HILL PUBLISHING

Advance in Sustainability, 2025, 5(2), 50-57
https://www.hillpublisher.com/journals/as/
ISSN Online: 2769-3074

Do Deterrence Policies Work? Assessing the Relationship Between Deterrence-based Anti-poaching Measures and Wildlife Population Trends in Assam, India

Younsung Kim*, **Sudha Balajapalli**

Department of Environmental Science and Policy, George Mason University, Fairfax, VA 22030, USA.

How to cite this paper: Younsung Kim, Sudha Balajapalli. (2025). Do Deterrence Policies Work? Assessing the Relationship Between Deterrence-based Anti-poaching Measures and Wildlife Population Trends in Assam, India. *Advance in Sustainability*, 5(2), 50-57.
DOI: 10.26855/as.2025.12.001

Received: September 30, 2025
Accepted: October 28, 2025
Published: November 26, 2025

Corresponding author: Younsung Kim, Department of Environmental Science and Policy, George Mason University, Fairfax, VA 22030, USA.

Abstract

Wildlife poaching poses a critical threat to biodiversity, disrupting trophic structures and undermining ecosystem health. In response, some governments have adopted deterrence measures, including the apprehension of poachers and the use of lethal force. This study evaluates how the deterrence-based practices relate to population trends of tigers, elephants, and rhinos in four national parks in Assam, India: Dibru-Saikhowa, Kaziranga, Nameri, and Orang. Contrary to the assumption that punitive threats ensure compliance with conservation laws and thereby reduce poaching, our findings indicate that deterrence-based antipoaching enforcement actions have limited influence on megafaunal population trends. Instead, ecological carrying capacity, proxied by park size, showed a stronger association with changes in species population. This research represents a novel approach to assessing the relationship between deterrence-based enforcement and population trends of elephants, tigers, and rhinos, offering important insights for antipoaching control that considers ecological features and community wellbeing.

Keywords

Deterrence policy; Anti-poaching enforcement; Carrying capacity; Tigers; Rhinos; Elephants

1. Introduction

Wildlife poaching poses a serious threat to biodiversity [1, 2], disrupting trophic structures and undermining ecosystem health [3-5]. In response, some conservation agencies have adopted deterrence measures, including lethal force—defined here as the intentional or accidental killing of suspected poachers during poaching activities. Although highly controversial, lethal force has been institutionalized in certain contexts through militarized or paramilitary operations, a process often referred to as green militarization [6, 7]. This approach, involving the deployment of military strategies and actors in conservation, has become increasingly common in protected areas, particularly across Africa [7, 8].

As poaching pressures escalate, policymakers in countries such as Malawi, the Democratic Republic of Congo, and Uganda have embraced deterrence-based strategies where lethal force has effectively become de facto policy [7-10]. Similar practices, though not formally codified, have been documented in South Africa's Kruger National Park and in Kaziranga National Park in Assam, India. [6, 8]. Between 2011 and 2016, an estimated 150-200 poachers were fatally subjected to enforcement actions in Kruger National Park [11], while approximately 50 were reportedly lethally neutralized by antipoaching operations in Kaziranga between 2014 and 2017 [8]. Such measures have been characterized as a "conflict against poaching" [12, 13].

Proponents argue that these tactics are necessary to protect both wildlife and local communities [14]. However, mounting evidence suggests that militarized approaches can generate unintended consequences, including deforestation, habitat degradation, and the displacement of indigenous populations [15]. Furthermore, deterrence measures often demonstrate limited long-term effectiveness, as poaching networks adapt to enforcement strategies and continue to sustain illegal activities through alternative means [16].

Despite the growing reliance on these approaches, empirical research assessing the effectiveness of deterrence-based antipoaching enforcement measures remains limited. Existing studies, often focused on single cases, have yielded mixed results. For instance, research on the Mexican grey wolf (*Canis lupus baileyi*) in the U.S. Southwest found higher rates of disappearance when lethal protections were relaxed [17]. Conversely, other studies conclude that lethal deterrence is largely ineffective and raises serious concerns over human rights abuses and community conflict [7, 15, 18]. Scholars further argue that lethal-based antipoaching measures exacerbate existing power asymmetries between conservation authorities and local communities, leading to violence disproportionately affecting marginalized groups [19, 20].

Beyond questions of effectiveness and ethics, scholars also contend that lethal force fails to address the root causes of poaching, which often lie in poverty, social marginalization, and the lack of alternative livelihoods in surrounding communities [12, 21, 22]. These socioeconomic drivers are particularly salient in regions such as Assam, India, where exceptional biodiversity coincides with porous borders and transnational wildlife trafficking networks. This intersection creates a highly challenging conservation landscape, within which poaching has remained pervasive [23, 24]. In Assam, poaching is fueled by its geographic proximity to Myanmar and Nagaland and the resulting cross-border smuggling of rhino horn, tiger parts, and elephant skin [25, 26]. These illegal wildlife products are often exchanged for firearms, creating a vicious cycle of violence and exploitation. As the region is known to show global ecological significance that contains multiple national parks and UNESCO-designated protected areas, deterrence policies, ranging from fines and imprisonment to lethal enforcement, remain the primary response to wildlife poaching. These policies are legally supported by the Indian Penal Code (Sections 428 and 429) and the Indian Wildlife Protection Act of 1972 (Section 51), which empower authorities to impose significant penalties on poachers [27]. The assumption behind these policies is that stronger legal consequences will discourage poaching activities.

Against this backdrop, the study presents a novel empirical analysis examining the extent to which deterrence-based antipoaching measures affect the population size of megafauna species vulnerable to poaching in Assam. We focus on two endangered megafaunas, tigers (*Panthera tigris tigris*), elephants (*Elephas maximus*), and megafauna rhinos (*Rhinoceros unicornis*) with vulnerable status by the IUCN (International Union for Conservation of Nature) [26] and use data from the Assam Forest Department. By assessing deterrence outcomes through a multi-species lens, this study adds to the ongoing debate about whether such policies are effective in controlling poaching and/or ethical in modern conservation. We find that deterrence-based approaches, particularly those incorporating apprehension of poachers and lethal enforcement, are not associated with increases in population size of the three different species of our interest.

To our knowledge, this study represents the first empirical assessment of deterrence outcomes across three endangered or vulnerable megafauna species within a unified legal and ecological framework. The findings suggest that conservation policies should adopt a more balanced approach—one that combines enforcement with meaningful community engagement, directly addresses the socioeconomic drivers of poaching, and incorporates habitat-specific management strategies. Importantly, deterrence-based measures warrant critical reconsideration where they risk undermining conservation objectives by imposing disproportionate burdens on forest-dependent communities, many of whom rely on these ecosystems for survival yet are not themselves engaged in poaching activities [19, 20].

2. Methods

2.1 Study Sites

Among Assam's extensive network of protected areas (1) Dibru-Saikhowa, Kaziranga, Nameri, and Orang National Parks hold special designations for the protection of megafauna. These parks vary from 78.90 km^2 to 430 km^2 in area, Kaziranga National Park being the largest and approximately five times the size of Orang National Park (Figure 1). Species composition also differs across each national park. For instance, both Kaziranga and Orang National Parks are home to elephants, tigers, and rhinos, whereas rhinos are absent in Nameri National Park. Additionally, Dibru-Saikhowa National Park, designated as a UNESCO Biosphere Reserve, only has wild elephants and spans vast terrestrial ecosystems providing habitat for numerous endangered/vulnerable mammals, birds, and reptiles [25]. Table 1 summarizes our study sites, special designations, park size, and megafauna species protected.

Table 1. Study Sites in Assam, India

Protected Area	Special Designations	Size (sq. km)	Megafauna
Dibru-Saikhowa National Park	Biosphere Reserve	340	Elephants
Kaziranga National Park	UNESCO World Heritage Site, Tiger Reserve	430	Elephant, rhino, tigers
Nameri National Park	Tiger Reserve	200	Elephant, tigers
Rajiv Gandhi Orang National Park	Tiger Reserve	78.80	Elephant, rhino, tigers

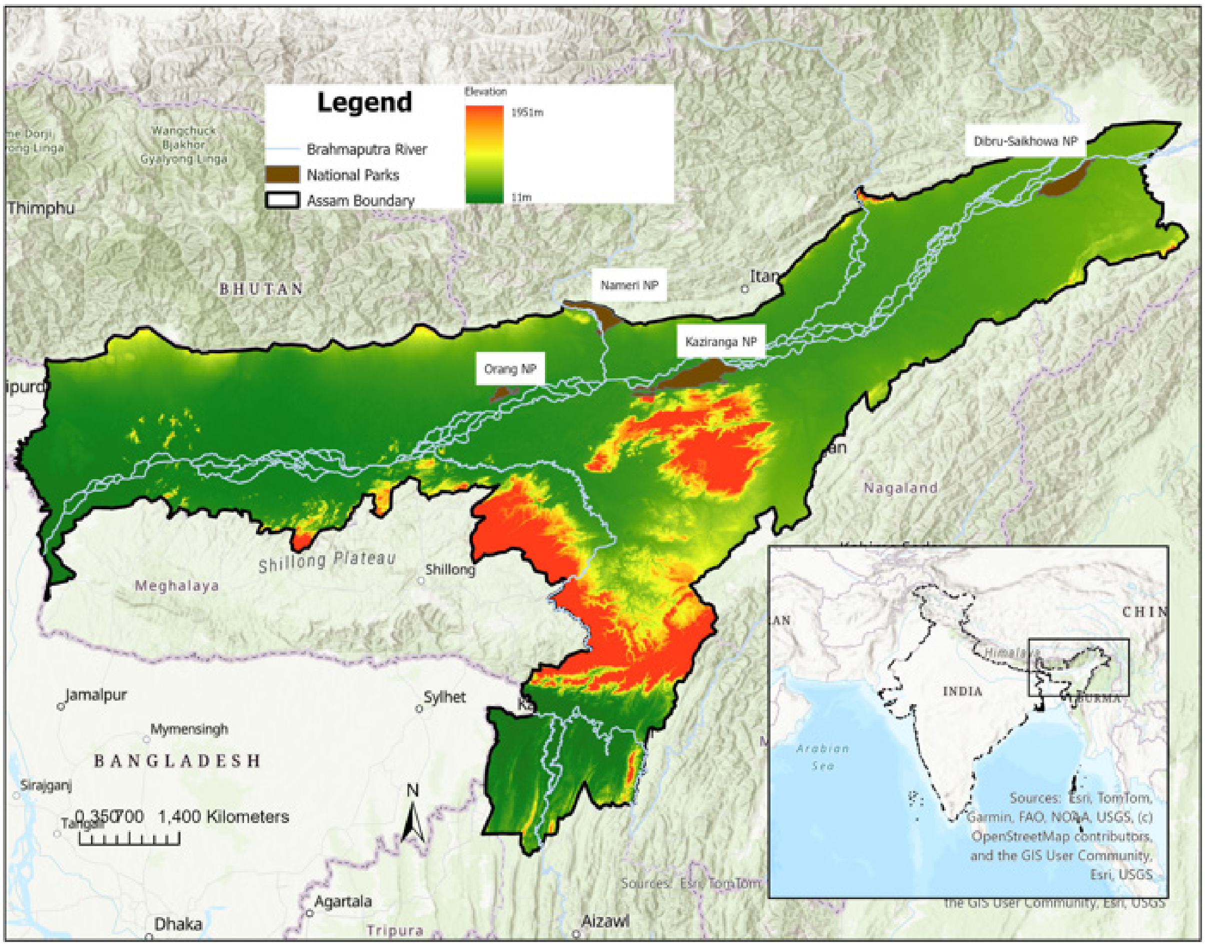

Figure 1. Diagrammatic map showing locations and landscapes of study sites.

2.2 Data and Analytic Methods

To examine the relationship between deterrence policies and wildlife conservation, a unique dataset was compiled, incorporating the number of poachers arrested and killed annually, along with wildlife census data from Kaziranga, Orang, Nameri, and Dibru-Saikhowa National Parks. The Assam Forest Department collected these data between 1985 and 2020, which were subsequently integrated with census records of rhinos, tigers and elephants across the four national parks. All variables were transformed to make them relative to a national park size as stated below.

1. *Census data*: Wildlife population density for endangered tigers and elephants, and vulnerable rhinos was calculated by using the ratio of population numbers to the national park area (km^2) and natural log transformed.

2. *Apprehension of poachers*: Animal Laws under Indian Penal Code of 1860 and the Wildlife Protection Act of 1972 deal with penalties regarding hunting of endangered/vulnerable species. There are fines and prison time associated with the Indian Penal Code and Wildlife Protection Act. Both authorize the Assam Forest Department to apprehend poachers. Lastly, poachers arrested per year were not normalized to the national park or log-transformed because the number of poachers arrested per year for each national park was generally zero with little variation.

3. *Use of lethal force toward poachers*: The number of poachers killed in self-defense was included in the regression models. Lastly, poachers killed per year was not normalized for the national park and log-transformed because the number of poachers killed per year for each national park was generally zero with little variation.

4. *Park area:* The 'park area' variable was added as a control. It is used to designate the area of the national park.

5. *Time*: The 'year' variable was added to account for population size changes with time. The data is from 1985 to 2020.

The relationships of interest were analyzed by OLS regression method in R [28]. It should be noted that outliers were not excluded from capturing the changes or variations of species population size that could be driven by changes in the environment and market demands. We performed group mean imputation for missing data of rhino, tiger, and elephant population density [29]. Each model was tested for multicollinearity using the variance inflation factor (VIF) criterion of four (4), and there was no evidence of heteroscedasticity in each model. Kaziranga National Park was chosen as the baseline for comparison due to its unique conservation status and protection.

3. Results

Table 2 presents three regression models for wild rhinos, tigers, and elephants. Our statistical models in Table 3 indicate that anti-poaching enforcement with apprehension and use of incidental force toward poachers were not statistically associated with changes in population size of wild tigers, elephants, and rhinos. In contrast, our findings reveal that park size and year are statistically associated with tiger, rhino, and elephant population trends. Larger protected areas exhibit higher carrying capacities, which is particularly important for species with low reproductive rates and high parental investment (e.g., tigers, rhinos, and elephants), and these species require extensive, undisturbed habitats to support their needs for breeding, foraging, and migration [4, 13, 30]. Additionally, the observed positive correlation between Orang National Park and tiger populations may be attributed to tiger movement between Kaziranga and Orang, suggesting ecological connectivity enhances species viability [31].

We also find a general annual increase in tiger and rhino populations, supported by census data from the Assam Forest Department. However, elephant populations have shown a slight decline over time, likely due to their dispersal from national parks to nearby elephant reserves. For example, elephants from Kaziranga National Park can migrate to Karbi Anglong Elephant Reserve. Moreover, Nameri National Park is linked to Sonitpur Elephant Reserve, and Dibru-Saikhowa National Park is near the Dihing-Patkai Elephant Reserve [25].

Table 2. Descriptive statistics of variables

	Observations	Mean	SD	Max	Min
Dibru Saikhowa National Park					
Elephant (*Elephas maximus*)	36	-0.336	0.083	-0.021	-0.628
Apprehension of poachers	36	0.528	1.134	4.000	0.000
Use of lethal force toward poachers	36	0.000	0.000	0.000	0.000
Kaziranga National Park					
Elephant (*Elephas maximus*)	36	0.416	0.019	0.478	0.342
Rhino (*Rhinoceros unicornis*)	36	0.608	0.073	0.749	0.400
Tiger (*Panthera tigris tigris*)	36	-0.849	0.025	-0.771	-0.939
Apprehension of poachers	36	37.583	26.096	113.000	2.000
Use of lethal force toward poachers	36	4.611	5.320	23.000	0.000

Table 2 Continued

Nameri National Park					
Elephant (*Elephas maximus*)	36	-0.116	0.046	0.063	-0.248
Tiger (*Panthera tigris tigris*)	36	-1.718	0.065	-1.602	-2.028
Apprehension of poachers	36	2.409	1.543	7.000	0.000
Use of lethal force toward poachers	36	0.000	0.000	0.000	0.000
Orang National Park					
Elephant (*Elephas maximus*)	36	-1.198	0.045	-1.053	-1.296
Rhino (*Rhinoceros unicornis*)	36	-0.025	0.054	0.107	-0.235
Tiger (*Panthera tigris tigris*)	36	-0.594	0.113	-0.366	-0.898
Apprehension of poachers	36	7.278	9.773	32.000	0.000
Use of lethal force toward poachers	36	0.444	0.909	3.000	0.000

Table 3. Regression models of the relationship between deterrence-based policy measures and megafaunal species population size (*= is separated from p<-0.05,p<0.01, ***=p<0.001)**

Megafaunal species	Variables	Model	
		Coefficients	*Standard Error*
Elephant (*Elephas maximus*)	Apprehension of poachers	5.761e-05	3.526e-04
	Use of lethal force toward poachers	-1.102e-05	-1.102e-05
	Park area (Dibru Saikhowa)	-7.494e-01***	1.849e-02
	Park area (Nameri)	-5.297e-01***	-1.811e-02
	Park area (Orang)	-1.613e+00***	1.697e-02
	Year	-2.156e-04	4.511e-04
	Observations	144	
	Adjusted R^2	0.9916	
Rhino (*Rhinoceros unicornis*)	Apprehension of poachers	0.0003	0.0004
	Use of lethal force toward poachers	0.0005	0.0020
	Park area (Orang)	-0.6214***	0.0193
	Year	0.0020**	0.0007
	Observations	72	
	Adjusted R^2	0.9656	
Tiger (*Panthera tigris tigris*)	Apprehension of poachers	-4.961e-05	5.092e-04
	Use of lethal force toward poachers	-1.971e-03	2.504e-03
	Park area (Nameri)	-8.799e-01***	2.600e-02
	Park area (Orang)	2.454e-01***	2.435e-02
	Year	9.920e-04	7.524e-04
	Observations	108	
	Adjusted R^2	0.9753	

4. Discussion

Our analysis finds that deterrence anti-poaching measures, including arrests and lethal enforcement, had no statistically significant effect on the population densities of tigers, rhinos, or elephants. Deterrence policies rest on the assumption that poaching is driven by rational self-interest of poachers and could be curbed through the threat of punishment [32]. In Assam, however, where demand for wildlife products remains high and prosecution rates are relatively low [33], fear-based strategies appear to have limited conservation value as supported by our findings.

By contrast, ecological factors, park size and year, emerge as significant predictors of population trends. Larger parks, such as Dibru-Saikhowa National Park (340 km²), sustain higher carrying capacities, which is especially critical for species with low reproductive rates and high parental investment [16, 34]. These megafauna depend on extensive, relatively undisturbed habitats for breeding, foraging, and migration [4, 30, 31]. We also find the positive correlation between tiger populations and Orang National Park, which suggests that landscape-level linkages enhance viability and buffer against localized declines [25, 35].

Temporal patterns further highlight the complexity of conservation outcomes. While tiger and rhino populations show steady increases, reflecting the benefits of sustained conservation, elephant populations show slight declines. Rather than direct losses within parks, this trend reflects elephants' dispersal into adjoining reserves such as Karbi Anglong, Sonitpur, and Dihing-Patkai reserves [25, 35]. These dynamics emphasize elephants' need for ecological networks beyond static park boundaries.

Our study suggests that conservation strategies for antipoaching centered narrowly on apprehensions and lethal enforcement operations are unlikely to achieve the desired policy outcomes. Instead, conservation in Assam and beyond can benefit from a shift in conservation policy toward non-lethal, community-centered, and preventive strategies. Community-based conservation initiatives—such as livelihood alternatives, revenue-sharing, and stewardship programs—have proven effective in reducing poaching pressures [36, 37]. Complementing these efforts, technological tools such as drones, AI-based hotspot prediction, and GPS (Global Positioning System) tracking can expand the conservation toolkit without escalating violence [26, 38]. As confirmed in our findings, habitat corridors and buffer zones can ensure long-term ecological viability while strengthening the coexistence of human and wildlife [39, 40]. Given that poaching is often embedded within organized criminal networks and global commodity chains [41, 42], national or state park authorities should evaluate deterrence-based anti-poaching measures within a broader global context that incorporates demand reduction [6, 43]. Furthermore, at higher governance levels, dismantling trafficking networks through intelligence-sharing and financial investigations can address the systemic drivers of illegal trade [44].

Future research could benefit from replicating this study with larger sample sizes and additional control variables that capture institutional contexts across multiple jurisdictions, as our methodological approach relied on a limited dataset within a single-country context. Nonetheless, this study makes a novel contribution to the literature on wildlife conservation and management by empirically evaluating the effectiveness of antipoaching measures using multi-species data from Assam, India.

The overarching lesson for policymakers and conservation practitioners is that, in areas characterized by high levels of poaching, greater attention should be devoted to designing antipoaching strategies that prioritize ecological and social foundations, maintain landscape connectivity, and engage local communities as partners rather than adversaries. Conservation policies aligned with these principles have the potential to be not only more effective in enhancing biodiversity outcomes but also more equitable and ethically defensible.

5. Conclusion

While deterrence-based antipoaching policies and enforcement operations are intended to reduce poaching, they remain highly controversial due to ethical, social, and practical concerns. These issues raise fundamental questions about the appropriateness and effectiveness of punitive, enforcement-based approaches against illegal poaching. In this study, we aim to assess whether lethal control measures in wildlife management are associated with changes in population size, even amidst the urgent imperative to protect endangered and vulnerable species such as tigers, rhinos, and elephants from poaching. Our findings from Assam indicate that deterrence-based policies, including apprehension and the use of lethal force against suspected poachers, are not linked to changes in population sizes. Instead, park size emerges as a more significant predictor of population trends, highlighting the central importance of habitat availability, ecological carrying capacity, and landscape connectivity. These results point to the need for a conservation policy that prioritizes ecological requirements while ensuring the well-being of local communities, rather than relying narrowly on punitive enforcement.

This research contributes to the literature on antipoaching and wildlife management by linking conservation biology with policy evaluation, drawing on approximately 40 years of data from India's national parks. Future work can extend this methodological foundation to other regions experiencing similar pressures on megafauna poaching. Comparative analyses across diverse socio-ecological contexts will be vital for refining strategies that are not only ecologically robust but also socially just. Such efforts will strengthen global biodiversity protection by advancing conservation approaches that balance ecological effectiveness with ethical responsibility.

Acknowledgements

A special thanks to PCCF/HOFF-Assam, Indian Forest Service, and Gauhati University for their support.

References

[1] Baruti K. Poaching as a security threat for Botswana and the region [Internet]. Monterey (CA): Naval Postgraduate School; 2018 [cited 2025 Sep 30]. Available from: https://apps.dtic.mil/sti/html/tr/AD1065569/index.html

[2] Wilson L, Boratto R. Conservation, wildlife crime, and tough-on-crime policies: Lessons from the criminological literature. Biol Conserv. 2020;251:108810. doi:10.1016/j.biocon.2020.108810.

[3] Ellis S, Talukdar B. Rhinoceros unicornis. The IUCN Red List of Threatened Species [Internet]. 2019 [cited 2025 Sep 30]. Available from: https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T19496A18494149.en

[4] Goodrich J, Wibisono H, Miquelle D, Lynam AJ, Sanderson E, Chapman S, et al. Panthera tigris. The IUCN Red List of Threatened Species [Internet]. 2022 [cited 2025 Sep 30]. Available from: https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T15955A214862019.en

[5] Williams C, Tiwari SK, Goswami VR, de Silva S, Kumar A, Baskaran N, et al. Elephas maximus. The IUCN Red List of Threatened Species [Internet]. 2020 [cited 2025 Sep 30]. Available from: https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T7140A45818198.en

[6] Duffy R, St John FAV, Büscher B, Brockington D. The militarization of anti-poaching: Undermining long term goals? Environ Conserv. 2015;42(4):345-8.

[7] Duffy R, Massé F, Smidt E, Marijnen E, Büscher B, Verweijen J, et al. Why we must question the militarisation of conservation. Biol Conserv. 2019;232:66-73. doi:10.1016/j.biocon.2019.01.013.

[8] Dickman A, Johnson P, Coals P, Harrington L, Tyrrell P, Somerville K, et al. Wars over wildlife: Green militarisation and just war theory. Conserv Soc. 2020;18(3):293. doi:10.4103/cs.cs_19_34.

[9] Louchouarn NX, Santiago-Ávila FJ, Parsons DR, Treves A. Evaluating how lethal management affects poaching of Mexican wolves. R Soc Open Sci. 2021;8(3):200330. doi:10.1098/rsos.200330.

[10] Mogomotsi GE, Mogomotsi PK. Law of armed conflict in non-international hostilities: The militarisation of wildlife conservation in Africa. J Int Wildl Law Policy. 2021;24(3-4):366-84.

[11] Shaw M, Rademeyer J. A flawed war: Rethinking 'green militarization' in the Kruger National Park. Politikon. 2016;43(2):173-92.

[12] Das D, Hussain I. Does ecotourism affect economic welfare? Evidence from Kaziranga National Park, India. J Ecotourism. 2016;15(3):241-60. doi:10.1080/14724049.2016.1192180.

[13] Williams PD. After Westgate: Opportunities and challenges in the war against Al-Shabaab. Int Aff. 2014;90(4):907-23. doi:10.1111/1468-2346.12147.

[14] Somerville K. Militarization of conservation: An army of occupation not protection. Global Geneva [Internet]. 2020 [cited 2025 Sep 30];I20. Available from: https://www.global-geneva.com/militarization-of-conservation-an-army-of-occupation-not-protection/

[15] Dutta A, Simlai T. If the army cuts trees, why can't we? Resource extraction, hunting and the impacts of militaries on biodiversity conservation. In: Enforcing Ecocide: Power, Policing & Planetary Militarization. Cham: Springer International Publishing; 2022. p. 199-225.

[16] Moreto WD, Gau JM. Deterrence, legitimacy, and wildlife crime in protected areas. In: Conservation criminology. 2017. p. 45-58.

[17] Louchouarn NX, Santiago-Ávila FJ, Parsons DR, Treves A. Evaluating how lethal management affects poaching of Mexican wolves. R Soc Open Sci. 2021;8(3):200330. doi:10.1098/rsos.200330.

[18] Duffy R, St John FAV. Poverty, poaching and trafficking: what are the links? Evidence on Demand [Internet]. UK: Department for International Development; 2013 [cited 2025 Sep 30]. 24 p. Report No.: HD059. doi:http://dx.doi.org/10.12774/eod_hd059.jun2013.duffy.

[19] Büscher B, Fletcher R. Accumulation by conservation. New Polit Econ. 2015;20(2):273-98. doi:10.1080/13563467.2014.923824.

[20] Bocarejo D, Ojeda D. Violence and conservation: Beyond unintended consequences and unfortunate coincidences. Geoforum. 2016;69:176-83. doi:10.1016/j.geoforum.2015.11.001.

[21] Devi MK. Ecotourism in assam: A promising opportunity for development. South Asian J Tour Herit. 2012;5(1):179-92.

[22] Dutta A. Forest becomes frontline: Conservation and counter-insurgency in a space of violent conflict in Assam, Northeast India. Polit Geogr. 2020;77:102117. doi:10.1016/j.polgeo.2019.102117.

[23] Talukdar BK. Importance of anti-poaching measures towards successful conservation and protection of rhinos and elephants, north-eastern India. Pachyderm. 2003;34:59-65.

[24] United Nations Office on Drugs and Crime (UNODC). The globalization of crime: A transnational organized crime threat assessment [Internet]. Vienna: UNODC; 2010 [cited 2025 Sep 30]. Available from: https://www.unodc.org/documents/data-and-analysis/tocta/TOCTA_Report_2010_low_res.pdf

[25] Government of Assam - Environment and Forest Department. National Parks [Internet]. 2024 [cited 2025 Sep 30]. Available from: https://environmentandforest.assam.gov.in/information-services/national-park

[26] International Union for Conservation of Nature (IUCN). The IUCN Red List of Threatened Species [Internet]. 2025 [cited 2025 Sep 30]. Available from: https://www.iucnredlist.org

[27] Wilson L, Boratto R. Conservation, wildlife crime, and tough-on-crime policies: Lessons from the criminological literature. Biol Conserv. 2020;251:108810. doi:10.1016/j.biocon.2020.108810.

[28] R Core Team. R: A language and environment for statistical computing [computer software]. Vienna, Austria: R Foundation for Statistical Computing; 2022. Available from: https://www.R-project.org/

[29] Donner A. The relative effectiveness of procedures commonly used in multiple regression analysis for dealing with missing values. Am Stat. 1982;36(4):378-81. doi:10.1080/00031305.2025.10483055.

[30] Ellis S, Talukdar B. Rhinoceros unicornis. The IUCN Red List of Threatened Species [Internet]. 2019 [cited 2025 Sep 30]. Available from: https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T19496A18494149.en

[31] Borthakur U, Barman RD, Das C, Basumatary A, Talukdar A, Ahmed MF, et al. Noninvasive genetic monitoring of tiger (Panthera tigris tigris) population of Orang National Park in the Brahmaputra floodplain, Assam, India. Eur J Wildl Res. 2011;57(3):603-13. doi:10.1007/s10344-010-0471-0.

[32] United Nations Office on Drugs and Crime (UNODC). The globalization of crime: A transnational organized crime threat assessment [Internet]. Vienna: UNODC; 2010 [cited 2025 Sep 30]. Available from: https://www.unodc.org/documents/data-and-analysis/tocta/TOCTA_Report_2010_low_res.pdf

[33] Bhattacharyya D. Market for animal body parts and tiger poaching: National environmental laws to counter this scenery. Jus Corpus Law J. 2022;2:121.

[34] Wisniewski R. Carrying capacity: Understanding our biological limitations. Humboldt J Soc Relat. 1980;7(2):55-70.

[35] Ministry of Environment, Forest and Climate Change, Government of India. Project Elephant [Internet]. 2024 [cited 2025 Sep 30]. Available from: https://moef.gov.in/en/division/forest-divisions-2/project-elephant-pe/introduction/

[36] Berkes F. Rethinking community-based conservation. Conserv Biol. 2004;18(3):621-30.

[37] Nyhus PJ, Osofsky SA, Ferraro P, Madden F, Fischer H. Bearing the costs of human-wildlife conflict: the challenges of compensation schemes. In: Woodroffe R, Thirgood S, Rabinowitz A, editors. People and wildlife, conflict or co-existence? Cambridge: Cambridge University Press; 2005. p. 107-21. (Conservation Biology). doi:10.1017/CBO9780511614774.008.

[38] Guo R. Using remote sensing imagery and machine learning to predict poaching in wildlife conservation parks. In: Proceedings of the AAAI Conference on Artificial Intelligence. 2021. p. 15962-3. Vol. 35(18). doi:10.1609/aaai.v35i18.17977.

[39] Hilty J, Worboys GL, Keeley A, Woodley S, Lausche B, Locke H, et al. Guidelines for conserving connectivity through ecological networks and corridors. Gland, Switzerland: IUCN; 2020.

[40] Roe D, Booker F, Day M, Zhou W, Allebone-Webb S, Hill NA, et al. Are alternative livelihood projects effective at reducing local threats to specified elements of biodiversity and/or improving or maintaining the conservation status of those elements? Environ Evid. 2015;4:22. doi:10.1186/s13750-015-0048-1.

[41] Duffy R, Emslie R, Knight MH. Rhino poaching: How do we respond? Evidence on Demand: Climate, Environment, Infrastructure and Livelihoods Professional [Internet]. UK: Department for International Development (DFID); 2013 [cited 2025 Sep 30]. 3 p. Report No.: HD087. doi:10.12774/eod_hd087.oct2013.

[42] Rademeyer J. Killing for Profit: Exposing the Illegal Rhino Horn Trade. Cape Town: Zebra Press; 2012.

[43] Zain S. Behaviour change we can believe in: Towards a global demand reduction strategy for tigers [Internet]. Cambridge, UK: TRAFFIC International; 2012 [cited 2025 Sep 30]. Available from: http://www.traffic.org/species-reports/traffic_species_mammals71.pdf

[44] Wich S, Koh LP. Conservation drones: Mapping and monitoring biodiversity. Oxford: Oxford University Press; 2018.