffering from sexual and labour harassment, women also face disparity in employment and promotion opportunities, fuelled mainly by gender stereotypes. To date, it is estimated that women constitute only 3–11 per cent of the ranger workforce (Seager, 2021).

Actions to promote equality and respect in the ranger workforce include carrying out systematic training for rangers on all aspects of discrimination; developing and/or improving protocols against all forms of discrimination, abuse and violence (including sexual harassment and gender-based violence) and ensuring the proper implementation of such protocols; and having policies in place that ensure that equality is guaranteed for hiring, promotion and remuneration.

Ensuring due process and access to effective remedy (judicial and non-judicial)

Rangers, just like everyone else, should have access to due process in the event that they are accused of misbehaviour, and to effective remedy in case they are wronged or are involved in accidents during work operations. Grievance redress mechanisms (GRMs) play a crucial role in the process of obtaining due process and eventually remedy, and should operate as open and transparent procedures for all parties while handling confidential information in a satisfactory manner. Adequate legal assistance (e.g. in the form of a legal regulatory body) and systems that safeguard rangers against unfair accusation and treatment are also needed to ensure rangers are cleared of unsubstantiated allegations with no further negative consequences for them. In cases where accusations are proven true, it is vital to have a fair process that leads to fines and/or penalties proportionate to the wrongdoing.

Enabling access to information and participation

Establishing trust within the sector, as well as between rangers and the people they come into contact with, can be facilitated by ensuring that everyone feels well-informed and listened to. Therefore, it is crucial to provide accessible, comprehensive and timely information to rangers, including regarding their rights, avenues for legal support, availability of medical support in case of emergencies and access to the GRM in the event of witnessing misconduct or experiencing unfair treatment. It is also important to go beyond the mere sharing of information and increase ranger participation in decision-making processes affecting their working conditions, role and mandate.

Supporting ranger welfare through good employment conditions

A good working environment, including good employment conditions, is essential to ensure a professionalised and efficient workforce. Unfortunately, these conditions are frequently not met in the ranger workforce. According to Belecky et al. (2019 and 2021), out of 6,241 rangers that participated in a survey from 28 countries, less than half (46.6 per cent) reported

Polisin'ala, community patrollers near Antenina in Ambaro Bay, Ambilobe, Madagascar. © Nick Riley / WWF-Madagascar

having access to paid sick leave, roughly one-third (33.7 per cent) said they had life insurance and only 48.3 per cent answered affirmatively when asked if the medical treatment provided was adequate when needed.

It should be ensured that rangers have a minimum acceptable remuneration, are paid on time, receive payment while on holiday, family or sick leave, and are provided with life and health insurance. It should also be guaranteed that all rangers have basic equipment and that well-defined procedures are established so that the workforce feel adequately equipped and supported while on duty. Supporting the mental health of the workforce is also a must and can be done by providing a proper work/life balance and psychological support, if needed.

Promoting integrity in the ranger workforce

Integrity is a desirable characteristic of any employee, and while part of it may come with personality, it can also be actively promoted. Superiors and organisations employing rangers can play a key role by leading by example, demonstrating strong moral principles and showing respect, appreciation and support for all members of the workforce. Having a robust recruitment and selection process in place can also help guarantee that rangers enter the profession with the right values and level of integrity. Additional measures can include establishing an oversight body and a reporting mechanism for rangers, implementing background checks and well-being plans, actively and openly including ranger unions and associations in any anti-corruption measures, and providing access to an independent, fair and safe whistleblowing mechanism.

Fostering transparent and effective collaboration

Encouraging transparency and collaboration is key, as is finding solutions to ranger–community problems with an understanding of the community's needs and efforts and its capacity to partner in conservation. This can be actively promoted by ensuring rangers have an in-depth understanding of the socio-cultural context of the community they will be operating in and understand the factors that may limit effective collaboration, in particular grievances over territory, rights and previous abuse. Establishing channels of communication and response systems (including associated training) in order to anticipate and mitigate any possible conflict and crisis is also important.

Building and consolidating mutual respect

Rangers are expected to demonstrate respect in many ways, including towards the law, the CoC, and the views and interests of Indigenous Peoples and local communities (IPLCs) and other vulnerable groups. However, a case can be made for how they themselves are not always treated with respect, as they can sometimes be subject to verbal and even physical abuse from both colleagues, local community members and visitors.

An internal policy or guidelines setting the terms for adequate behaviour at work that emphasise collaborative

and respectful relationships is a must-have in any organisation. It is also important to encourage the adoption of practices and attitudes that build trust and respect between rangers and communities (see Stolton et al., 2022), and having operating procedures and training in tolerance, patience and conflict avoidance.

Conferring and exercising responsible authority

Those in charge must also be able to exercise responsible authority and sound judgement while also delegating authority appropriately to others. Given the nature of the ranger profession, this is particularly important as those in charge need to know how to act and lead those under their responsibility in what can sometimes be very dangerous situations (e.g. encounters with poachers and other armed groups, wildlife attacks or serious accidents). The political realities of protected and conserved areas and lack of proper financing also mean that these areas sometimes face limitations in terms of adequate management, and those responsible should ensure that these constraints do not exacerbate the problems already faced by rangers (see the Convention on Biological Diversity's Programme of Work, Goals 1.4 (especially 1.4.6) and 3.2 (CBD, 2004).

Performing leadership tests and employee evaluations, instituting capacity building programmes for superiors and setting up procedures to monitor whether authority is exercised appropriately are actions that organisations employing rangers can implement to work towards guaranteeing that authority is exercised in a responsible manner. Efforts also need to be made to ensure that superiors are being more proactive in supporting rangers, as rangers are often seen not only as leaders within their communities but also as breadwinners, which can lead to significant pressure to perform.

CONCLUSION AND WAY FORWARD

The principles presented here serve as a guide to protect the rights and interests of rangers and other actors with whom they interact and, as such, are part of a broader social safeguards framework of policies, codes and standards that aim to uphold human rights and achieve transparency, non-discrimination, public participation and accountability, among other goals.

The value and potential beneficial impact of the principles, however, depend on their proper implementation by the relevant authorities. The developed documentation, which includes an accompanying spreadsheet designed as a planning tool, offers more detailed guidance, tools and resources to support an appropriate application of the principles at different institutional levels. These can be found at https://www.ursa4rangers.org/ursa4rangers-resources/

The principles and guidance documents are recent and socialisation of them has only just started. They were presented in a recent IRF Ranger Roundtable Webinar and further outreach opportunities are explored. The medium-term objective is to pilot their implementation in practice, which would allow their further refinement and adjustment over time and thus optimise their impactful implementation.

ABOUT THE AUTHORS

Sara Barrueco is a Safeguards and Policy Analyst at AAE, where her work has focused mainly on environmental and social standards, risk and impact assessments/due diligence and the development of policy guidance, in particular for the Latin America, Caribbean and Africa regions. Her background is primarily in environmental politics and ethics and climate change.

María Jesús Iraola is a geographer who has worked as an environmental consultant for the past eight years specialising in E&S safeguards. She has worked in Latin American and African countries, producing Strategic E&S Impact Assessments, including organising consultations with multiple stakeholders and producing E&S Management Frameworks.

Monika Bertzky has almost 20 years' experience in international conservation, with a focus on E&S safeguards/standards, Strategic E&S Assessments, E&S Impact Assessments, E&S Management Frameworks/ Plans and other tools for human-rights based conservation. She is a member of the WCPA and of the Commission on Environmental, Economic and Social Policy.

Rohit Singh has over 17 years' experience in wildlife law enforcement, anti-poaching and ranger related work. He is Director Protected and Conserved Areas Management and Governance at World Wildlife Fund and also the Asia representative of the International Ranger Federation.

Chris Galliers is the President of the International Ranger Federation, having been on the IRF Committee since 2012.

SUPPLEMENTARY ONLINE MATERIAL

Iraola, M. J., Barrueco, S., Bertzky, M., Singh, R. & Galliers, C. M. (2023). *Safeguarding the rights and well-being of rangers. Part 1: Principles*. Universal Ranger Support Alliance (URSA).

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RESUMEN

Los guardas forestales están en primera línea de la conservación y prestan un servicio crucial a la naturaleza y a la humanidad. Muchos de ellos se enfrentan periódicamente a situaciones difíciles y peligrosas. Pueden encontrarse con cazadores furtivos y otros grupos delictivos y potencialmente armados mientras patrullan, apoyan misiones de rescate, luchan contra incendios o evitan que la fauna salvaje dañe los cultivos, arriesgando así, y a veces incluso costándoles, la vida. A pesar de estos peligros y adversidades, las disposiciones vigentes para salvaguardar sus intereses y su seguridad a menudo se quedan cortas a la hora de ofrecer una respuesta y una protección significativas, y carecen del mismo reconocimiento que reciben otros trabajadores de primera línea. Los "Principios para Salvaguardar los Derechos y el Bienestar de los Guardaparques" se desarrollaron en un esfuerzo por contribuir a la mejora de la situación a la que se enfrentan los guardaparques en todo el mundo y proporcionar normas claras para los profesionales y los responsables de la toma de decisiones para orientar la política y la acción. También se elaboraron orientaciones y herramientas para la aplicación de los principios con el fin de ayudar a cerrar la brecha entre la teoría y la práctica.

RÉSUMÉ

Les gardes forestiers sont en première ligne de la conservation, fournissant un service crucial à la nature - et à l'humanité. Nombre d'entre eux sont régulièrement confrontés à des situations difficiles et dangereuses. Ils peuvent rencontrer des braconniers et d'autres groupes criminels et potentiellement armés au cours de leurs patrouilles, participer à des missions de sauvetage, lutter contre les incendies ou empêcher les animaux sauvages d'endommager les cultures, ce qui risque de leur coûter la vie et parfois même la leur. Malgré ces dangers et ces difficultés, les dispositions en place pour protéger leurs intérêts et leur sécurité sont souvent loin d'apporter une réponse et une protection significatives, et ils ne bénéficient pas de la même reconnaissance que les autres travailleurs de première ligne. Les "Principes pour la sauvegarde des droits et du bien-être des rangers" ont été élaborés dans le but de contribuer à l'amélioration de la situation des rangers dans le monde et de fournir des normes claires aux praticiens et aux décideurs afin de guider les politiques et les actions. Des conseils et des outils pour la mise en œuvre des principes ont également été développés pour aider à combler le fossé entre la théorie et la pratique.