

Insufficient numbers and poor working conditions for rangers protecting tigers

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Abstract

Protected area rangers are planetary health care workers and are at the front-line of the protection of wildlife and wild places. Ensuring that there are sufficient rangers in protected areas, and that these rangers are equipped and provided with decent working conditions, is critical to protecting iconic species such as tiger *Panthera tigris*. Using data from a global survey of public-sector ranger numbers, we estimate the shortfall in the number of rangers required to safeguard protected areas in Tiger Conservation Landscapes (TCLs) across the 10 Asian countries with breeding tigers. We calculate the cost required to address this shortfall in ranger numbers. We also estimate the costs for meeting a subset of the welfare needs of rangers aligned to the Chitwan Declaration of the World Ranger Congress. We estimate that a minimum of 12,500 more rangers are required across ~320,000 km² of tiger-bearing protected areas. We estimate this would cost US\$ 45.8 million annually. The majority (63%) of these rangers are required in three Southeast Asian countries, which have declining tiger numbers. To meet a subset of the basic welfare needs of rangers, we estimate that an additional US\$ 7.8 million is required annually across the 10 countries. While the funding gap that we estimate excludes many aspects of effective protected area management, we provide further evidence that protected areas in the biodiverse tropics remain underfunded. Increasing funding for rangers is a critical component of what is required to protect the tiger and tiger landscapes. We urge tiger range country governments, and the global conservation community, to secure this funding. Increasing the numbers of rangers, and effectively supporting their welfare, will increase our ability to protect the tiger and the ecologically significant landscapes in which it occurs.

KEYWORDS

Asia, conservation spending, financing gap, protected area, wildlife economy

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1 | INTRODUCTION

Effectively managed protected areas are essential for addressing the Anthropocene extinction crisis (Butchart et al., 2012; Gray et al., 2016; Hilborn et al., 2006). Protected areas have been instrumental in the recovery and conservation of many species (Bolam et al., 2021), including the tiger *Panthera tigris*; the majority of the global population of which is inside protected areas (Jhala et al., 2021). However, while the global coverage of protected areas continues to increase, their effectiveness in conserving wildlife is varied. The majority of protected areas, particularly in biodiverse regions, have inadequate resources in terms of staffing and budget for effective operations (Lindsey et al., 2018). A global review of protected area effectiveness found that only one in four protected areas have adequate resources to properly function (Coad et al., 2019) while approximately 90% of protected areas with African lions *Panthera leo* are insufficiently funded (Lindsey et al., 2018). The overall annual deficit in global protected area funding was recently estimated at US\$ 43.7 billion, compared to US\$ 24.3 billion currently invested (Waldron et al., 2020).

A significant component of the cost of managing protected areas is the employment, equipping, care, and management of field rangers. Rangers (i.e., frontline staff involved in patrolling activities) are essential for the effective management and operations of protected areas (Belecky et al., 2019a). Rangers both ensure compliance with protected area rules and help develop and strengthen partnerships with local communities. Globally, there are not enough rangers to fulfill their role as planetary custodians, and increasing the number of rangers within protected areas is a conservation priority (Appleton et al., 2022; Stolton et al., 2023). Poor ranger welfare and a lack of appropriate equipment and training have also been identified as challenges facing rangers (Moreto, 2016). The essential roles, responsibilities, and needs of rangers were encapsulated in the Chitwan Declaration, adopted by ranger associations from around the world at the 9th World Ranger Congress in November 2019 (Singh et al., 2021). The Chitwan Declaration highlights key elements required by rangers, particularly access to communication networks and devices, shelter, clean water, training in first aid and fire management, effective medical evacuation plans, and adequate health care, both in terms of access and coverage.

We use data from two comprehensive global surveys of ranger numbers and working conditions (Appleton et al., 2022; Belecky et al., 2019b) to estimate the funding required to (i) meet minimum ranger densities and (ii) address basic standards of ranger welfare, across protected areas within Tiger Conservation Landscapes (TCLs) in the 10 countries with breeding populations of the tiger.

We use this analysis to estimate the funding increase required to reach minimum required ranger numbers and meet some of the important aspects of ranger welfare identified within the Chitwan Declaration.

2 | METHODS

We estimated the cost required to meet minimum ranger densities (Table 1), and a subset of the standards of ranger welfare defined in the Chitwan Declaration (Table 1), across all protected areas within TCLs (Sanderson et al., 2010) within the 10 countries with extant tiger populations (Bangladesh, Bhutan, China, India, Indonesia, Malaysia, Myanmar, Nepal, Thailand, Russia). Tiger Conservation Landscapes are areas of suitable connected habitat, which are sufficiently large to support five female home ranges and with evidence of recent tiger presence. TCLs comprise both protected and unprotected areas. We focused our analysis solely within protected areas within the TCLs (Table S1). Protected area coverage was obtained from the World Database on Protected Areas (www.protectedplanet.net; accessed January 2021) and totaled 321,472 km² within TCLs across the 10 countries (Table S1). While a revision of TCL boundaries was published in 2023 (Sanderson et al., 2023), we restricted our analysis to the TCLs defined by Sanderson et al. (2010) while removing areas within the three Southeast Asian countries, which subsequently lost their tiger populations (Cambodia, Lao PDR, and Viet Nam; Goodrich et al., 2022). Our analysis follows Belecky et al. (2019a) and focuses exclusively on rangers, whom we define as protected area staff who are involved in patrolling activities on a regular basis and who work in the public sector in the sense that they are paid wages by a government and their position is characterized by accountability and duties to a government authority. While we calculated costs for each country, we present data regionally. This was due to limitations on the publishing of country-specific data as per project permission agreements with most governments. We present results based on three geographic regions: South Asia (India, Bangladesh, Nepal, Bhutan), Southeast Asia (Malaysia, Indonesia, Thailand, Myanmar), and East Asia (Russia, China). For each region, we summed the results from each relevant country to estimate the costs required to achieve minimum ranger numbers and improve ranger welfare.

2.1 | Ranger densities

We obtained data on current ranger numbers and densities from Appleton et al. (2022), who used a combination

TABLE 1 Minimum ranger standards used to calculate the funding gap for rangers within protected areas in Tiger Conservation Landscapes (TCLs) across 10 Asian countries.

Element of the Chitwan declaration	Justification	Minimum standards	Source of data	Costing source
Ranger Numbers	Effective management of protected areas requires a minimum number of rangers to mitigate threats and productively engage with local communities.	10 rangers per 100 km ² in South and Southeast Asia; 5 rangers per 100 km ² in East Asia ^a	Appleton et al. (2022)	Mean ranger salaries per country were obtained from Belecky et al. (2019b). These were adjusted per subsequent national inflation.
Injury Insurance Life Insurance	Rangers undertake a dangerous job and effective insurance is necessary as both a duty-of-care to rangers and to enhance performance	100% of rangers insured 100% of rangers insured	Belecky et al. (2019a)	Country-specific quotes for insuring rangers (Singh et al., 2021)
Access to communications devices	Effective communications while on patrol is essential for both health and safety and also coordinating enforcement operations	1 device per four rangers		Country-specific online price quotes for hand-held two-way radio-sets (Motorola MT-918 or equivalent)
First Aid training	Rangers undertake a dangerous job in often remote conditions. As such, knowledge of first aid is essential	Each ranger trained once every 3 years		Country-specific quotes for delivering accredited First Aid Training for groups of rangers
Crime Scene Investigation training	Patrolling by rangers can more effectively deter illegal activity if the certainty and severity of punishment to offenders are high. Professionally managing crime scenes and evidence increases the likelihood of successful legal action against natural resource criminals	Each ranger trained once every 2 years		A generic estimate of the cost for delivering Crime Scene Investigation Training from experience in Cambodia and Thailand. This was US\$ 200 per person

^aEast Asia refers to TCLs in Russia and China.

of questionnaires, analysis of literature and government reports, and direct information requests to governments to estimate protected area ranger numbers from 163 countries globally. We used this data to estimate national protected area ranger densities in each country by dividing the total numbers of rangers per country by each country's total protected area coverage obtained from the World Database of Protected Areas (www.protectedplanet.net; accessed January 2021). We then applied this density to the coverage of protected areas within TCLs in each country to estimate the current numbers of rangers. This was compared to an estimate of a minimum numbers of rangers required to effectively protect the tiger in order to identify any shortfall in current ranger numbers. There is no uniform agreement on minimum densities of rangers, and the optimum density will vary considerably based on the nature of a site. This is reflected in the variety of published estimates of minimum ranger densities (Table S2). For our analysis, we defined the minimum ranger density as 10 individuals per 100 km² in South and Southeast Asia and 5 individuals per 100 km² within the East Asian range of the Amur tiger. We chose different thresholds for

minimum ranger densities between the two regions to reflect both tiger ecology, tiger home ranges and thus densities are much lower in the temperate forests of North East China and the Russian Far East than in other parts of the extant range, as well as the low human population densities within these regions. We choose these thresholds based on our experience working in protected area and conservation law enforcement across Asia and we believe these ranger densities are both realistically achievable and likely to provide sufficient human resources for effective conservation. We acknowledge that these thresholds are higher than some published estimates of minimum ranger densities (Table S2) but we believe they reflect the unique difficulties of conserving tiger: a high value species in illegal trade markets, which is dependent on sufficient densities of ungulate prey and which requires effective management of potential conflict with humans. We also note that the minimum ranger density we use in South and Southeast Asia (10 individuals per 100 km²) has been recommended by governments in at least two Asian countries: Viet Nam and the Philippines (Appleton et al., 2022).

To calculate the cost of employing any additional rangers required, we obtained current ranger salary information from Belecky et al. (2019b) (see below). Ranger salaries were adjusted within each country for annual inflation since the surveys, which were delivered between 2016 and 2019. Annual inflation since the surveys was estimated in May 2021 using data from the International Monetary Fund (https://www.imf.org/external/datamapper/PCPIPCH@WEO/WEO_WORLD).

2.2 | Ranger welfare

We identified three important requirements for ranger welfare and conditions from the Chitwan Declaration: (i) provision of life and injury insurance; (ii) access to communications devices when patrolling; and (iii) provision of training (Table 1). For each element, we identified minimum conditions (Table 1) and the cost, per ranger, of meeting these conditions within each country (Table 1). We compared the minimum conditions with the current situation for rangers within protected areas inside TCLs in each country. These data were obtained from a comprehensive global assessment of ranger working conditions (Belecky et al., 2019a). We used the results of Belecky et al. (2019b) to calculate the number and percentage of rangers that were fully insured, had access to communications devices, and had received recent (<3 years ago) training in First Aid and Crime Scene Investigation. This number was compared to the minimum ranger number for the

country (see above) to calculate the gap in funding required.

3 | RESULTS

3.1 | Ranger densities

Country-specific estimated ranger densities varied between 0.5 and 26.4 rangers per 100 km² of protected area (Figure 1). In Southeast and East Asia, the mean number of rangers (6.4 and 0.7 per 100 km², respectively) was insufficient for effective protection (Table 2). While in three countries (two in South Asia and one in Southeast Asia) ranger density exceeded our minimum thresholds of required rangers (Figure 1), there is an overall shortfall of 12,481 rangers within TCL-protected areas. Two-thirds of the required rangers (8,286) are needed in three Southeast Asian countries with declining tiger numbers (Malaysia, Indonesia, and Myanmar). Mean (pre-inflation) ranger salary varied between US\$ 137 and US\$ 563 per month with salary levels relatively similar between the three regions (Table 2). Based on estimated ranger numbers, and mean salaries, currently US\$ 155.6 million is invested annually by the 10 countries in ranger salaries within protected areas inside TCLs. Most of this current investment (69%) is in South Asia (Table 2). The shortfall for ranger salaries across the region was estimated at US\$ 45.8 million with the majority of additional investment required in Southeast (63%) and East Asia (33%) (Tables 2 and 4).

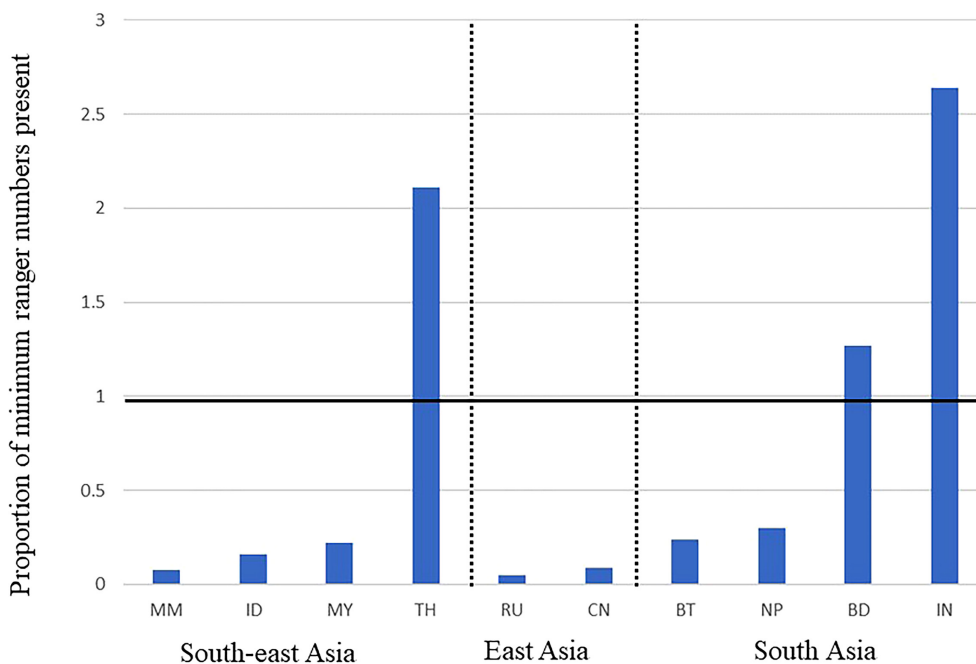


FIGURE 1 Proportion of the optimum ranger densities (10 rangers per 100 km² in South and Southeast Asia; 5 rangers per 100 km² in East Asia) within the 10 countries with breeding tiger populations. BD, Bangladesh; BT, Bhutan; CN, China; ID, Indonesia; IN, India; MM, Myanmar; MY, Malaysia; NP, Nepal; RU, Russia; TH, Thailand.

TABLE 2 Numbers of rangers surveyed, ranger densities, and estimated costs of meeting optimum ranger densities within protected areas inside Tiger Conservation Landscapes (TCLs) within three geographic regions of extant tiger occurrence.

	South Asia	Southeast Asia	East Asia
Number of countries	4	4	2
Number of protected areas surveyed (Belecky et al., 2019a)	27	54	17
Number of rangers surveyed (Belecky et al., 2019b)	810	615	184
Mean (\pm SD) national ranger density (Appleton et al., 2022)	11.1 \pm 9.7	6.4 \pm 8.5	0.7 \pm 0.2
Current estimated rangers' numbers within protected areas inside TCLs	22,532	10,236	456
Additional rangers required to meet optimum densities across protected areas inside TCLs	765	8,286	3,429
Mean national ranger salary (inflation adjusted; US\$/month; Belecky et al., 2019a)	232 \pm 89	337 \pm 150	360 \pm 44
Current total ranger salaries within protected areas inside TCLs (inflation adjusted; US \$/year)	107,023,687	46,495,284	2,060,946
Costs of additional rangers required to meet optimum densities across protected areas inside TCLs (US\$/year)	1,912,715	28,849,541	15,075,502

TABLE 3 Mean (\pm SD comparing between countries) % of rangers meeting minimum standards (see Table 1) of health and life insurance, access to communications devices, and training within Protected Areas inside Tiger Conservation Landscapes (TCLs) within three Asian regions. For each region, the estimate costing gap is also provided.

	South Asia	Southeast Asia	East Asia
Mean % of rangers receiving injury insurance	28.5 \pm 12.9	27.5 \pm 20.8	64.2 \pm 8.0
Mean % of rangers receiving life insurance	36.7 \pm 3.5	32.6 \pm 2.7	61.9 \pm 7.5
Total estimated cost of insurance for existing and required rangers (US\$)	588,596	653,941	194,111
Mean % of rangers with access to communication devices on patrol	35.3 \pm 23.0	32.6 \pm 8.8	78.8 \pm 8.4
Total estimated cost required for communication devices (US\$)	90,115	423,617	158,342
Mean % of rangers receiving annual First Aid Training	14.9 \pm 3.5	29.5 \pm 15.4	51.6 \pm 2.6
Mean % of rangers receiving annual Crime Scene Investigation Training	24.0 \pm 4.0	36.1 \pm 19.1	45.9 \pm 12.9
Total estimated costs required for annual training	3,532,402	1,603,630	552,391

TABLE 4 Estimated US\$ funding gaps (and % of total funding gap of US\$ 53.7 million) for additional rangers, full ranger insurance, communications equipment,^a and training^b within protected areas across Tiger Conservation Landscapes (TCLs) in three Asian regions.

Item	South Asia	Southeast Asia	East Asia	All Tiger range countries
New rangers	1,912,715 (4%)	28,849,541 (54%)	15,075,502 (28%)	45,837,758 (85%)
Insurance	588,596 (1%)	653,941 (1%)	194,111 (<1%)	1,436,649 (3%)
Communications equipment ^a	90,115 (<1%)	423,617 (1%)	158,342 (<1%)	672,074 (1%)
Training ^b	3,523,402 (7%)	1,632,630 (3%)	552,391 (1%)	5,708,424 (11%)
Total	6,114,829 (11%)	31,559,730 (59%)	15,980,346 (30%)	53,654,905

^aOne device per four rangers; note additional infrastructure such as radio masts may be required.

^bFirst Aid and Crime Scene Investigations.

3.2 | Ranger welfare

A total of 1,609 rangers were surveyed from 98 protected areas within TCLs in the 10 countries with extant tiger populations (Belecky et al., 2019b). Half of the interviewed rangers were in South Asia with 38% in Southeast

Asia and 12% in East Asia (Table 2). Less than half of currently employed rangers received injury or life insurance (Table 3) with the proportion of insured rangers higher in East Asia. In South and Southeast Asia, slightly more rangers had access to life as opposed to injury insurance though the reverse was the case in East Asia (Table 3).

Annual insurance costs provided were relatively low (mean US\$ 73 per ranger per year) with a total gap (current and required rangers) of US\$ 1.4 million for ranger insurance annually across the 10 countries (Table 4). We note that a proportion of the rangers who reported receiving insurance might have inadequate insurance (i.e., falling below the standard we used) so the financing gap for ranger insurance could be higher than we report.

Approximately 50% of rangers rarely or never had access to communication devices on patrol with greater access to devices in East Asia (Table 3). An additional 2,535 communication devices (mean cost US\$ 185 ± SD 102.3) are required across the 10 countries at an estimated total cost of US\$ 672,000 (Table 4). Approximately one-third of rangers received annual training on First Aid and Crime Scene Investigations with a higher percentage of rangers receiving annual training in East Asia (Table 3). The additional cost of training was estimated at US\$ 2.3 million for First Aid (mean cost US\$ 151 per participant ± SD 80.1) and US\$ 3.3 million for Crime Scene Investigations (mean US\$ 200 per participant). This gives a gap of funding for First Aid and Crime Scene Investigation training of approximately US\$ 5.7 million annually—61% of which is required in South Asia.

4 | DISCUSSION

Protected areas are the cornerstone of global efforts to safeguard biodiversity, and rangers are essential for effective protected area management (Singh et al., 2021; Stolton et al., 2023). Ensuring that a sufficient number of rangers are employed, and that they are equipped and valued, is essential if we are to limit the impacts of the Anthropocene extinction crisis. Currently, insufficient resources are invested by the global community into protected area rangers (Appleton et al., 2022; Belecky et al., 2019a; Coad et al., 2019). We demonstrate that this pattern holds true across protected areas supporting one of the planet's most iconic, and threatened, species: the tiger. Increasing funding for rangers is a critical component of what is required to protect the tiger and tiger landscapes. Through securing protected areas, and the ecosystem services therein, rangers generate considerable positive benefits for the planet. It has been estimated that funding protected areas generates a 5:1 return on investment (Waldron et al., 2020) and the role of rangers as planetary health stewards is increasingly recognized (Stolton et al., 2023). Investing in rangers, both in terms of increasing numbers and improving their working conditions, must be viewed a part of a post-Coronavirus economic revival through stimulating rural economies and strengthening the protection of nature and thus

reducing probabilities of future pandemics (Hockings et al., 2020; Terraube & Fernández-Llamazares, 2020).

There are not enough rangers in government protected areas in at least seven of the 10 countries with breeding wild tiger populations. We estimate that a minimum of an additional 12,500 rangers are required for these protected areas. We estimate that this would cost US\$ 45.8 million annually. Given that we estimate that more than US\$ 150 million annually is invested in ranger salaries within these countries, the additional funding required represents an increase, across current tiger range, of just over one-third. However, in many Asian countries, tigers occur widely outside the protected area network: indeed our estimate of ~320,000 km² of tiger-bearing protected areas represents just over one-third of the extent of Tiger Conservation Landscapes identified by Sanderson et al. (2023). Some of these landscapes represent areas under Other Effective Conservation Measures (OECMs) and will likely require further human resources to safeguard tigers. We also document a funding gap of approximately US\$ 7.8 million for meeting a subset of the more important standards of ranger welfare. Unlike the gap for additional rangers, which is mostly in Southeast Asia, additional funding for ranger welfare and conditions is necessary across all tiger range countries. We only assessed a subset of the costs required to effectively manage protected areas but believe this subset, focused around ranger numbers and key aspects of their welfare, provides a valuable insight into the resource gaps needed to secure tiger populations. The aspects of welfare that we assessed, focused around the safety of rangers (e.g., insurance and communication tools), have been self-identified by rangers as among their most significant concerns (Belecky et al., 2019b; Moreto et al., 2016), but clearly do not represent the full suite of interventions required to comprehensively enhance ranger well-being. Equally as important as increasing the numbers of protected area rangers is increasing their effectiveness, and it is essential that any increases in ranger numbers are paired with increased levels of evidence-based policing and community engagement (Lam et al., 2023).

There is a clear geographic discrepancy as to where additional investment is required. Almost 60% of the funding gap we identify (US\$ 31.6 million) is for rangers (both increased numbers and improved welfare) in four Southeast Asian countries. These countries have small tiger populations that have declined, in both numbers and distribution, over the past 20 years (Goodrich et al., 2022; Sanderson et al., 2023). Southeast Asia is at the center of the contemporary extinction crisis with growing human populations and an increasing middle

class driving unsustainable hunting and consumption of wild animals (Gray et al., 2018; Sodhi et al., 2010). Insufficient funding resulting in low numbers of poorly equipped and unmotivated protected areas rangers further exacerbates this regional wildlife crisis. Ineffective protected area management in Southeast Asia has been implicated in significant population declines of iconic species, including the tiger, elephants, rhinoceros, and wild cattle (Brook et al., 2014; Duckworth et al., 2012; Figel et al., 2021; Groenenberg et al., 2023; Rasphone et al., 2019). A fundamental tenet of our analysis is that more resources for protected area rangers, and thus increased ranger numbers and improved ranger welfare, correlate with conservation success. This assumption merits empirical testing, and we highlight this as an important area of future research.

Several caveats exist regarding the data we use and our interpretation. While we only estimated funding gaps across the 10 countries with extant tiger populations, the TCLs (Sanderson et al., 2010) cover a larger area than the current distribution of the tiger. This is particularly the case in, for example, parts of northern Thailand and Myanmar and areas of eastern India (Suttidate et al., 2021). As such, some of the protected areas within our analysis, such as Phu Khieo Wildlife Sanctuary in Thailand, do not currently support the tiger. However, these protected areas still require effective management for tiger conservation, particularly as, in a number of landscapes, future tiger reintroduction is possible (Gray et al., 2023). Conversely, some protected areas, for example those under the jurisdiction of the Karen National Union's Kawthoolei Forestry Department (KFD), whose protected area system and land management regime differ from the central Myanmar Government, are not included within the World Database of Protected Areas.

We also assumed that the density of rangers within protected areas inside TCLs was similar to the national average provided by Appleton et al. (2022). In many countries, it seems possible that protected areas supporting the tiger may have higher densities than the national average and therefore we may have overestimated the additional number of rangers required. However, we note that the ranger densities for India which were provided by Appleton et al. (2022) are very similar to independently derived estimates exclusively from tiger reserves (Jhala et al., 2021). Farhadinia et al. (2023) provide ranger densities across Asia using a similar, but apparently independent, approach to that of Appleton et al. (2022). These estimates of ranger density are similar to those which we provide (Figure S1) with the data from Farhadinia et al. (2023) supporting our conclusion that there are insufficient ranger numbers across the majority of tiger range countries (Figure S1). The data from

Appleton et al. (2022) and Belecky et al. (2019a), and thus our analysis, focus largely on public sector rangers working within government managed protected areas. Nongovernment protected areas, now commonly referred to as OCEMs, are increasingly recognized as essential for species conservation and nature-based solutions. OCEMs are often managed for biodiversity and conservation by Indigenous communities. Further empowering and equipping community conservation stewards could help address the gap in ranger densities we identify. Additional alternatives to increase the number and effectiveness of protected area rangers, and decrease the financial burden on often under-resourced Environmental Ministries, could include partnering with other government agencies such as the Military, which has been successful in Nepal (Mahatara et al., 2018), or exploring the establishment of innovative comanagement approaches for protected areas (Gray et al., 2020). However, increased militarization of protected area management in Asia needs to be approached cautiously with strong safeguards in place to support and benefit local communities.

Protected area rangers are planetary health care workers and are at the frontline of the protection of wildlife and wild places (Stolton et al., 2023). For conservation-dependent species such as the tiger, ensuring that there are sufficient resources and support for rangers is essential for preventing local extinctions and for supporting population recovery. There is an urgent need to increase funding to support rangers across the 10 Asian countries with breeding tiger populations. Increasing the number of protected area rangers needs to be identified and prioritized in national conservation planning. We recommend adding measurable goals for increasing the number, and efficacy, of protected area rangers into both National Biodiversity Strategy and Action Plans (NBSAPs) and national Tiger Action Plans. Reporting on these commitments should be incorporated into reporting under the Convention on Biological Diversity (CBD) and the Global Tiger Recovery Program (GTRP). While not a panacea to the multiple threats assailing Asian wildlife the additional investment which we identify would make a significant contribution to our ability to protect the tiger. Moreover, bolstering resources and support could improve workplace conditions and morale of rangers, which, in turn, could enhance and improve job satisfaction and community relations (Moreto et al., 2016; Moreto et al., 2017). Expanded resources, including those allocated to specific forms of training such as Problem-Oriented Policing, intelligence, and community education, would extend alternatives and options needed to respond to potential threats in and around protected area landscapes (see Cowan et al., 2019; Moreto & Charlton, 2019). We urge tiger range country

governments and the global conservation community to secure this funding. Increasing the levels of funding to rangers, as identified in this paper, would unquestionably increase the ability of the global community to protect the tiger and the ecologically significant landscapes in which they live.

AUTHOR CONTRIBUTIONS

TNEG conceived the study; MB, RS, and WDM designed and undertook data collection; TNEG, MB, and WDM analyzed the data; TNEG, MB, RS, WDM, and SC wrote the paper.

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DATA AVAILABILITY STATEMENT

All data can be provided on request to the lead author for reasonable use. However individual, site-specific, or country-specific results from the ranger perception survey (Belecky et al., 2019b) cannot be published due to confidentiality of the data and respondents.

REFERENCES

- Appleton, M. R., Courtiol, A., Emerton, L., Slade, J. L., Tilker, A., Warr, L. C., Malvido, M. Á., Barborak, J. R., de Bruin, L., Chapple, R., & Daltry, J. C. (2022). Protected area personnel and ranger numbers are insufficient to deliver global expectations. *Nature Sustainability*, 5(12), 1100–1110.
- Belecky, M., Singh, R., & Moreto, W. (2019a). Life on the frontline 2019: A global survey of the working conditions of rangers. https://files.worldwildlife.org/wwfmsprod/files/Publication/file/k36blpy2c_wwf_rangers_survey_report_2019.pdf?_ga=2.11781949.866533539.1661848419-1321414086.1661848419
- Belecky, M. M., Singh, R., & Moreto, W. (2019b). Life on the frontline of tiger protection. A survey of the working conditions of patrol rangers employed in Asia's tiger landscapes, WWF Tigers Alive Initiative. <https://tigers.panda.org/reports/?uNewsID=5757466>
- Bolam, F. C., Mair, L., Angelico, M., Brooks, T. M., Burgman, M., Hermes, C., Hoffmann, M., Martin, R. W., McGowan, P. J. K., Rodrigues, A. S. L., Rondinini, C., Westrip, J. R. S., Wheatley, H., Bedolla-Guzmán, Y., Calzada, J., Child, M. F., Cranswick, P. A., Dickman, C. R., Fessl, B., ... Butchart, S. H. M. (2021). How many bird and mammal extinctions has recent conservation action prevented? *Conservation Letters*, 14, e12762. <https://doi.org/10.1111/conl.12762>
- Brook, S. M., Dudley, N., Mahood, S. P., Polet, G., Williams, A. C., Duckworth, J., Van Ngoc, T., & Long, B. (2014). Lessons learned from the loss of a flagship: The extinction of the Javan rhinoceros *Rhinoceros sondaicus annamiticus* from Vietnam. *Biological Conservation*, 174, 21–29.
- Butchart, S. H. M., Scharlemann, J. P. W., Evans, M. I., Quader, S., Aricò, S., Arinaitwe, J., Balman, M., Bennun, L. A., Bertzky, B., Besançon, C., Boucher, T. M., Brooks, T. M., Burfield, I. J., Burgess, N. D., Chan, S., Clay, R. P., Crosby, M. J., Davidson, N. C., de Silva, N., ... Woodley, S. (2012). Protecting important sites for biodiversity contributes to meeting global conservation targets. *PLoS One*, 7, e32529. <https://doi.org/10.1371/journal.pone.0032529>
- Coad, L., Watson, J. E., Geldmann, J., Burgess, N. D., Leverington, F., Hockings, M., Knights, K., & di Marco, M. (2019). Widespread shortfalls in protected area resourcing undermine efforts to conserve biodiversity. *Frontiers in Ecology and the Environment*, 17, 259–264. <https://doi.org/10.1002/fee.2042>
- Cowan, D., Burton, C., & Moreto, W. D. (2019). Conservation-based intelligence-led policing: An intra-organizational interpersonal examination. *Policing: An International Journal*, 42, 108–122.
- Duckworth, J., Batters, G., Belant, J., Bennett, E., Brunner, J., Burton, J., Challender, D. W. S., Cowling, V., Duplaix, N., Harris, J. D., Hedges, S., Long, B., Mahood, S. P., McGowan, P. J. K., McShea, W. J., Oliver, W. L. R., Perkin, S., Rawson, B. M., Shepherd, C. R., ... Mainguy, G. (2012). *Why south-east Asia should be the world's priority for averting imminent species extinctions, and a call to join a developing cross-institutional programme to tackle this urgent issue*. SAPI EN. S. Surveys and Perspectives Integrating Environment and Society.
- Farhadinia, M. S., Johnson, P. J., Kamath, V., Eid, E., Hikmani, H. A., Ambarli, H., Alom, Z., Askerov, E., Buchakiet, P., Buuveibaatar, B., & Gavashelishvili, A. (2023). Economics of conservation law enforcement by rangers across Asia. *Conservation Letters*, 16, e12943.
- Figel, J. J., Hambal, M., Krisna, I., Putra, R., & Yansyah, D. (2021). Malignant snare traps threaten an irreplaceable megafauna community. *Tropical Conservation Science*, 14, 1940082921989187.
- Goodrich, J., Wibisono, H., Miquelle, D., Lynam, A. J., Sanderson, E., Chapman, S., Gray, T. N. E., Chanchani, P., & Harihar, A. (2022). *Panthera tigris*. The IUCN red list of threatened species 2022: E. T15955A214862019.
- Gray, C. L., Hill, S. L. L., Newbold, T., Hudson, L. N., Börger, L., Contu, S., Hoskins, A. J., Ferrier, S., Purvis, A., & Scharlemann, J. P. W. (2016). Local biodiversity is higher inside than outside terrestrial protected areas worldwide. *Nature Communications*, 7, 12306. <https://doi.org/10.1038/ncomms12306>
- Gray, T. N., Rosenbaum, R., Jiang, G., Izquierdo, P., Yongchao, J. I. N., Kesaro, L., Lyet, A., Pasha, M. K. S., Patterson, D. J., Channa, P., & Jinzhe, Q. I. (2023). Restoring Asia's roar: Opportunities for tiger recovery across the historic range. *Frontiers in Conservation Science*, 4, 1124340.
- Gray, T. N. E., Hughes, A. C., Laurance, W. F., Long, B., Lynam, A. J., O'Kelly, H., Ripple, W. J., Seng, T., Scotson, L., & Wilkinson, N. M. (2018). The wildlife snaring crisis: An insidious and pervasive threat to biodiversity in Southeast Asia.

- Biodiversity and Conservation*, 27, 1031–1037. <https://doi.org/10.1007/s10531-017-1450-5>
- Gray, T. N. E., O'Kelly, H., Eames, J. C., & Hedges, S. (2020). Conservation concessions to avert the south east Asian biodiversity crisis? Lessons from Cambodia. *Animal Conservation*, 23(1), 1–2.
- Groenewald, M., Crouthers, R., Yoganand, K., Banet-Eugene, S., Bun, S., Muth, S., Kim, M., Mang, T., Panha, M., Pheaktra, P., & Pin, T. (2023). Snaring devastates terrestrial ungulates whilst sparing arboreal primates in Cambodia's Eastern Plains landscape. *Biological Conservation*, 284, 110195.
- Hilborn, R., Arcese, P., Borner, M., Hando, J., Hopcraft, G., Loibooki, M., Mduma, S., & Sinclair, A. R. E. (2006). Effective enforcement in a conservation area. *Science*, 314, 1266. <https://doi.org/10.1126/science.1132780>
- Hockings, M., Dudley, N., Elliott, W., Ferreira, M., MacKinnon, K., Pasha, M., Phillips, A., Stolton, S., Woodley, S., Appleton, M., Chassot, O., Fitzsimons, J., Galliers, C., Kroner, R. C., Goodrich, J., Hopkins, J., Jackson, W., Jonas, H., Long, B., ... Yang, A. (2020). Editorial essay: Covid-19 and protected and conserved areas. *Parks*, 26, 7–24.
- Jhala, Y., Gopal, R., Mathur, V., Ghosh, P., Negi, H. S., Narain, S., Yadav, S. P., Malik, A., Garawad, R., & Qureshi, Q. (2021). Recovery of tigers in India: Critical introspection and potential lessons. *People and Nature*, 3, 281–293. <https://doi.org/10.1002/pan3.10177>
- Lam, W. Y., Phung, C. C., Mat, Z. A., Jamaluddin, H., Sivayogam, C. P., Zainal Abidin, F. A., Sulaiman, A., Cheok, M. K. Y., Osama, N. A. W., Sabaan, S., & Abu Hashim, A. K. (2023). Using a crime prevention framework to evaluate tiger counter-poaching in a southeast Asian rainforest. *Frontiers in Conservation Science*, 4.
- Lindsey, P. A., Miller, J. R. B., Petracca, L. S., Coad, L., Dickman, A. J., Fitzgerald, K. H., Flyman, M. V., Funston, P. J., Henschel, P., Kasiki, S., Knights, K., Loveridge, A. J., Macdonald, D. W., Mandisodza-Chikerema, R. L., Nazerali, S., Plumptre, A. J., Stevens, R., van Zyl, H. W., & Hunter, L. T. B. (2018). More than \$1 billion needed annually to secure Africa's protected areas with lions. *Proceedings. National Academy of Sciences United States of America*, 115, E10788–E10796. <https://doi.org/10.1073/pnas.1805048115>
- Mahatara, D., Rayamajhi, S., & Khanal, G. (2018). Impact of anti-poaching approaches for the success of rhino conservation in Chitwan National Park, Nepal. *Banko Janakari*, 28(2), 23–31.
- Moreto, W. D. (2016). Occupational stress among law enforcement rangers: Insights from Uganda. *Oryx*, 50, 646–654. <https://doi.org/10.1017/S0030605315000356>
- Moreto, W. D., Brunson, R. K., & Braga, A. A. (2017). “Anything we do, we have to include the communities”: Law enforcement Rangers' attitudes towards and experiences of community-ranger relations in wildlife protected areas in Uganda. *British Journal of Criminology*, 57, 924–944. <https://doi.org/10.1093/bjc/azw032>
- Moreto, W. D., & Charlton, R. (2019). Rangers can't be with every elephant: Assessing rangers' perceptions of a community, problem-solving policing model for protected areas. *Oryx*, 55, 89–98. <https://doi.org/10.1017/S0030605318001461>
- Moreto, W. D., Lemieux, A. M., & Nobles, M. R. (2016). “It's in my blood now”: The satisfaction of rangers working in queen Elizabeth National Park, Uganda. *Oryx*, 50, 655–663. <https://doi.org/10.1017/S0030605316000387>
- Rasphone, A., Kéry, M., Kamler, J. F., & Macdonald, D. W. (2019). Documenting the demise of tiger and leopard, and the status of other carnivores and prey, in Lao PDR's most prized protected area: Nam et-Phou Louey. *Global Ecology and Conservation*, 20, e00766.
- Sanderson, E. W., Forrest, J., Loucks, C., Ginsberg, J., Dinerstein, E., Seidensticker, J., Leimgruber, P., Songer, M., Heydlauff, A., O'Brien, T., Bryia, G., Klenzendorf, S., & Wikramanayake, E. (2010). Setting priorities for Tiger conservation. In *Tigers of the world* (pp. 143–161). Elsevier. <https://doi.org/10.1016/B978-0-8155-1570-8.00009-8>
- Sanderson, E. W., Miquelle, D. G., Fisher, K., Harihar, A., Clark, C., Moy, J., Potapov, P., Robinson, N., Royte, L., Sampson, D., & Sanderlin, J. (2023). Range-wide trends in tiger conservation landscapes, 2001–2020. *Frontiers in Conservation Science*, 4, 1191280.
- Singh, R., Galliers, C., Appleton, M., Hoffmann, M., Long, B., Cary-Elwes, J., Fritze, C., McCallum, J., & Parry Jones, R. (2021). The vital role of rangers in conservation. *Parks Stewardship Forum*, 37. <https://doi.org/10.5070/P537151745>
- Sodhi, N. S., Posa, M. R. C., Lee, T. M., Bickford, D., Koh, L. P., & Brook, B. W. (2010). The state and conservation of southeast Asian biodiversity. *Biodiversity and Conservation*, 19, 317–328.
- Stolton, S., Timmins, H. L., Dudley, N., Biegus, O., Galliers, C., Jackson, W., Kettunen, M., Long, B., Rao, M., Rodriguez, C. M., Romanelli, C., Schneider, T., Seidl, A., Singh, R., & Sykes, M. (2023). Essential planetary health workers: Positioning rangers within global policy. *Conservation Letters*, 16, e12955. <https://doi.org/10.1111/conl.12955>
- Suttidate, N., Steinmetz, R., Lynam, A. J., Sukmasuang, R., Ngoprasert, D., Chutipong, W., Bateman, B. L., Jenks, K. E., Baker-Whetton, M., Kitamura, S., Ziólkowska, E., & Radeloff, V. C. (2021). Habitat connectivity for endangered Indochinese tigers in Thailand. *Global Ecology and Conservation*, 29, e01718.
- Terraube, J., & Fernández-Llamazares, Á. (2020). Strengthening protected areas to halt biodiversity loss and mitigate pandemic risks. *Current Opinion in Environmental Sustainability*, 46, 35–38.
- Waldron, A., Adams, V., Allan, J., Arnell, A., Asner, G., Atkinson, S., Baccini, A., Baillie, J. E. M., Balmford, A., Beau, J. A., Brander, L., Brondizio, E., Bruner, A., Burgess, N., Burkart, K., Butchart, S., Button, R., Carrasco, R., Cheung, W., ... Zhang, Y. P. (2020). Protecting 30% of the planet for nature: costs, benefits and economic implications. <https://helda.helsinki.fi/handle/10138/326470>

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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