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Multidimensional indicators to improve management effectiveness monitoring of protected areas

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Abstract

Protected areas are designed to protect the remaining ecological frontiers for biodiversity conservation. However, global studies claim that the PA systems seem to fail in securing large ecosystem mosaics that are needed to protect threatened and endemic species. There is a myriad of metrices to measure the management effectiveness of protected areas. This review paper explored the use of Management Effectiveness Tracking Tool (METT) for assessing management capacity of protected areas in the Philippines and other possible indicators that are measurable and verifiable to holistically assess PA performance. Our review showed the following results: 1) Philippine protected areas showed improvement from poor to fair in METT scores from 2013 to 2017; 2) PA design elements did not fully cover species survival envelopes and suitable habitats; and 3) there was an undesirable inverse relationship between habitat quality and METT scores. To address these, we suggest the adoption of a suite of multidimensional approaches that will take into account a system level performance metric, a performance-based metric, and an ecological/biophysical metric. The combination of these metrics will provide management solutions in ensuring a strategic and sustainable delivery of the twin objectives of the protected areas in the Philippines.

Keywords: Management Effectiveness Tracking Tool, METT, protected area management, species survival envelopes, biodiversity conservation, Philippines, endemic species, threatened species

Introduction

It is widely believed that establishing protected areas is an effective 'wholesale' approach in conserving biodiversity (Fuller et al. 2006). Developing a network of parks and reserves that sufficiently cover as much biodiversity as possible should be considered as one of its main goals (Jepson et al. 2002; Lee et al. 2007). Historically, protected areas have served as set-asides for biodiversity conservation, setting apart selected elements of biodiversity or exceptional landscapes from anthropogenic processes that threaten their existence (Kalamandeen & Gillson 2007; Terborgh 1999). This set-asides concept of protected areas was exemplified by the system of protection of the Yellowstone National Park, from the early 1870s. This approach to protection was characterized by a system of restrictions and punishments relating to disruptive human access and behaviour (Dressler et al. 2006; Kalamandeen & Gillson 2007). This system of partial exclusion and elimination of exploitation has been the model of management by many countries and for many years (Alcala & Russ 2006; Kaimowitz & Sheil 2007). However, implementation experience quickly showed that in most parts of the world, people live within these protected areas, with legitimate historical claims to the land (McNeely 1982, 1991, 1993b). For example, as much as 85% of the world's protected areas are inhabited by indigenous peoples, whilst most remaining areas of natural ecosystems are either claimed or owned by them through statutory or customary rights (Hayes 2007; Sodhi et al. 2008). At present, especially in developing countries, the dynamics created by exponential growth in human population and migration, as well as economic expansion and globalisation, has made the old exclusionary approach problematic and, in some cases, simply obsolete (Bhagwat & Rutte 2006; Lu et al. 2006). Integrated conservation and development projects (ICDPs) that are designed to bridge the gap between the approaches that emphasise protection of biodiversity and conservation in support

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of people are preferred (Baral et al. 2007; Chapman 2003). In general, one of the key issues in protected area management is that PA plans often were not properly formulated and implemented because governments announced their intention of establishing them long before their legal structure was in place. This results in the establishment of paper parks or protected areas that exist only in name, but has no legal status, no staff, no infrastructure, and may not even be clearly defined geographically (Mulongoy & Chape 2004). Another glaring issue often is the lack of clear, quantitative, and meaningful measures of protected area effectiveness in terms delivering biodiversity conservation targets (Chape et al. 2005).

In the Philippines, after more than two decades since the enactment of the National Integrated Protected Areas System Law of 1992, there is an assumption that a strong legal framework exists, decentralized and collaborative institutional arrangements are available, and a multi-sector and participatory approach in protected area planning and management is the norm (Saway and Mirasol, 2004). A strong institutional support mechanism is one of the key elements in protected area management (Brandon et al. 2005; Brown 1994). The weakness, however, lies in the absence of a strong, scientifically defensible set of conservation planning tools for many protected areas. This gap between management systems/infrastructure and science-based conservation planning clearly undermines the efficacy of protected areas (Kapos et al., 2008; Mallari et al. 2015). There are many protected areas, especially in the developing world, where there is a dearth of technical experience and expertise to support and guide conservation planning, and measuring impacts of the various conservation activities on biodiversity (Hayes 2006; Lovejoy 2006; Nagendra et al. 2006; Pavese et al. 2007). This gap between management systems/infrastructure and science-based conservation planning has been confirmed in Mallari et al. (2015), a Philippines-based PA-efficacy study, which concluded that many protected areas were not positioned properly to cover key biodiversity areas, their land zonation systems were not appropriate to protect biodiversity, and the low capacities of PAs failed to deliver the conservation targets.

Currently, the main tool for assessment of PA management capacity is the Management Effectiveness Tracking Tool (METT; Guiang and Braganza, 2014; Madarang et al., 2017). The METT is a rapid assessment tool based on the World Commission on Protected Areas (WCPA) framework, which provides standards for assessments and reporting in PA management (WWF International, 2007; Stolton and Dudley, 2016). The WCPA framework suggests that the process of an effective protected area management starts by understanding the existing values and threats of a given PA (context), followed by designing the management interventions (planning), allocation of resources (inputs), implementation (processes) of management actions, goods and services (outputs), all of which eventually result in impacts (outcomes; Hockings et al., 2006; Hockings et al., 2015). These six elements are used to evaluate the performance of protected areas to deliver conservation and development outcomes. The assessment tool consists of 30 questions with corresponding scores (ranging between 0, for poor, to 3, for excellent) to objectively quantify each element. Many countries, including the Philippines, have used METT as the main tool for assessing management effectiveness (Hockings et al., 2006; Stolton et al., 2019).

In 2013, an analysis of METT scores of 63 protected areas in the Philippines was conducted to create an initial depiction of PA management effectiveness since the *NIPAS Act* was ratified in 1992. The result of this analysis demonstrated that average METT score for 63 PAs was 33, out of a possible maximum score of 110 (Guiang and Braganza, 2014). However, this result may be an overestimation of actual conditions of the country's PA management because substantial data to support METT scores were lacking and inappropriateness of some indicators is apparent (Guiang and Braganza, 2014). In 2017, a similar analysis of METT scores was conducted for 64 protected areas and an additional 100 proposed/new protected areas. Results showed an improved average METT score from 33 (Guiang and Braganza, 2014) to 49 (Madarang et al., 2017). However, scores for the 100 new and proposed PAs was substantially lower, at 27 (Madarang et al., 2017). The authors of the latter study attributed the increase in METT scores to development of management plans, resource inventories, the number of stakeholders involved in planning, increases in foot patrols, and increased in PA staffing (Madarang et al., 2017). Furthermore, Madarang et al. (2017) noted that despite the marked improvement of METT scores, the downhill trend of the quality of ecosystems continues to be unabated. The inverse relationship between METT scores and ecosystem quality suggests that METT only measures parts of the whole conservation continuum, and that having high METT scores may not guarantee conservation success. In this paper, we explored the shortfalls of using a singular tool such as METT and proposed practical remedies to improve the way we measure management effectiveness.

Analytical approach

We assessed the management effectiveness scores of 58 terrestrial protected areas using the METT scorecard adopted by the Philippine government's Biodiversity Management Bureau and validated by third party assessors through the National

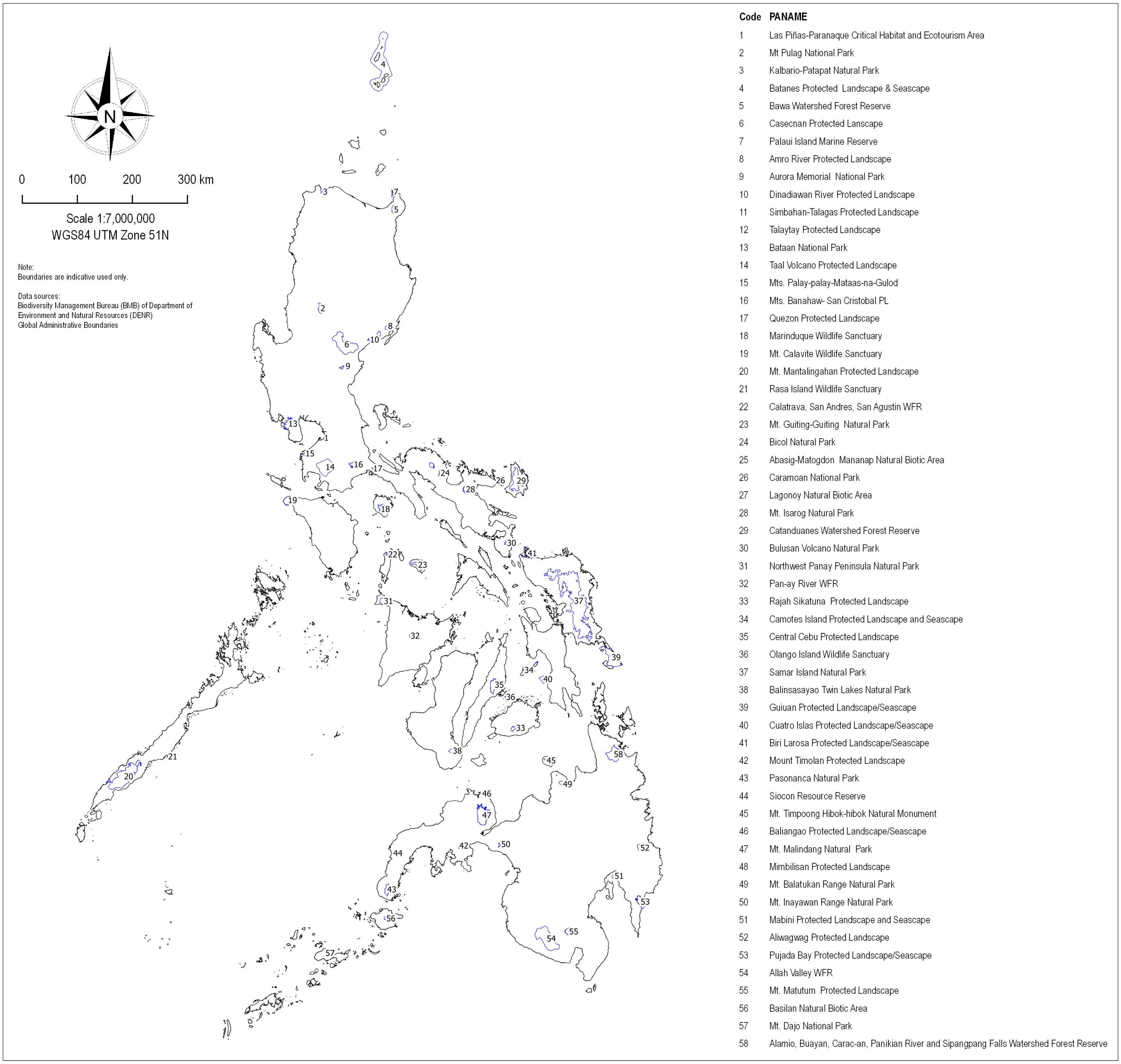

Figure 1. Map showing the location of the 58 protected areas.

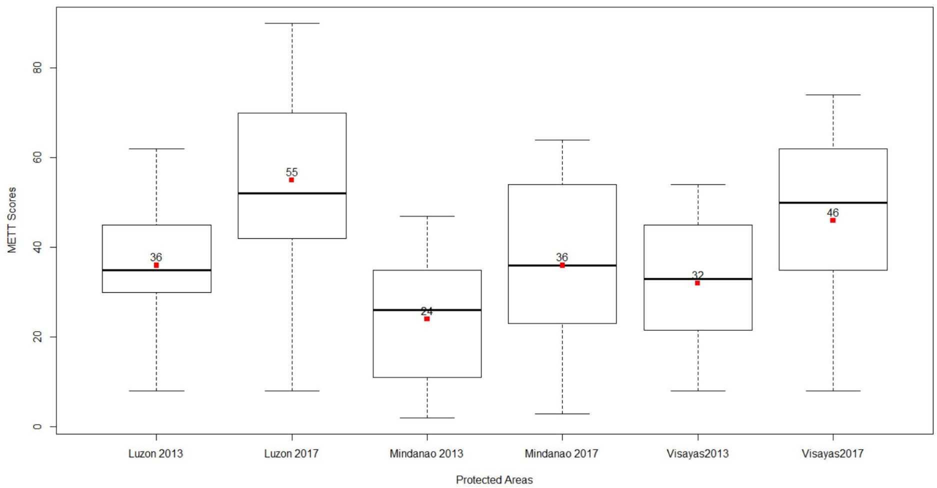

Figure 2. Protected area performance based on their METT scores from 2013 to 2017.

Management Effectiveness and Capacity Assessment (NMECA) of the Protected Area Management Enhancement (PAME) Project. Variation of METT scores (2013 to 2017; across sites in the three political regions of the Philippines, namely Luzon, Visayas and Mindanao) were summarized by a box-and-whiskers plot (Figure 2). Average METT scores (mean ± one standard deviation) for each indicator were calculated to demonstrate changes in management effectiveness (Table 1). Scores for METT indicators represented a scale from no management ($\mu = 0$) to excellent management standards ($\mu = 3$), whereas sub-indicators, are scaled from no management ($\mu = 0$) to effective management ($\mu = 1$).

To further show links between the METT scores and biophysical evidence of response towards management effectivity metrics, we chose five protected areas as exemplars, Bataan National Park, Mt. Malindang Range Natural Park, Mt. Hamiguitan Range Wildlife Sanctuary, Mt. Mantalingahan Protected Landscape, and Samar Island Natural Park (Figure. 1). Individual species distribution models (SDMs) were produced for 104 threatened and endemic bird species, at two time periods, using the Maximum Entropy algorithm (MaxEnt; Elith et al., 2006; Pearson 2007; Johnston et al., 2015). Birds are proven to be one of the better indicators in setting management priorities because of their ability to respond to small and large-scale disturbances (Song et al., 2015; Mekonen 2017). We produced historical SDMs (inclusive years: 1960 to 1994) and fairly recent SDMs (1995-2018), using nine bioclimatic parameters such as temperature, precipitation, seasonality, mean diurnal range, and forest cover (Hijmans et al., 2006), and species occurrence records that coincide within the same time period (Figure 2). The 104 SDMs were overlaid to determine umbrella sites, which show degrees of congruence/ overlap of species survival envelopes (sets of requisite ecological parameters for species survival) with PA boundaries to determine adequacy of PA coverage (Figures 3-7).

We also compared extent of forest cover (= tree cover; Hansen et al., 2013) with the extent of PA boundaries. Images containing information on tree cover percentage were accessed from the Global Tree Cover dataset annually generated by the University of Maryland (Hansen et al., 2013). The dataset was processed to show changes between 2001 and 2018 (Figure 9). Area of tree cover loss and gain was estimated (Table 3). All image processing and analysis were performed using Quantum GIS (QGIS).

Results and discussion

Overall METT scores improved from "poor to fair" in four years

All 58 terrestrial protected areas showed improvement in their METT scores from 2013 to 2017 (Table 1). The scores improved from a mean from 36 to 54 for PAs on Luzon, 32 to 46 for PAs in the Visayas, and from 24 to 36 for PAs on Mindanao. However, overall METT scores remained low, indicating that most PAs still fall below basic management requirements. Based on Madarang et al. (2007), the overall standing of the PA network in the Philippines is "fair," despite increased investments in capacity (PAME project, Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience or B+WISER Program, Lawin Forest and Biodiversity Protection System or Lawin, Biodiversity Partnership Program or BPP, etc). Perhaps additional future increased investments should be targeted towards rectifying the gaps in management effectiveness.

A high variability in METT scores was noted amongst the regions (Table 1). This variabiation became more apparent when

Table 1. List of the 58 protected Areas with their 2013 and 2017 METT scores (maximum score = 110).

Region	PAME Sites	Ecosystem	METT Total Scores 2013	METT Total Scores 2017
NCR	Las Piñas-Paranaque Critical Habitat and Ecotourism Area (LPPCHEA)	Wetlands	43	40
CAR	Mt. Pulag National Park (MPNP)	Terrestrial	45	85
1	Kalbario-Patapat Natural Park (KPNP)	Terrestrial	30	71
2	Batanes Protected Landscape and Seascape (BPLS)	Terrestrial/Marine	58	65
2	Baua-Wangag Watershed Forest (BWWFR)	Terrestrial	31	70
2	Casecnan Protected Landscape	Terrestrial	36	70
2	Palaui Island Protected Landscape and Seascape (PIPLS)	Terrestrial/Marine	39	54
3	Amro River Protected Landscape	Terrestrial	21	52
3	Aurora Memorial National Park (AMNP)	Terrestrial	30	78
3	Dinadiawan River Protected Landscape (DRPL)	Terrestrial	15	31
3	Simbahan-Talagas Protected Landscape (STPL)	Terrestrial	24	50
3	Talaytay Protected Landscape	Terrestrial	33	52
3	Bataan Natural Park	Terrestrial	45	73
4A	Taal Volcano Protected Landscape	Wetlands	62	34
4A	Mts. Palay-palay/Mataas na Gulod Protected Landscape	Terrestrial	35	27
4A	Mts. Banahaw-San Cristobal Protected Landscape (MBSCPL)	Terrestrial	50	50
4A	Quezon Protected Landscape (QPL)	Terrestrial	35	71
4B	Marinduque Wildlife Sanctuary (MWS)	Terrestrial	30	30
4B	Mt. Calavite Wildlife Sanctuary (MCWS)	Terrestrial	23	69
4B	Mt. Mantalingahan Protected Landscape (MMPL)	Terrestrial	55	90
4B	Rasa Island Wildlife Sanctuary (RIWS)	Terrestrial/Marine	55	81
4B	CALSANAG Watershed Forest Reserve	Terrestrial	8	8
4B	Mt. Guiting-guiting Natural Park	Terrestrial	48	48
5	Bicol Natural Park (BNP)	Terrestrial	44	35
5	Abasig-Matogdon-Mananap Natural Biotic Area (AMMNBA)	Terrestrial	36	58
5	Caramoan National Park (CNP)	Terrestrial	23	45
5	Lagonoy Natural Biotic Area (LNBA)	Terrestrial	23	42
5	Mt. Isarog Natural Park (MINP)	Terrestrial	33	49
5	Catanduanes Watershed Forest Reserve (CWFR)	Terrestrial	41	63
5	Bulusan Volcano Natural Park (BVNP)	Terrestrial	33	45
6	Northwest Panay Peninsula Park (NWPPNP)	Terrestrial	33	33
6	Panay River Watershed Forest Reserve (PRWFR)	Terrestrial	8	8
7	Rajah Sikatuna Protected Landscape (RSPL)	Terrestrial	44	38
7	Camotes Island Mangrove Swamp Forest Reserve (CIMSFR)	Wetlands	33	27
7	Central Cebu Protected Landscape (CCPL)	Terrestrial/Marine	26	74
7	Olango Island Wildlife Sanctuary (OIWS)	Terrestrial/Marine	54	55
8	Samar Island Natural Park (SINP)	Terrestrial	46	62
7	Balinsasayao Twin Lakes Natural Park (BTLNP)	Terrestrial	48	50
8	Guiuan Marine Reserve and Protected Landscape/ Seascape (GMRPLS)	Terrestrial/Marine	30	37

Table 1 cont. List of the 58 protected Areas with their 2013 and 2017 METT scores (maximum score = 110).

Region	PAME Sites	Ecosystem	METT Total Scores 2013	METT Total Scores 2017
8	Cuatro Islas Protected Landscape/Seascape (CIPLS)	Terrestrial/Marine	17	62
8	Biri-Larosa Protected Landscape/Seascape (BLPLS)	Terrestrial/Marine	16	65
9	Mt. Timolan Protected Landscape (MTPL)	Terrestrial	30	27
9	Pasonanca Natural Park (PNP)	Terrestrial	35	35
9	Siocon Resource Reserve (SRR)	Terrestrial	11	11
10	Mt. Timpoong-Hibok-hibok Natural Monument	Terrestrial	35	46
10	Baliangao Protected Landscape and Seascape (BPLS)	Terrestrial/Marine	36	36
10	Mt. Malindang Range Natural Park (MMRNP)	Terrestrial	46	54
10	Mimbilisan Protected Landscape	Terrestrial	22	47
10	Mt. Balatukan Range Natural Park (MBRNP)	Terrestrial	28	30
10	Mt. Inayawan Range Natural Park	Terrestrial	9	23
11	Mabini Protected Landscape and Seascape (MPLS)	Terrestrial/Marine	23	42
11	Aliwagwag Protected Landscape (APL)	Terrestrial	25	55
11	Pujada Bay Protected Landscape and Seascape (PBPLS)	Terrestrial/Marine	26	55
12	Allah Valley Protected Landscape	Terrestrial	47	64
12	Mt. Matutum Protected Lanscape (MMPL)	Terrestrial	29	58
ARMM	Basilan Natural Biotic Area	Terrestrial	3	9
ARMM	Mt. Dajo National Park (Bud Dajo National park)	Terrestrial	2	3
13	Alamio, Buyaan, Carac-an, Panikian Rivers and Sipangpang Falls Watershed Forest Reserve (ABCPRSFWFR)	Terrestrial	7	14

scores were compared among the PA networks in Luzon, Visayas, and Mindanao. The protected area network in Luzon included a mix of well-managed and poorly-managed PAs (Figure 1). On average, at least 25% are above the upper quartile of the METT score (>75), whereas half of the PAs are below the median (52). These Luzon PAs performed better than PAs in Visayas and Mindanao where none received an above average score. Perhaps these low METT scores were connected to the proximity of Luzon PAs to the country's capital where the national government offices were located. The Luzon's high PA performance further suggests that remoteness (e.g., distance and travel time to major cities), accessibility (infrastructure development), socioeconomic factors (income, education, employment), and political circumstances (safety and security issues, governance) may have had an influence on the Pas performance. Future studies should be conducted to test these potential correlates.

Increased PA activities resulted in improved METT scores

Elements that contributed to high METT scores were related to context and PA planning. Improvement in METT scores was observed in elements that focused on PA planning and the designing of work and financial programs. Almost 75% of PAs have reportedly defined and adopted their management plans. However, these management plans have not necessarily been implemented, and therefore may not have improved PA spatial designs involving species and habitat protection, and/or threat reduction, in cases where indicators #4 protected area objectives, #5 protected area design, or #21 planning for adjacent land and water use remained at basic management levels. Third party NMECA validators reported that regulations for legal and traditional controls of zoning boundaries were not well-defined in management plans, resulting in conflicts among stakeholders (local communities, indigenous peoples, and/or private landowners) on managing land and water resources (Madarang et al., 2017).

Indicators under the 'Inputs' element, relating to staff capacity, improved to basic management, while indicators relating to financial security scored below an acceptable level (Table 2). The mean score for #13 indicator (staff number) improved from a low score (0.84 ± 0.64) in 2013 to moderate (1.38 ± 0.77) in 2017, and #14 indicator (staff training) also improved from low (1.21 ± 0.67) in 2013 to moderate (1.71 ±0.88) in 2017. This indicates that increase staff complement and skills may achieve capacity enhancement. The mean score for #3 indicator (law enforcement) also increased from 0.90 ± 0.67 to 1.52 ± 0.86, which suggests that PAs based their scores for this indicator on the numbers of deputized enforcement officers, and frequency/distance of foot patrols during monitoring activities (BMS, Lawin Forest and Biodiversity Protection System). Perhaps limitations of implementation and rollout of training and enforcement activities were connected to constraints on budget and resource management in this case. We noted 45 PAs that rated themselves as inadequately financed whereas five PAs revealed that they have no budget for management. Securing sustainable financing has become challenging because most PAs are reliant on irregular project funding from civil society groups, private stakeholders, and volunteer support from academic institutions. On the other hand, PAs with sufficient budget (e.g., Mt. Pulag National Park, Batanes Protected Landscape and Seascape, Aurora Memorial National Park, Mt. Mantalingahan Protected Landscape, and Cuatro Islas Protected Landscape) secured their budget from tourism revenues and visitor facility fees to supplement core government NIPAS funding.

Scores for indicators #10 protection systems (0.67 ± 0.73 in 2013 to 1.47 ± 0.90 in 2017), #11 research (0.88 ± 0.77 in 2013 to 1.62 ± 1.02 in 2017), and #12 resource management (0.83 ± 0.65 in 2013 to 1.52 ± 0.75 in 2017) substantially increased from weak to moderately effective management. The PAs based these improvements on three indicators: patrol conditions, number of apprehensions, and biodiversity status. Regarding patrol conditions, most of the PAs reported an (1) increased number of patrollers (e.g., DENR's forest rangers, deputized wardens from Local Government Units (LGUs) and Peoples Organization (POs)); (2) increased patrol frequency (from quarterly monitoring to monthly); and/or (3) increased distance covered through the adoption of DENR's Lawin Forest and Biodiversity Protection System (USAID Philippines, 2019). As a result of these increased patrol efforts, the number of apprehensions decreased. However, this should not always be interpreted as a decrease in forestry and wildlife law violations. For example, Abasig-Matogdon-Mananap Natural Biotic Area (AMMNBA) monitoring reports showed that at least 50% of patrol observations were of abandoned timber or remnants of logged trees (Mallari et al., 2017). Thorough planning of patrol timing and routes will likely improve efficiency and detection of violators. Effective protection systems should also be aimed at proper implementation of enforcement laws. For example, in Mt. Isarog National Park, most apprehensions were limited to confiscations or recording of incidents which did not progress to cases filed against the violators (Mallari et al., 2017). Imposing appropriate sanctions and convictions are crucial to effective resource use control.

The common PA research design employed involves conducting species inventories and individual species counts. However, the few studies that have focused on understanding conservation requirements of vulnerable species have not been incorporated into the relevant action plans for their respective PAs. Biodiversity monitoring plans, for example, are still focused on measuring species richness and diversity wherein high diversity index values are considered as a barometer of effective management (BMB-DENR and GIZ, 2017). Studies have shown that species diversity indices do not necessarily equate to ecosystem health (Buckland et al., 2005; Chiarucci et al., 2011) because this approach only measures a narrow perspective of the overall condition of a focal PA. Studies on metrics using species diversity indices show that although there is an increasing pattern across disturbance, habitat and elevational gradients, there is a bulging effect at intermediate habitats and a pronounced decrease in species diversity as the ecosystem reaches homogeneity or climax (Rahbek, 1995; Mallari, 2009; Mallari et al., 2011, Millington et al., 2012). We noticed that some PAs began conducting Biodiversity Monitoring System (BMS) activities without baselines or benchmarks in place. For example, Mt. Timpoong-Hibok-hibok Natural Monument (MTHHNM) reported that biodiversity increased in the last two years based on the increasing number of priority species encountered on BMS. The MTHHNM conducted quarterly terrestrial monitoring on the same transect route ("permanent monitoring transects or plots"). It was our understanding that in the BMS manual (NORDECO and DENR, 2001; DENR Administrative Order No. 2000-13) a baseline inventory must first be undertaken. From this list, DENR and communities involved in the BMS monitoring must select a group of indicator species, and transect surveys should report presence or absence of such species. The report of 'an increase' in number of priority species violates basic BMS transect protocol which is designed to capture information of continued presence of indicator species or increase/decrease of encounter rates of the species in question.

In this case, perhaps an increasing trend in biodiversity represents a sampling artefact in which a false replication and duplication of species encountered occurred. This example led us to conclude that establishing ecological baselines, or species survival envelopes, is crucial to determining successive, repeated-measures patterns of biodiversity. Once established, PAs can use baseline data to select priority and indicator species for use as indicators of environment health instead of looking at harvest (e.g., fish catch) per se, or accumulated number of generalist species. Increasing and expanding BMS monitoring efforts to cover a wide range of habitats will allow PAs to infer effectiveness of respective protection systems, design research accordingly, and promote effective resource management.

Building partnerships, collaborations, and good communication strategies are essential in managing PAs (Don Carlos, 2013; Muller et al., 2015). Protected area relations with local stakeholders considerably improved (indicators #22, #23, and #24). Representatives from local communities, indigenous peoples, people's organizations, academic institutions, local government units and even tourism operators were generally involved in management planning. Local communities provided support in the form of patrolling and monitoring activities, biodiversity surveys, and enforcement (e.g., deputized community wardens). Various stakeholders were also active on conducting information and awareness campaigns (indicator #20).

On measuring management 'Outcomes', scores of METT indicators #25 economic benefits (1.48 ± 0.82 in 2013 to 1.57 ± 0.82 in 2017) and #30 condition of values (1.43 ± 0.82 in 2013 1.57 ± 0.75 in 2017) showed a slight increase in mean scores but remained in the moderate range. Third party validators of the NMECA reported providing alternative livelihood to the communities such as ecotourism and selling non-timber forest products. However, mean scores relating to impact of initiatives on the welfare of communities' lag behind. It seems that although threats and social issues are being addressed, efforts were not sufficient to deliver results or it might still be too early to observe detectable development.

Protected Areas do not fully cover Species Survival Envelopes of Threatened and Endemic Species

The establishment of protected area system in the Philippines are based on a series of procedures under the NIPAS Act of 1992 (Section 5), the Revised IRR (Rule 6 of DAO No.2008-26), and the Expanded NIPAS act of 2018 that mainly account for unique biodiversity features (*i.e.* naturalness of the area, abundance and diversity of species, presence of threatened and endemic species, and unique geological structures), and that often does not take into consideration species survival envelopes (SSE) as a metric for estimating large landscape conservation. This has resulted in a number of declared protected areas within a biogeographic region which lack habitat connectivity. In this paper, we maximize the use of species distribution modeling (SDM) to identify umbrella sites which effectively reconfigures the old KBAs system (CI Philippines et al., 2006, 2009; Ambal et al., 2012) through the understanding of species survival envelopes. By over-laying SDMs of each species, this exercise predicts a range of suitable habitats for the survival of species in question. The areas that these SSEs occupy are what ecologists refer to as "umbrella sites". These umbrella sites have the potential to support viable populations of a large assemblage of threatened and endemic species, and which can then be used as a metric for establishing protected areas.

The 1994 SSE model of threatened and endemic bird species revealed a wide range of suitable habitats across the archipelago (Figure 2), however, the polygons of the old KBAs tend to be smaller than the 1994 SSEs (Ambal et al., 2012). This implies inadequate coverage by the old KBAs of suitable habitats for many species. However, in the fairly recent 2010 SSE model, the distribution prediction of SSEs appropriately fits into identified PA boundaries under NIPAS Act. This indicates that unique biodiversity features and landscape should not only be the basis for classifying areas for conservation. Habitat suitability models and survival envelopes should be considered as a metric to measure the entirety of conservation areas. To illustrate this, we modeled the umbrella areas and overlaid these with five exemplar PAs (Bataan National Park (Figure 3), Mt. Malindang Range Natural Park (Figure 4), Mt. Hamiguitan Range Wildlife Sanctuary (Figure 5), Mt. Mantalingahan Protected Landscape (Figure 6), and Samar Island Natural Park (Figure 7)). Our results confirmed inadequacy of PA coverage (required suitable habitats are larger than the designated PAs) leaving KBAs and other important ecosystems vulnerable to exploitation.

Species survival envelopes contracted in 18 years

We compared the SSE of the five exemplar PAs using the 1994 and 2010 data models. The fairly recent (2010) SSEs of all five exemplar PAs have shown visible contraction suggesting a reduction of suitable habitats in 18 years (Figure 3). These contractions potentially increase extinction risks for species with narrow climate niches that may be unable to adapt to the changing environment (Carvalho et al., 2010; Sutton et al., 2015; Sugden 2017; Ashrafzadeh et al., 2019). Species that are likely to be affected by this SSE contraction are species that cannot tolerate degradation or loss of natural habitats such as forest obligate or dependent species. On the other hand, species that are tolerant of habitat changes may not be as sensitive and are considered generalist species with no known habitat requirements.

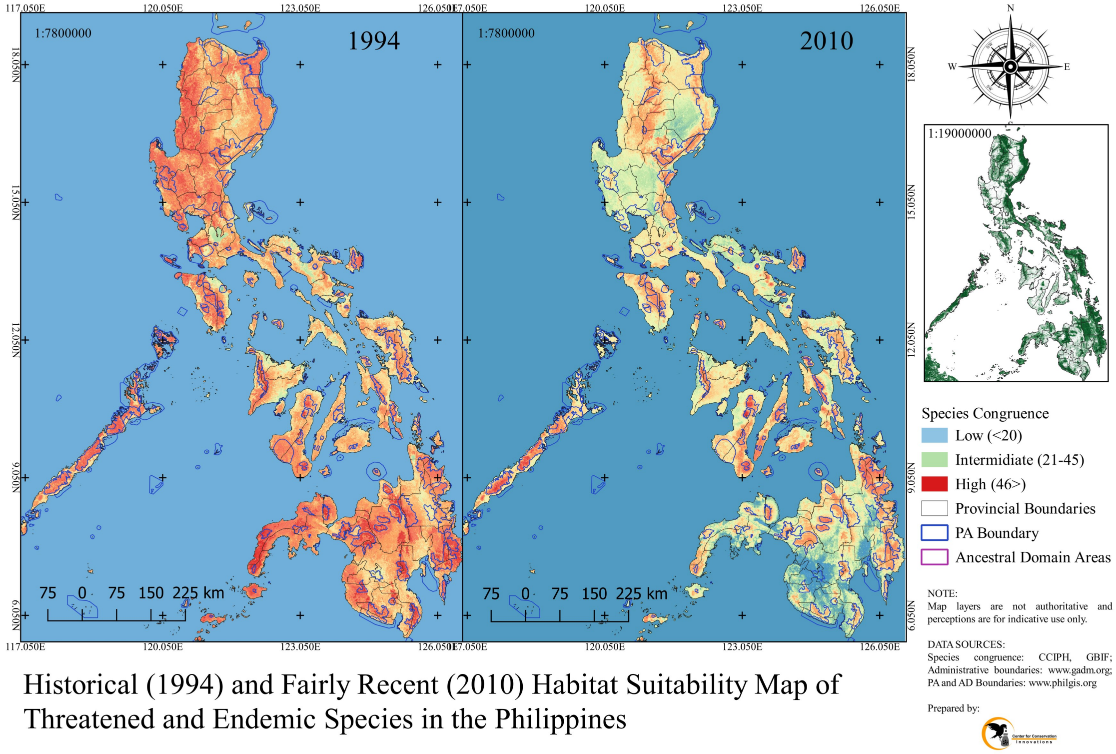

Figure 3. Species distribution modelling (SDM) of threatened and endemic species in the Philippines.

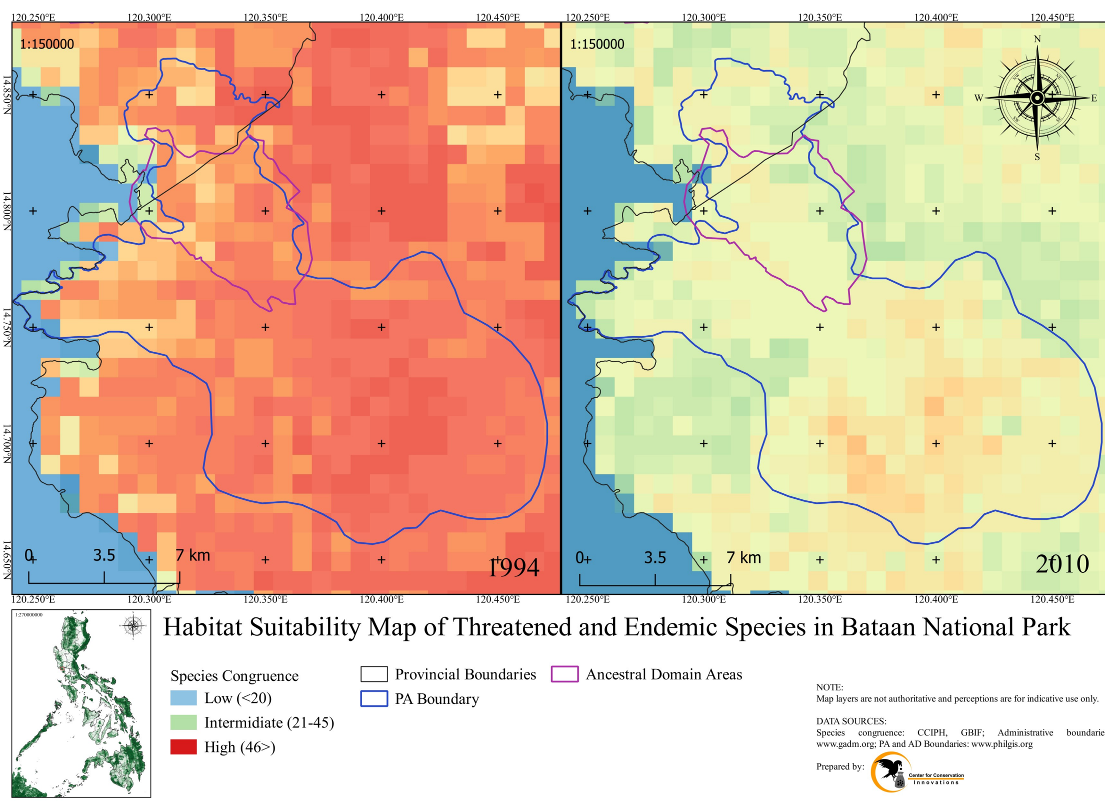

Figure 4. Species survival envelopes (SSEs) of threatened and endemic species in Bataan National Park (BNP) with two time period prediction model (1994 and 2010).

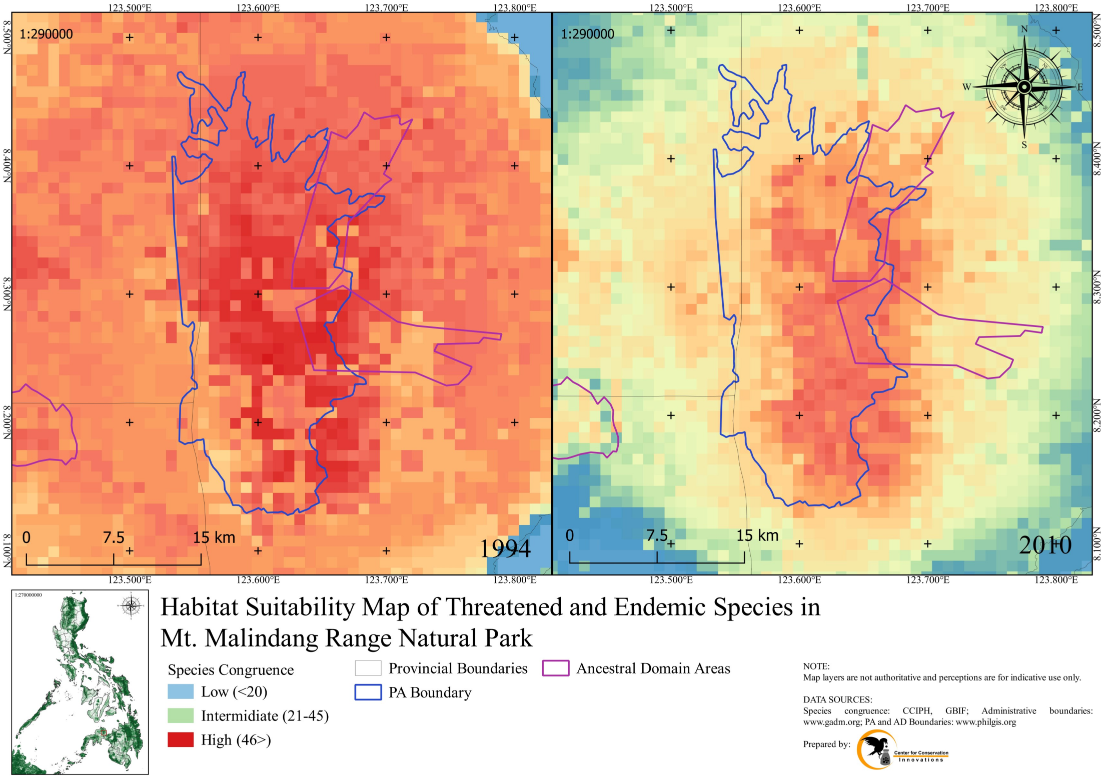

Figure 5. Species survival envelopes (SSEs) of threatened and endemic species in Mt. Malindang Range Natural Park (MMRNP) with two time period prediction model (1994 and 2010).

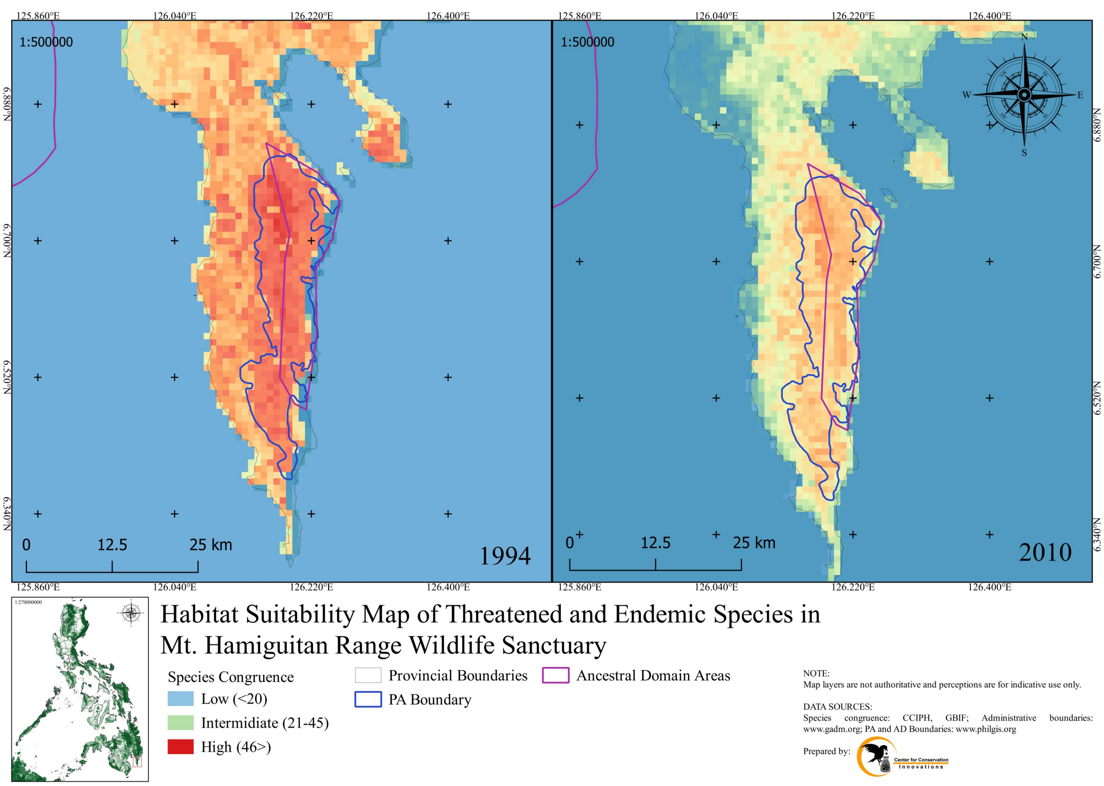

Figure 6. Species survival envelopes (SSEs) of threatened and endemic species in Mt. Hamiguitan Range Wildlife Sanctuary with two time period prediction model (1994 and 2010).

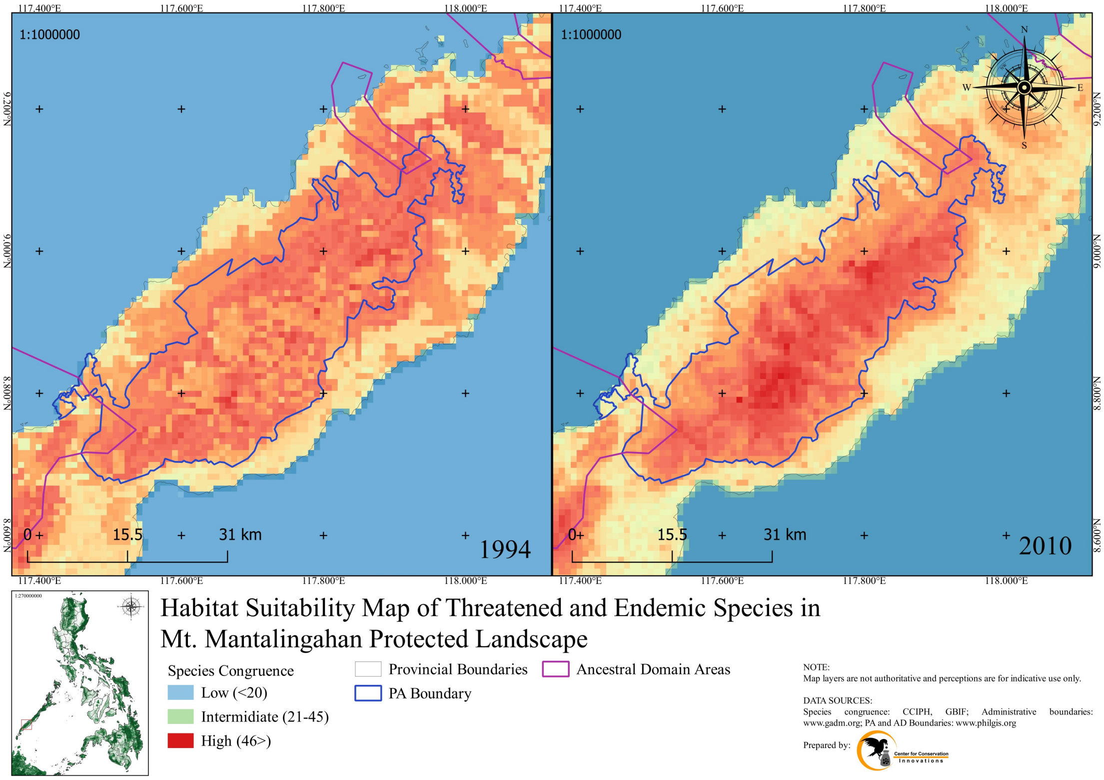

Figure 7. Species survival envelopes (SSEs) of threatened and endemic species in Mt. Mantalingahan Protected Landscape (MMPL) with two time period prediction model (1994 and 2010).

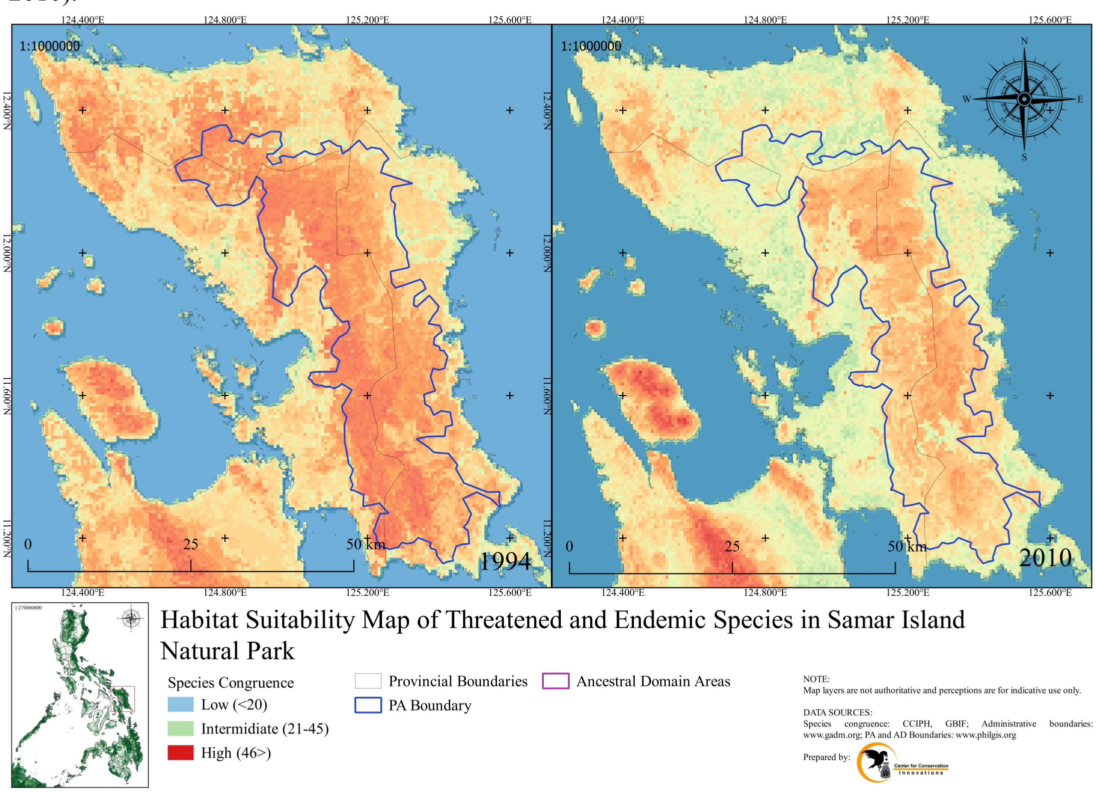

Figure 8. Species survival envelopes (SSEs) of threatened and endemic species in Samar Island National Park (SINP) with two time period prediction model (1994 and 2010).

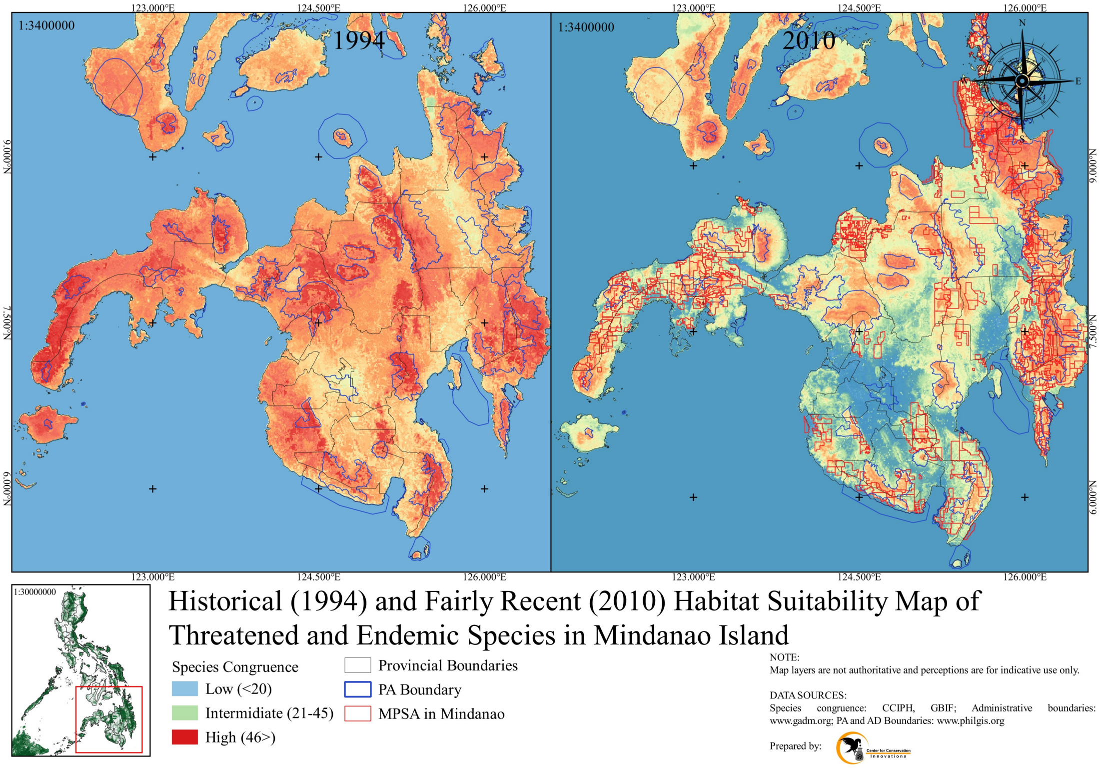

Figure 9. Remaining coverage of species survival envelopes (SSEs) in Mindanao Island threatened with intense Mineral Production Mining Agreement (MPSA).

It was also observed that the movement of contraction of the SSEs are from the peripheries towards the center which usually coincide with the increase in elevation. This suggests that degradation of suitable habitats happens in the lowlands first and then creeps into mid-elevation, and so on. As a result, what remained as SSEs were mostly in mid to high elevations. This also suggests that there may be an inter-elevational movement of suitable habitats for many species which is perhaps related to the reduction of lowland forests and/or climate change effects (Early and Sacks 2014; Mestre 2017; Ashrafzadeh et al., 2019). Bataan National Park and Mt. Hamiguitan Range Wildlife Sanctuary, have pronounced SDM shifts from low to high elevation areas of the PA which resulted in fewer suitable habitat areas for conservation. The contraction of the SSEs in other exemplar PAs (Mt. Malindang Range Natural Park, Mt. Mantalingahan Protected Landscape, and Samar Island Natural Park) now coincided with the old KBA boundaries. Concordance of SSEs and KBA boundaries suggests that further contraction of these SSEs will significantly diminish the biodiversity value of these PAs. A reconfiguration of the existing boundaries and management regimes to take into account the SSEs should be based on recent and future SDMs to predict range shifts and potential impacts of habitat loss and climate change while maintaining large ecosystem mosaics (Parmesan and Yohe, 2003).

Contraction of the SSEs was observed in Mindanao Island (Figure 8). The contraction showed fragmentation of SSEs and encompassed areas that are not under NIPAS or other form of protection. Our results showed significant range shifts of SSEs of threatened and endemic species towards the Eastern Mindanao Region extending from Davao Oriental, Compostela Valley, Agusan del Sur and Norte, up to Surigao del Sur and Surigao del Norte. This result underscored the importance of the Eastern Mindanao Corridor in ensuring survival of some 20 threatened endemic Mindanao avian species. However, it must be noted that the remaining SSEs in Eastern Mindanao are currently threatened with timber poaching, agricultural expansion, habitat degradation, large and small-scale mining, and the huge expansion of approved Mineral Production Sharing Agreement (MPSA; Lipo-Paz et al., 2016; DENR-MGB 2019). These unsustainable practices put at risk not only many key species but also threaten livelihood and traditional practices of indigenous peoples in the Eastern Mindanao Corridor. Forming a management framework that encompasses the biodiversity corridor for the Eastern Mindanao will maximize biodiversity and habitat connectivity, which are critical for sustaining viable populations of threatened and endemic species (Habibzadeh and Ashrafzadeh, 2018; Ashrafzadeh et al., 2019).

Table 2. Average METT indicator scores for 58 Protected Areas in 2013 and 2017.

METT No.	Elements	Indicators	Highest Possible Score	2013 indicator scores: mean (SD) N = 58	2017 indicator scores: mean (SD) N = 58
1	Context	Legal Status	3	2.09 (0.28)	2.09 (0.28)
2	Planning	Protected Area Regulations	3	1.14 (0.89)	1.50 (0.88)
3	Input	Law enforcement	3	0.90 (0.67	1.52 (0.86)
4	Planning	Protected Area Objectives	3	1.07 (0.86)	1.62 (0.81)
5	Planning	Protected Area Design	3	1.34 (0.93)	1.45 (0.92)
6	Process	Protected Area Boundary Demarcation	3	1.28 (0.72)	1.57 (0.84)
7	Planning	Management Plan	3	1.22 (0.86)	1.67 (0.78)
7.a	Planning	Planning process allows adequate opportunity for stakeholders	1	0.71 (0.46)	0.62 (0.49)
7.b	Planning	Established schedule for periodic reviews and updating	1	0.21 (0.41)	0.52 (0.54)
7.c	Planning	Monitoring, research, and evaluation are routinely incorporated into planning	1	0.09 (0.28)	0.43 (0.50)
7.d	Planning	Operations Manual	1	0.07 (0.26)	0.22 (0.42)
7.e	Planning	Enforcement Manual	1	0.05 (0.22)	0.21 (0.41)
8	Planning	Regular Work plan (annual AWFP)	3	0.86 (0.80)	1.53 (0.92)
9	Input	Resource Inventory	3	0.93 (0.86)	1.43 (0.86)
10	Process	Protection systems	3	0.67 (0.73)	1.47 (0.90)
11	Process	Research	3	0.88 (0.77)	1.62 (1.02)
12	Process	Resource Management	3	0.83 (0.65)	1.52 (0.75)
13	Input	Staff Numbers	3	0.84 (0.64)	1.38 (0.77)
14	Input	Staff Training	3	1.21 (0.67)	1.71 (0.88)
15	Input	Current Budget	3	0.93 (0.56)	1.43 (0.77)
16	Input	Security of Budget	3	0.86 (0.58)	1.31 (0.90)
17	Process	Management of Budget	3	0.93 (0.83)	1.53 (0.92)
18	Input	Equipment	3	0.26 (0.52)	1.16 (0.81)
19	Process	Maintenance of Equipment	3	0.24 (0.51)	1.07 (0.93)
20	Process	Education and Awareness	3	0.83 (0.68)	1.52 (0.86)
21	Planning	Planning for adjacent land and water use	3	1.29 (0.96)	1.60 (0.84)
21.a	Planning	Land and water planning for habitat conservation	1	0.29 (0.46)	0.41 (0.53)
21.b	Planning	Land and water planning for connectivity	1	0.16 (0.37)	0.29 (0.46)
21.c	Planning	Land and water planning for ecosystem services and species conservation	1	0.14 (0.35)	0.36 (0.48)
22	Process	State and Commercial Neighbors	3	1.03 (0.70)	1.22 (0.82)
23	Process	Indigenous People	3	1.28 (1.08)	1.82 (1.00)
24	Process	Local Communities	3	1.86 (0.69)	2.03 (0.92)
24.a	Process	Open communication and trust among stakeholders	1	0.71 (0.46)	0.60 (0.49)
24.b	Process	Programmes to enhance welfare of communities are being implemented	1	0.36 (0.48)	0.50 (0.50)
24.c	Process	Local and/or indigenous people actively support the protected area	1	0.47 (0.50)	0.55 (0.50)
25	Outcome	Economic benefit	3	1.41 (0.82)	1.57 (0.82)
26	Process	Monitoring and Evaluation	3	0.76 (0.68)	1.48 (0.84)
27	Output	Visitor Facilities	3	0.69 (0.86)	1.17 (0.88)
28	Process	Commercial Tourism Operators	3	0.36 (0.58)	0.81 (0.89)
29	Input	Fees	3	0.76 (0.90)	0.91 (0.92)
29a	Input	At least 20% of IPA is allocated for sustainable financing activities	1	0.02 (0.13)	0.16 (0.37)
30	Outcome	Condition of Values	3	1.43 (0.75)	1.57 (0.75)
30.a	Outcome	Assessment of conditions of values is based on research/monitoring	1	0.09 (0.28)	0.50 (0.50)
30.b	Outcome	Programmes to address threats to biodiversity and cultural values are implemented	1	0.33 (0.47)	0.48 (0.50)
30.c	Outcome	Activities to maintain key biodiversity and cultural are a routibe part of management	1	0.16 (0.37)	0.48 (0.50)

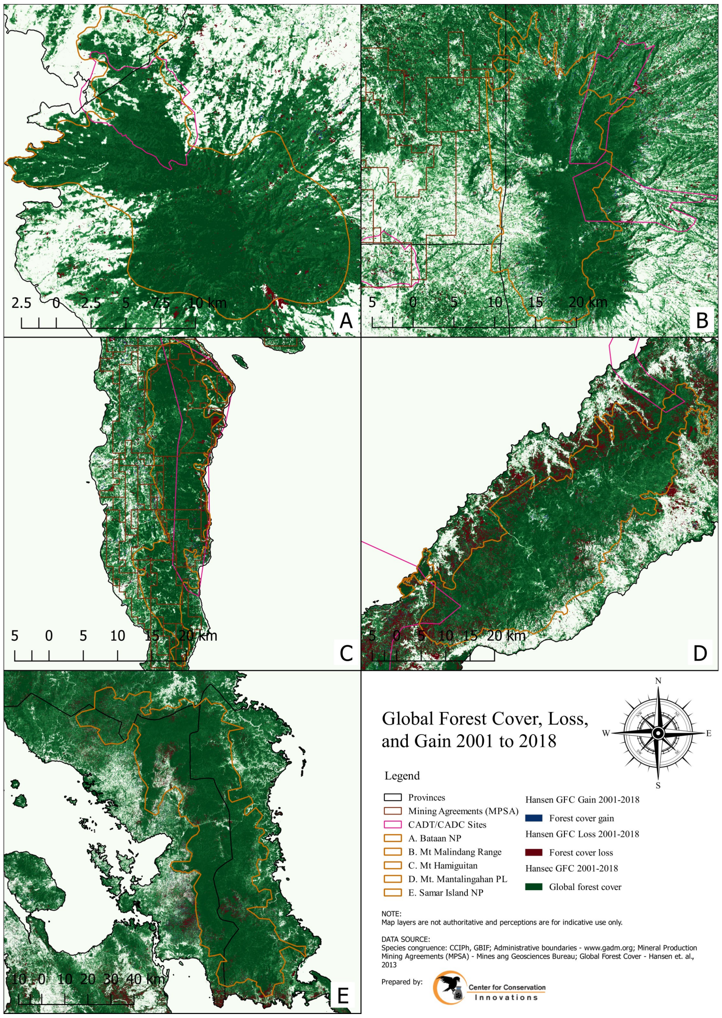

Figure 10. Forest cover gain and loss in five exemplar PAs.

Habitat Loss in five exemplar PAs despite increasing METT Scores

All of the five PA exemplars (except Mt Hamiguitan which did not have a METT baseline in 2013) showed more than 30% increase in their METT scores from 2013-2017 (see Table 2). The increase in METT scores was an indicator of improved systems level management in Protected Areas. We examined the forest cover change of these exemplar PAs approximately within the same inclusive periods when the METT scores were done (Figure 9). Results of the calculations revealed a huge loss in forest cover for all the five exemplar PAs. Therefore, the increase in METT scores is inversely correlated with the forest cover gain and loss. For example, Mt. Mantalingahan Protected Landscape had a 64% increase METT score but the PA lost over 13.2% of its total forest coverage from 2001 to 2018. Bataan National Park, with the same level of increase in METT score, lost 1.3% of forest cover (see Table 2). Intuitively, one would expect that increasing METT scores would translate to increasing management effectivity and therefore habitat protection, however, we observed the opposite. This suggests METT score may not be the most informative metric in assessing effectiveness of management in PAs. This also suggests that METT scores only reflect an improvement of PA management system, but does not reflect an improvement on achievement of conservation outcomes such as securing the forests from degradation. In the final analysis, the combination of the actual protection and rehabilitation of key wildlife habitats, together with the improvement of management systems, are the recommended metrics of the effectiveness of the PA. Ultimately, it is actual habitat protection and improvement in quality that is the ultimate metric of the success of a protected area system.

Conclusion and Recommendations

Improving the overall METT scores of PAs within the System

The variability between METT scores of individual PAs is contingent upon which aspect of management a given site has performed extremely well or performed poorly. Currently, efforts to legally gazette PAs, which is a fundamental element in PA establishment and design, provides an immediate disincentive to land use conversion and habitat degradation. Administrative measures to define zoning boundaries and resource use should be consistent with the provisions of the National Integrated Protected Areas System Act of 1992 RA 7586 (NIPAS Act), Expanded National Integrated Protected Areas System Act of 2018 RA 11038 (E-NIPAS Act), Indigenous Peoples Rights Act of 1997 RA 8371 (IPRA), and the Local Government Code.

Management plans should be adopted and periodically reviewed. Improving PA planning is critical for strategizing sustainable use of natural capital, equitable sharing of PA benefits, species survival, responses to threats and violations, and securing funds for implementation. According to the revised Implementing Rules and Regulations of the NIPAS Act, 75% of the revenues generated by each PAs will be used for its development and maintenance while the remaining 25% should go to the national fund (Integrated Protected Areas Fund or IPAF) for other PAs that are not generating enough revenues. Some PAs have either not been able to access these funds or deemed the funds inadequate to support their activities. PAs could exercise business planning and look to other sources for funding opportunities. Functional matching and monitoring of human resources are also encouraged to ensure that a team of competent technical and operational staff are able to contribute to effective management. Moreover, the number of well-equipped PA staff must be proportional to the size and scope of

Table 3. Forest cover loss of exemplar PAs under study from 2001 to 2018, and corresponding METT scores (2013 and 2017).

Protected Area / KBA	GFC 2001 (hectares)	GFC 2018 (hectares)	GFC Loss 2001-2018 (hectares)	METT Score 2013	METT Score 2017
Bataan National Park	23,392.26	23,098.14	294.12 (1.3%)	44.76	73.33
Mt. Malindang Range Natural Park (MMRNP)	36,916.02	36,045.99	870.03 (2.4%)	45.71	54.29
Mt. Hamiguitan Range Wildlife Sanctuary	31,300.11	30,271.23	1,028.88 (3.4%)	-	59
Mt. Mantalingahan Protected Landscape (MMPL)	116,635.1	103,033.89	13,601.16 (13.2%)	55.24	90.48
Samar Island Natural Park (SINP)	449,537.8	426,046.78	23,490.98 (5.5%)	45.71	63.73

the individual PA.

Education and information campaigns are essential to enhance conservation values and encourage sustainable management of resources. Local people's perceptions of PAs could be influenced by their dependence on natural resources, social status, demographical factors, and anticipated costs and benefits from PAs. Assessing these perspectives are crucial for PA management and mitigate human pressure. Partnerships between the government and stakeholders could also be improved by making sure that there is an equitable participation by Indigenous Peoples and local communities in PA decision-making.

Retrofitting the scope of the PA system to cover biodiversity corridors and SSEs

In the current PA zoning system, biodiversity corridors and SSEs are generally found in buffer zones or multiple use zones which correspond to lower levels of protection. With only 36% of the total coverage of terrestrial KBAs that overlap with the PA system (Mallari et al., 2015), there is an urgent need to expand the scope of PAs and their conservation capacities, to ensure existing protected areas, and surrounding high conservation value forests, are managed to support viable populations of globally threatened species. This expansion of the scope and coverage of the existing protected areas will allow for the movement of wildlife, pollination, reproduction, and other processes that support recovery and improve natural resiliency to external development and climatic shocks. Immediate action should be taken to modify these management schemes with respect to recent and future SSEs of threatened taxa. Perhaps it is time to re-evaluate the entire PA network and conduct Protected Area Suitability Assessment (PASA; BMB Technical Bulletin 2016-04) for existing PAs. We support the efforts of the Philippine government to complete the crafting of the National Protected Areas Masterplan, which has the potential to be a blueprint for aligning the country's national biodiversity conservation and national development targets through an inclusive, science-driven, and dynamic protected area systems.

Moving towards multi-indicators for effective PA management

The Philippines has made great strides in improving the scope and management effectiveness of its network of protected areas. This has been evident in the improvement of METT scores over time. However, we observed inverse relationship between the improvement of management effectiveness score and the quality and extent of forest cover. Relying solely on the information generated by this one metric will likely result in inappropriate management prescriptions. As a result of this review, we recommend using a suite of indicators to ensure that management authorities are better informed and equipped to deliver the conservation and sustainable development goals of the protected areas:

1. *Systems level performance metric* – METT gives us an indicator of how each PA and the overall system are performing against management elements (*context*, *planning*, *inputs*, *processes*, *outputs* and *outcomes*). Programmatic capacity building for PA management authorities and governing bodies must be continued and augmented. Roll-out of financial support and other resources for PAs in remote areas, often inaccessible because of poor infrastructure development and security issues, should be enhanced. We support the development of more inclusive and sustained communication and capacity building programs, strengthening multi-sectoral partnerships, and expanding connectivity within the PA network.

2. *Performance-based metrics* – A metric developed to measure outcomes of PA activities in terms of achieving the objectives set in the management plan and addressing the causality of the development barriers through various management actions. This performance-based metric takes into account the impacts of the management activities on human

Table 4. Key bird species used in the species distribution modeling with their endemism and IUCN Red List status (IUCN, 2019).

Species	Common Name	IUCN Status	Endemism
Aceros leucocephalus	Writhed Hornbill	NT	Endemic
Aceros waldeni	Rufous-headed Hornbill	CR	Endemic
Acrocephalus sorghophilus	Streaked Reed-warbler	EN	Resident
Actenoides hombroni	Blue-capped Kingfisher	VU	Endemic
Aerodramus palawanensis	Palawan Swiftlet		Endemic
Aethopyga linaraborae	Lina's Sunbird	NT	Endemic
Alcedo argentata	Southern Silvery Kingfisher		Endemic
Anas luzonica	Philippine Duck	VU	Endemic
Anthracoceros marchei	Palawan Hornbill	VU	Endemic
Anthracoceros montani	Sulu Hornbill	CR	Endemic
Aythya baeri	Baer's Pochard	CR	Endemic
Basilornis miranda	Apo Myna	NT	Endemic
Bradypterus caudatus	Long-tailed Bush Warbler	LC	Endemic
Bubo philippensis	Philippine Eagle-owl	VU	Endemic
Cacatua haematuropygia	Philippine Cockatoo	CR	Endemic
Centropus steerii	Black-hooded Coucal	CR	Endemic
Centropus unirufus	Rufous Coucal	NT	Endemic
Cettia seebohmi	Philippine Bush-warbler	LC	Endemic
Ceyx melanurus	North Philippine Dwarf-kingfisher	VU	Endemic
Chloropsis flavipennis	Philippine Leafbird	VU	Endemic
Chloropsis palawanensis	Yellow-throated Leafbird	LC	Endemic
Ciconia boyciana	Oriental Stork	EN	Endemic
Collocalia palawanensis	Uniform Swiftlet	LC	Endemic
Collocalia whiteheadi	Whitehead's Swiftlet	DD	Endemic
Copsychus cebuensis	Black Shama	EN	Endemic
Copsychus niger	White-vented Shama	LC	Endemic
Coracina coerulescens	Blackish Cicadabird	LC	Endemic
Coracina ostenta	White-winged Cicadabird	VU	Endemic
Cyornis herioti	Blue-breasted Blue-flycatcher	NT	Endemic
Cyornis lemprieri	Palawan Blue-flycatcher	NT	Endemic
Dasylophus superciliosus	Red-crested Malkoha	LC	Endemic
Dicaeum anthonyi	Yellow-crowned Flowerpecker	NT	Endemic
Dicaeum haematostictum	Flame-crowned Flowerpecker	VU	Endemic
Dicaeum quadricolor	Cebu Flowerpecker	CR	Endemic
Dicaeum retrocinctum	Scarlet-collared Flowerpecker	VU	Endemic
Ducula carola	Spotted Imperial Pigeon	VU	Endemic
Ducula mindorensis	Mindoro Imperial Pigeon	EN	Endemic
Ducula pickeringii	Grey Imperial Pigeon	VU	Endemic
Egretta eulophotes	Chinese Egret	VU	Resident
Emberiza sulphurata	Yellow Bunting	VU	Resident
Erythropitta kochi	Whiskered Pitta	NT	Endemic
Erythrura viridifacies	Green-faced Parrotfinch	VU	Endemic
Eurylaimus samarensis	Visayan Wattled Broadbill	VU	Endemic

Table 4 cont. Key bird species used in the species distribution modeling with their endemism and IUCN Red List status (IUCN, 2019).

Species	Common Name	IUCN Status	Endemism
Eurylaimus steerii	Mindanao Wattled Broadbill	VU	Endemic
Ficedula basilanica	Little Slaty Flycatcher	VU	Endemic
Ficedula crypta	Cryptic Flycatcher	LC	Endemic
Ficedula disposita	Furtive Flycatcher	NT	Endemic
Ficedula platenae	Palawan Flycatcher	VU	Endemic
Gallicolumba crinigera	Mindanao Bleeding-heart	VU	Endemic
Gallicolumba keayi	Negros Bleeding-heart	CR	Endemic
Gallicolumba luzonica	Luzon Bleeding-heart	NT	Endemic
Gallicolumba platenae	Mindoro Bleeding-heart	CR	Endemic
Gorsachius goisagi	Japanese Night Heron	EN	Resident
Hypocryptadius cinnamomeus	Cinnamon Ibon	LC	Endemic
Hypothymis coelestis	Celestial Monarch	VU	Endemic
Hypothymis helenae	Short-crested Monarch	NT	Endemic
Hypsipetes everetti	Yellowish Bulbul	LC	Endemic
Hypsipetes rufigularis	Zamboanga Bulbul	NT	Endemic
Hypsipetes siquijorensis	Streak-breasted Bulbul	EN	Endemic
Iole palawanensis	Sulphur-bellied Bulbul	LC	Endemic
Lanius validirostris	Mountain Shrike	NT	Endemic
Lepidogrammus cumingi	Scale-feathered Malkoha	LC	Endemic
Lewinia mirifica	Brown-banded Rail	DD	Endemic
Lophozosteops goodfellowi			Endemic
Malacocincla cinereiceps	Ashy-headed Babbler	LC	Endemic
Malacopteron palawanense	Melodious Babbler	NT	Endemic
Mearnsia picina	Philippine Spine-tailed Swift	NT	Endemic
Micromacronus leytensis	Visayan Miniature Babbler	DD	Endemic
Mimizuku gurneyi	Giant Scops Owl	VU	Endemic
Muscicapa randi	Ashy-breasted Flycatcher	VU	Endemic
Napothera rabori	Cordillera Ground Warbler		Endemic
Oriolus albiloris	White-lored Oriole	LC	Endemic
Oriolus isabellae	Isabela Oriole	CR	Endemic
Orthotomus cinereiceps	White-eared Tailorbird	LC	Endemic
Orthotomus derbianus	Grey-backed Tailorbird	LC	Endemic
Orthotomus nigriceps	Black-headed Tailorbird	LC	Endemic
Orthotomus samarensis	Yellow-breasted Tailorbird	NT	Endemic
Otus elegans	Ryukyu Scops Owl	NT	Resident
Otus fuliginosus	Palawan Scops Owl	NT	Endemic
Otus longicornis	Luzon Scops Owl	NT	Endemic
Otus mantananensis	Mantanani Scops Owl	NT	Resident
Otus mindorensis	Mindoro Scops Owl	NT	Endemic
Otus mirus	Mindanao Scops Owl	NT	Endemic
Pachycephala albiventris	Green-backed Whistler	LC	Endemic
Pardaliparus amabilis	Palawan Tit	NT	Endemic
Pelecanus philippensis	Spot-billed Pelican	NT	Resident

Table 4 cont. Key bird species used in the species distribution modeling with their endemism and IUCN Red List status (IUCN, 2019).

Species	Common Name	IUCN Status	Endemism
Penelopides affinis	Mindanao Hornbill	LC	Endemic
Penelopides manillae	Luzon Hornbill	LC	Endemic
Penelopides mindorensis	Mindoro Hornbill	EN	Endemic
Penelopides panini	Visayan Hornbill	EN	Endemic
Penelopides samarensis	Samar Hornbill	LC	Endemic
Phaenicophaeus cumingi	Scale-feathered Malkoha	LC	Endemic
Phaenicophaeus superciliosus	Rough-crested Malkoha	LC	Endemic
Phapitreron brunneiceps	Mindanao Brown Dove	VU	Endemic
Phapitreron cinereiceps	Tawi-tawi Brown Dove	EN	Endemic
Phyllergates heterolaemus	Rufous-headed Tailorbird	LC	Endemic
Phylloscopus ijimae	Ijima's Leaf Warbler	VU	Resident
Picoides ramsayi	Sulu Pygmy Woodpecker	VU	Endemic
Pithecophaga jefferyi	Philippine Eagle	CR	Endemic
Pitta steerii	Azure-breasted Pitta	VU	Endemic
Platalea minor	Black-faced Spoonbill	EN	Resident
Polyplectron napoleonis	Palawan Peacock-Pheasant	VU	Endemic
Prioniturus luconensis	Green Racket-tail	EN	Endemic
Prioniturus montanus	Montane Racket-tail	NT	Endemic
Prioniturus platenae	Blue-headed Racket-tail	VU	Endemic
Prioniturus verticalis	Blue-winged Racket-tail	CR	Endemic
Prioniturus waterstradti	Mindanao Racket-tail	NT	Endemic
Prionochilus plateni	Palawan Flowerpecker	LC	Endemic
Ptilinopus arcanus	Negros Fruit Dove	CR	Endemic
Ptilinopus marchei	Flame-breasted Fruit Dove	VU	Endemic
Ptilinopus merrilli	Cream-breasted Fruit Dove	NT	Endemic
Ptilocichla falcata	Falcated Wren-Babbler	VU	Endemic
Ptilocichla mindanensis	Striated Wren-Babbler	LC	Endemic
Pyrrhula leucogenis	White-cheeked Bullfinch	LC	Endemic
Rhabdornis grandis	Grand Rhabdornis	LC	Endemic
Rhinomyias albigularis	White-throated Jungle-flycatcher	EN	Endemic
Rhinomyias goodfellowi	Slaty-backed Junge-flycatcher	NT	Endemic
Rhinomyias insignis	White-browed Jungle-flycatcher	VU	Endemic
Rhipidura nigrocinnamomea	Black-and-cinnamon Fantail	LC	Endemic
Rhyacornis bicolor	Luzon Water Redstart	VU	Endemic
Serinus estherae	Mountain Serin		Endemic
Sittiparus semilarvatus	White-fronted Tit	NT	Endemic
Spizaetus philippensis	Philippine Hawk-Eagle	EN	Endemic
Stachyris capitalis	Rusty-crowned Babbler	LC	Endemic
Stachyris dennistouni	Golden-crowned Babbler	NT	Endemic
Stachyris hypogrammica	Palawan Striped Babbler	NT	Endemic
Stachyris latistriata	Panay Striped Babbler	NT	Endemic
Stachyris nigrorum	Negros Striped Babbler	EN	Endemic

Table 4 cont. Key bird species used in the species distribution modeling with their endemism and IUCN Red List status (IUCN, 2019).

Species	Common Name	IUCN Status	Endemism
Stachyris plateni	Mindanao Pygmy Babbler	NT	Endemic
Stachyris speciosa	Flame-templed Babbler	EN	Endemic
Stachyris striata	Luzon Striped Babbler	NT	Endemic
Stachyris whiteheadi	Chestnut-faced Babbler	LC	Endemic
Sterna bernsteini	Chinese Crested Tern	CR	Resident
Terpsiphone cyanescens	Blue Paradise Flycatcher	LC	Endemic
Todiramphus winchelli	Rufous-lored Kingfisher	VU	Endemic
Treron formosae	Whistling Green Pigeon	NT	Endemic
Trichastoma woodi	Bagobo Babbler	LC	Endemic
Trichoglossus johnstoniae	Mindanao Lorikeet	NT	Endemic
Tringa guttifer	Nordmann's Greenshank	EN	Resident
Turnix ocellata	Spotted Buttonquail	LC	Endemic
Turnix worcesteri	Worcester's Buttonquail	DD	Endemic
Zoothera cinerea	Ashy Thrush	VU	Endemic

[1]CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient

communities and ecosystems under pressure. This metric assesses actual delivery of the conservation objectives, aside from current practice based on whether a management plan exists. Recognizing underlying causes of success or failure of an initiative, especially those associated with varying economic and cultural status of PA stakeholders, should improve multiple elements of management effectiveness. For example, prioritizing social benefits and community involvement in PAs could mitigate destructive poverty-driven activities. By reviewing how a PA budget is actually allocated and rationalizing financial inputs, stakeholders can maximize conservation outputs and outcomes.

3. *Ecological/biophysical metrics* – The use of SSEs is highly recommended to ensure that PAs are designed and positioned appropriately to cover suitable habitats of endemic and threatened species. Managers would then be able to determine gaps in extent of biodiversity protection and make decisions on which conservations actions must be prioritized. This metric is dependent on ecological baselines that are established, and monitoring carried out to measure biophysical changes after management interventions such as increase in biomass or vegetative cover over time, or improvement of water quality of rivers. This metric detects changes in species communities, and their habitats, as a response to natural disturbance (e.g., climatic factors like typhoons and anthropogenic perturbances such as land use changes, pollution etc.). This metric will take into account deforestation, natural rates of forest restoration and rehabilitation, tree cover change, land use change, and development of road networks, which could objectively orient PA management authorities to appropriate actions that will address these challenges via the management plan or PA program of work. Monitoring protocols should be consistent with conservation objectives of PAs. For example, instead of monitoring all species occurring in a PA, it may be more effective and efficient to select a small list of indicator species that will provide information on ecosystem health. Patrol strategies could also be improved by considering spatial, seasonal, and temporal factors that maximize detection of threats and violations. Stricter implementation of law enforcement (e.g., arresting, prosecution, and conviction of violators) should also be considered.

These three metrics should not be taken separately. The adoption of this suite of multidimensional metrics will help triangulate the different measures of management effectiveness that will consider a system-level performance metric, performance-based metric, and an ecological/biophysical metric. This will provide a better feedback loop for adaptive management to ensure a strategic, restorative, and sustainable delivery of the twin objectives of the protected areas, i.e., secure species survival envelopes and human survival envelopes, in the Philippines.

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