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

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

* Corresponding author: TJL222@cornell.edu

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

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

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

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

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

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

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

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

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

METHODS

Landscape assessment site

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

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

Rapid visual landscape assessment

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

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

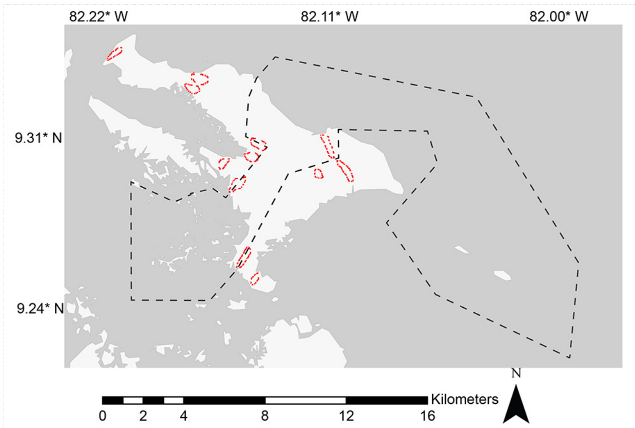

Figure 1. Bastimentos Island National Marine Park. Protected area is represented by dotted black line. Dotted red polygons represent areas where data was collected on Bastimentos Island.

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

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

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

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

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

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

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

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

Data analysis

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

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

RESULTS

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

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

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

DISCUSSION

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

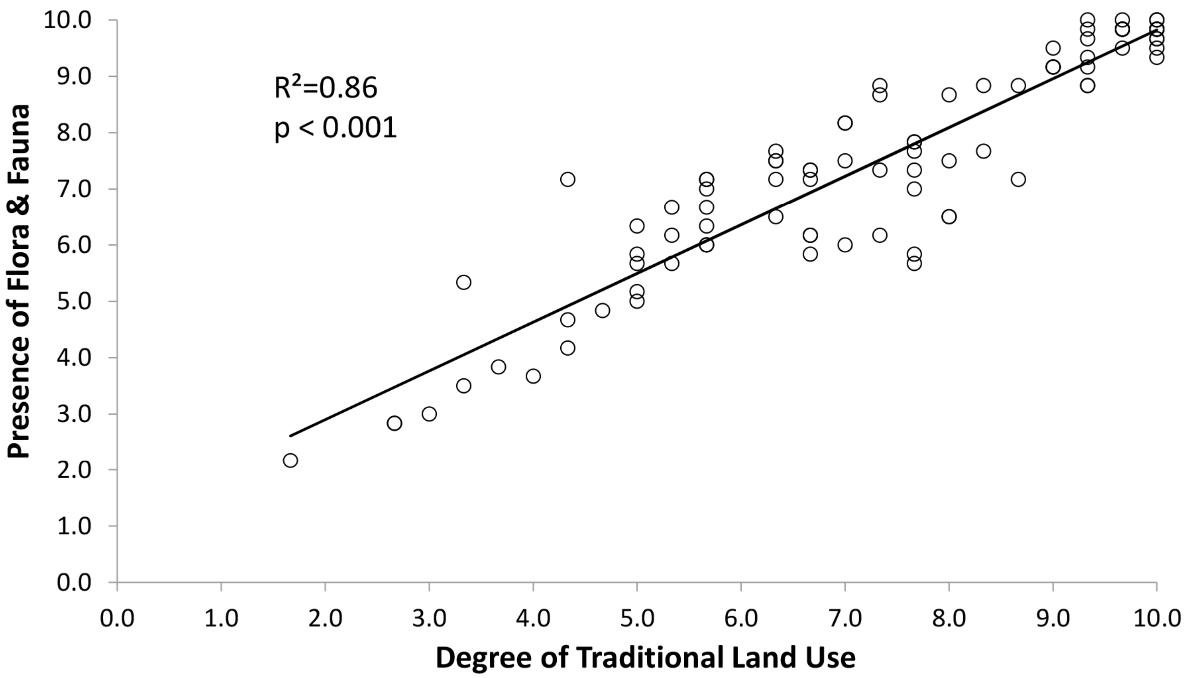

Figure 2. Relationship between the presence of flora and fauna, and the degree of traditional land use across Bastimentos Island. The presence of flora and fauna is a composite indicator that is based on averaging the flora, and wildlife and wildlife habitat metrics, which ranges from minimal (0) to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

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

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

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

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

CONCLUSION

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

ACKNOWLEDGEMENTS

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

ABOUT THE AUTHORS

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

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

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

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

REFERENCES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Golden Kroner, R.E., Qin, S., Cook, C.N., Krithivasan, R., Pack, S.M., Bonilla, O.D., Cort-Kansinally, K.A., Coutinho, B., Feng, M., Martínez Garcia, M.I., He, Y., Kennedy, C.J., Lebreton, C., Ledezma, J.C., Lovejoy, T.E., Luther, D.A., Parmanand, Y., Ruíz-Agudelo, C.A., Yerena, E., Zambrano, V.M. and Mascia, M.B. (2019). The uncertain future of protected lands and waters. *Science* 364: 881–886. https://doi.org/10.1126/science.aau5525

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

RESUMEN

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

RÉSUMÉ

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