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LETTER

Mammal and bird species ranges overlap with armed conflicts and associated conservation threats

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Abstract

Armed conflicts are a pervasive global threat, but their implications for wildlife conservation remain unclear. Using a 30-year spatial dataset of armed conflicts in conjunction with species range maps, we found that conflicts during 1989–2018 occurred within at least 4291 (78%) and 9056 (85%) terrestrial mammal and bird species ranges, respectively. For 4% overall and 5–7% of threatened species, conflicts within ranges have been both widespread (≥50% of range) and frequent (≥15 years). Further, an examination of International Union for Conservation of Nature Red List assessments revealed that ranges overlap with armed conflicts is associated with declining population trends of threatened species and distinct species threat portfolios in which hunting and habitat loss and degradation are more prominent. Our findings call for greater recognition and understanding of direct and indirect threats from armed conflicts in species conservation assessments and underscore the importance of addressing conflict resiliency in conservation plans for a wide suite of species.

KEYWORDS

armed conflicts, endangered species, habitat loss, hunting, nontactical pathways, population decline, tactical pathways, threat, war and civil strife, wildlife

1 | INTRODUCTION

War and armed civil strife are pervasive global problems. Over the past 30 years, such armed conflicts have occurred in at least 120 countries, leading to thousands of human deaths, alongside massive human suffering and displacement (UNHCR, 2018). In addition to impacts on humans, there is growing recognition of threats posed by armed conflicts to global biodiversity (Daskin & Pringle, 2018; Dudley et al., 2002; Hanson et al., 2009). Although conflicts could result in inadvertent conservation gains (Martin & Szuter, 1999), most studies suggest negative impacts on biodiversity and habitats, underlain by a suite of direct and indirect pathways (Gaynor et al., 2016). Conflicts are increasingly recognized as significant standalone threats, or threat multipliers, to already imperilled wildlife. For example, conflict-affected regions are four times more likely to experience deforestation compared with conflict-free areas globally (Landholm et al., 2019), and research from Africa suggests a link between recurring conflicts and population declines of large mammals (Beyers et al., 2011; Brito et al., 2018; Daskin & Pringle, 2018; Stalmans et al., 2019). Given that armed conflicts are widespread and overlap with regions of high biodiversity (Hanson et al., 2009) (Figures 1A and 1B), understanding the extent to which species are exposed to armed conflicts, and the nature of

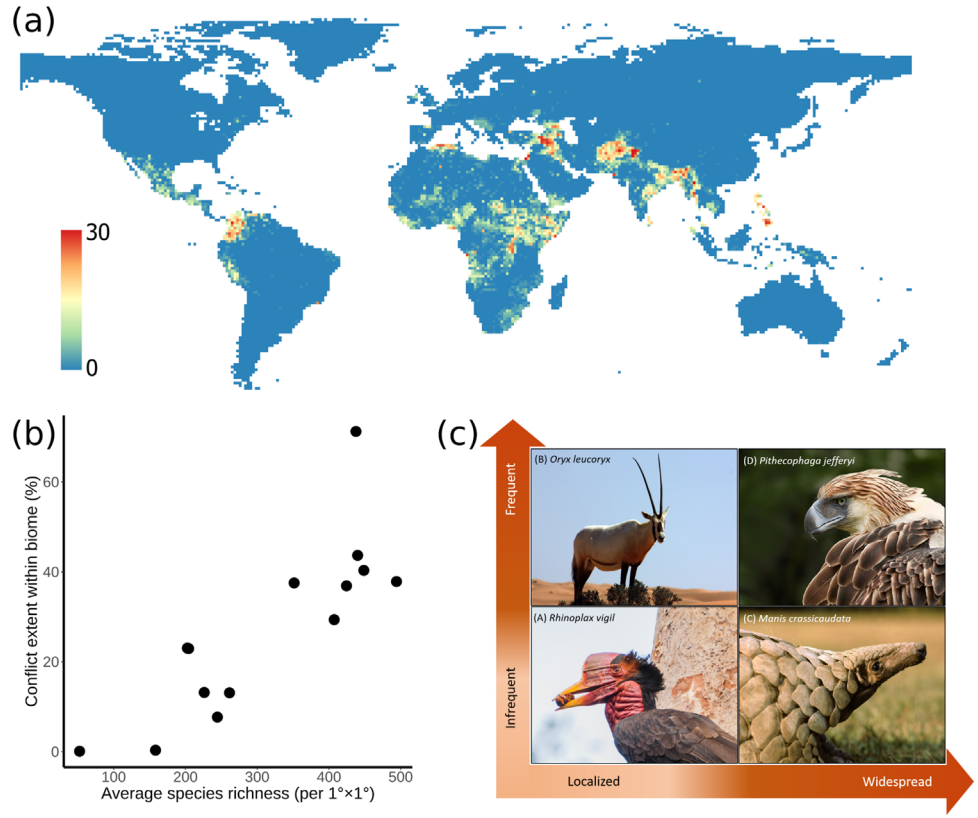

FIGURE 1 (A) Global patterns of armed conflicts between 1989 and 2018 depicted by the number of years of conflicts at a 1°× 1° resolution [derived from UCDP GED (Pettersson & Öberg, 2020; Sundberg & Melander, 2013)]. (B) Armed conflicts are relatively more extensive within terrestrial biomes (Olson et al., 2001) that harbor more species on average per 1°× 1° [combined mammal and bird species richness data derived from IUCN Red List (IUCN, 2019)]. See Figure S1 for biome labels. (C) Species exposure to armed conflict can range in spatial extent from absent or localized to widespread, and in temporal persistence from absent or infrequent to frequent. Representative threatened species of conservation concern from four extent-persistence contexts are depicted. Photo credits: Sanjitpaal Singh/jitspics.com, Charles J Sharp/Wikimedia Commons, Gerald Cubitt, Sinisa Djordje Majetic/Wikimedia Commons

threats facing species in conflict-affected regions, is crucial for conservation.

Conservation threats associated with armed conflicts may arise from both direct and indirect mechanisms. Direct threats could take the form of certain species being targeted by members of conflicting parties, such as African Elephants (*Loxodonta africana*) being hunted for meat and ivory (potentially to fund terror groups) in Mali and the Democratic Republic of Congo (Beyers et al., 2011; Brito et al., 2018), or Eastern Gorillas (*Gorilla beringei*) being killed inadvertently due to landmines in Rwanda (Kanyamibwa, 1998). Moreover, conflicts may modify habitats resulting in habitat loss and degradation both during conflict periods (Van Etten et al., 2008) and often after their cessation (Clerici et al., 2020; Heidarlou et al., 2020). Besides such direct pathways, armed conflicts also trigger wide-ranging socioeconomic and institutional changes that underlie indirect and often nontactical pathways, such as the weakening of regulatory institutions leading to overexploitation of natural resources (Dutta, 2020; Gaynor et al., 2016; Glew & Hudson, 2007; Negret et al., 2019). Taken together, it is evident that the impacts of conflicts on wildlife and habitats can extend beyond the period of active hostilities and amplify existing threats to species.

This study assessed the global pool of terrestrial mammal and bird species for spatial and temporal overlap with armed conflicts, and explored conservation threats associated with conflict overlap, focusing on species recognized by the International Union for Conservation of Nature (IUCN) as facing a greater threat of extinction. We assessed the extent and temporal persistence of armed conflicts across the geographical ranges of all extant mammal and bird species (and a subset comprising threatened species) using species geographic range maps in conjunction with data on armed conflict dates and locations from 1989 to 2018 (Figure 1C). Using IUCN species assessments, we examined whether and how species population trajectories and conservation threats differ based on the presence or absence of conflicts within their geographic ranges and between threatened and less-threatened species.

2 | METHODS

Data on armed conflicts were obtained from the Uppsala Conflict Data Program's Georeferenced Event Dataset (UCDP GED) (Pettersson & Öberg, 2020; Sundberg & Melander, 2013). Spanning all countries (except Syria), from 1989 to 2018, the dataset comprises the geographic locations and dates of 152,616 conflict incidents, where an incident is defined as the occurrence of organized violence with at least one reported fatality. We overlaid a 1°× 1° global terrestrial grid on this dataset and extracted information on the total number of conflict incidents and the number of years of conflict reported within each grid cell (hereafter, gridded conflict dataset).

Spatial data on known geographic ranges of terrestrial mammal and bird species were obtained from the IUCN Red List (IUCN, 2019) and BirdLife International and Handbook of the Birds of the World (BirdLife International & Handbook of the Birds of the World, 2019), respectively. Extinct species were excluded from the assessment. Only known extant natural ranges were retained for all extant species, whereas former, introduced, and uncertain parts of species ranges were excluded from further analysis. We then overlaid the gridded conflict dataset, and for each species (mammals: 5533; birds: 10,619), estimated (1) conflict extent as a percentage of extant range; and (2) conflict frequency as the percentage of conflict years out of 30, averaged across all extant range grid cells that experienced any conflict during the focal period. Next, we extracted the most recent assessments of species population trends (decreasing, increasing, stable, or unknown) from the IUCN Red List database. We examined whether and how the proportion of species assessed as having a declining population trend differed between the set of species that overlapped with recent conflicts (2008–18) and the set of species that did not overlap with conflicts over the same period. As the response variable is binary (population decrease present or absent), we used a generalized linear model with a binomial error distribution, running separate models for threatened (CR, EN, or VU) and less-threatened species of mammals and birds.

Similarly, we extracted the most recent assessments of species conservation threats, where available, from the IUCN Red List database (IUCN, 2019). The IUCN defines conservation threats under 12 broad categories further split into 99 second- and third-order (sub-)categories. The 12 broad categories of conservation threats correspond to urban development, agricultural activity, energy production, transport, overexploitation, human disturbance, system modification, invasion and disease, pollution, geological events, climate change, and others (IUCN, 2019; Maxwell et al., 2016). For every species having threat assessments (2866 mammal and 3091 bird species), we recorded the presence or absence of each of the 99 threat subcategories. With these data, we described each species' threat profile in terms of the "prominence" of the 12 broad categories, where prominence is defined as the number of threats belonging to a given category divided by the total number of identified threats expressed as a percentage. We then examined how the prominence of the 12 broad threats differed between species that witnessed conflicts within their range during 2008–18 and those that did not, treating mammals and birds separately and running separate models for all and threatened species. As the response variables are proportions, we used a generalized linear model with a binomial error distribution.

All data extraction, analyses, and visualization were performed using R 4.0.0 (R Core Team, 2020) and Q-GIS (QGIS, 2020).

3 | RESULTS

We found that at least 4291 (78%) terrestrial mammal species and 9056 (85%) terrestrial bird species experienced armed conflicts within their ranges during 1989–2018. Armed conflicts were widespread (i.e., overlapped ≥50% of geographic range) for at least 1871 (34%) mammal and 3809 (36%) bird species (Figures 2A and 2B; Table S1). The number of species faced with frequent conflicts, defined here as those with the number of conflict years per 1° × 1° cell averaging at least 15 years (50%) across conflict-affected cells, was 246 (4.4%) for mammals and 425 (4.0%) for birds (Figures 2A and 2B; Table S1). For 225 (4.0%) mammal and 390 (3.7%) bird species, conflicts were both widespread and frequent (Figures 2A and 2B; Table S1). For birds, restricting the above comparisons to breeding ranges alone (excluding nonbreeding and passage ranges) generated very similar patterns (Table S1). Exposure to frequent and widespread conflicts among threatened species (CR/EN/VU) ranged from 5% to 7% (Figures 2C and 2D; Table S1). In comparison, the IUCN currently recognizes 107 species (87 mammals, 20 birds) in total as threatened by "war, civil unrest and military exercises," most of which are not contained within the set of species identified as exposed to widespread and frequent conflicts in the current analysis (Table S1).

A substantially higher proportion of threatened species that overlapped with conflicts were associated with population declines (mammals: 86%; birds: 95%) compared with threatened species not overlapping with conflicts (mammals: 79%; birds: 76%) during 2008–18, according to generalized linear models ($p < 0.01$; Figure 3 and Table S2). Differences between species with and without overlap with conflicts were less pronounced among species of lower conservation concern ($p \geq 0.10$; Figure 3 and Table S2).

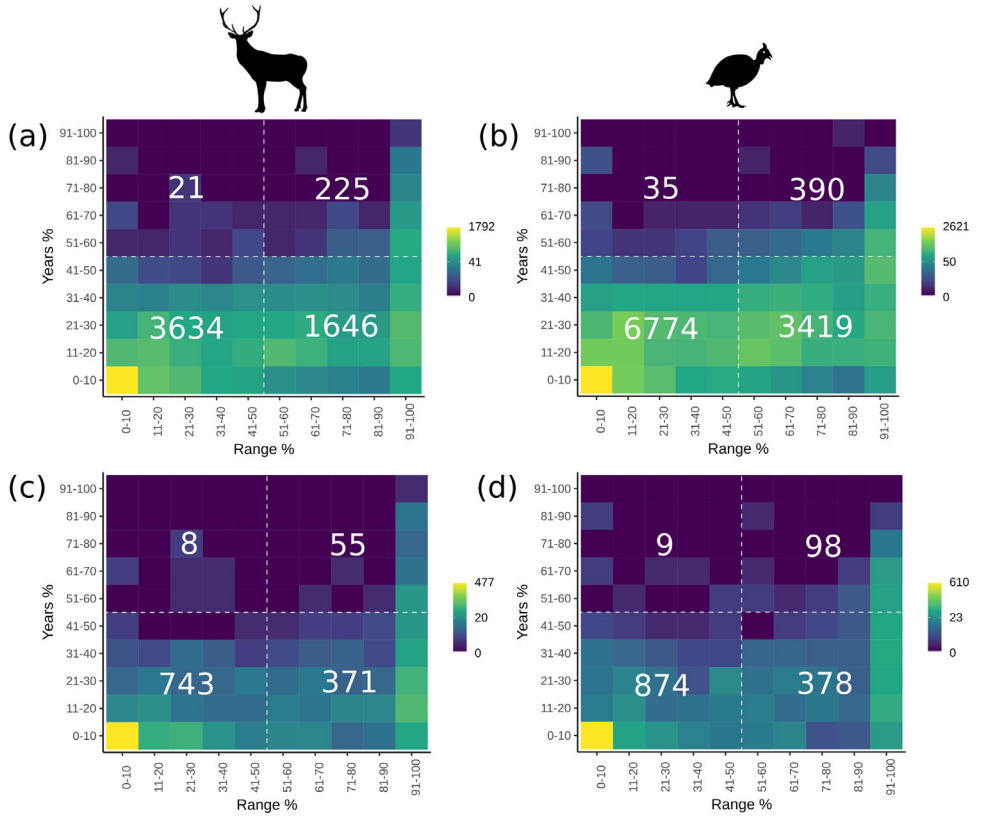

FIGURE 2 Heat maps showing the numbers of species with different levels of armed conflict in their ranges in terms of conflict extent (range %; *X*-axis) and persistence (years %; *Y*-axis). Range % describes the percentage of a species geographic range that experienced armed conflicts over the 30-year period from 1989 to 2018. Years % describes the average duration of conflicts within species ranges as a percentage of 30. The color gradient depicts the numbers of species within each 10 × 10 conflict extent %–persistence % combination. The total numbers of species falling within each 50 × 50 extent %–persistence % quarter are displayed in their respective quarters. Panels correspond to all mammal (A) and bird (B) species, and threatened mammal (C) and bird (D) species

Narrowing the comparisons to the tropics and subtropics (35°S-35°N) alone, because of the concentration in this zone of mammal and bird diversity and reported conflict incidents, did not alter the above patterns (Table S2).

Generalized linear models showed that overlap with conflicts was associated with greater prominence of threats from biological overexploitation (e.g., hunting, logging) relative to other threats for all (7.3% more prominent) and threatened (3.9% more prominent) mammal species, compared with mammals that did not overlap with conflicts during the 2008–18 period, based on threat assessments by the IUCN ($p < 0.01$; Figure 4 and Table S3). Human disturbances, including "war, civil unrest and military exercises" (all species: 1.4%) and agricultural activities (threatened species: 6.2%), were also more prominent among the conflict-overlapping suite of mammals ($p < 0.01$; Figure 4 and Table S3). By contrast, the prominence of threats from invasive species and disease, and climate change, was lower among conflict-affected mammals (−1.8% to −5.5%; $p < 0.01$), while other threats to mammals did not differ consistently based on overlap with conflicts during the focal period (Figure 4 and Table S3). For birds, threats associated with overexploitation (all species: 2.1%; threatened species: 3.9%) and land-use intensification, particularly agricultural activities, energy production, system modification, and pollution, were more prominent among conflict-affected species (all: 1.2%−4.8%; threatened: 1.1%−8.5%) compared with ones that did not overlap with conflicts during 2008–19 ($p \leq 0.01$; Figure 4 and Table S3). Threats to birds from invasive species and disease, geological events (all species), and climate change (threatened species) were less prominent relative to other threats (−0.3% to −13.6%; $p < 0.01$) among bird species exposed to conflicts (Figure 4 and Table S3). Narrowing the comparisons to the tropics and subtropics (35°S-35°N) alone did not alter the above patterns (Table S3).

4 | DISCUSSION

As the recognition of conservation threats associated with armed conflicts continues to expand, our study sheds light

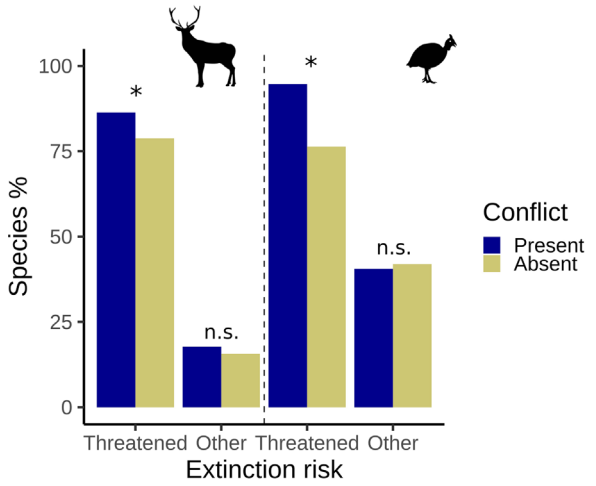

FIGURE 3 The percentage of mammal and bird species showing population declines among species that overlapped with conflicts during 2008–18 (present) versus species that did not (absent). Percentages for threatened and less-threatened species are shown separately. * depicts a statistically significant difference at $p < 0.01$ based on binomial generalized linear models. See Table S2 for model details

on three key characteristics of this threat based on a global analysis. First, we show that armed conflicts potentially affect an extensive suite of terrestrial mammal and bird species, with over 70% of all species potentially encountering conflicts within their ranges at present or in the recent past, including 4% (615 species) with both widespread (≥50% of range) and frequent (≥15 of 30 years) exposure to conflicts. Notably, conflicts were more widespread and frequent (up to 7%) among species classified by the IUCN as threatened with extinction. For these species, with small range sizes, low population densities, slow life histories, and other traits that make them susceptible to a wide range of threats (Purvis et al., 2000; Harris & Pimm, 2008), armed conflicts could constitute a significant threat multiplier. Our findings suggest that armed conflicts potentially threaten a wider suite of terrestrial mammal and bird species than is currently recognized (i.e., 615 vs. 107 species by the IUCN) and therefore warrant greater consideration in species threat assessments and conservation strategies.

Second, we found that range overlap with conflicts was associated with population declines (as per IUCN assessments) for the large majority of threatened mammal (86%) and bird (95%) species. This was a higher percentage compared to threatened species not overlapping with conflicts (76%–79%) and less-threatened species with or without conflict overlap (16%–42%). This finding underscores the importance of addressing conflict resiliency in conservation plans for threatened species. Planning for conflict resiliency could encompass several approaches depending on circumstances and focus both within and beyond active conflict zones. For example, captive breeding and reintroduction programs may need to be considered for highly endangered species that experience conflicts throughout their ranges (Davies, 2017; Farhadinia et al., 2020; Harding et al., 2007). For species whose ranges extend beyond active conflict zones, proactive conservation measures in nonconflict areas could play a role in facilitating post-conflict recovery (McDonald-Madden et al., 2008).

Our third key finding is that range overlap with armed conflicts is consistently associated with threats such as hunting and habitat modification/degradation, including agricultural expansion, natural resource extraction, and pollution. We found that these threats were more prominent (i.e., reported more frequently relative to other threats) in the threat portfolios of species that overlap with conflicts, while climate change, geological events, and invasive species were equally or less prominent, compared with the portfolios of nonconflict-overlapping species. While it is possible that hunting and other extractive threats could also be reduced in some instances, leading to conservation opportunities in conflict landscapes (Martin & Szuter, 1999), we found little evidence for this at the global scale. Although our study does not examine the mechanisms linking conflicts to these threats, evidence from other studies suggests a few potential pathways. For example, hunting for food by members of warring groups (Beyers et al., 2011), and deforestation, hunting, and other forms of natural resources extraction by human communities disrupted and displaced by conflicts (Baumann & Kuemmerle, 2016; Glew & Hudson, 2007; Landholm et al., 2019) are known to exacerbate these threats in conflict landscapes.

While our findings establish general associations between armed conflicts, species population declines, and conservation threats, they cannot confirm armed conflicts as driving the observed patterns. This is because our global analysis cannot control for potential confounding factors, such as cooccurence of armed conflicts with other drivers of species decline and conservation threats (e.g., conflicts more likely to occur closer to human population centers). Another caveat is the uncertainty associated with coarse-scale global datasets of species ranges and conflict occurrence, and the qualitative nature of IUCN population trend assessments, which can bias outcomes in either direction. In order to reduce uncertainty and verify the mechanisms underlying these associations, empirical research and monitoring is key. Research priorities for strengthening conservation planning include reliable estimation of population sizes and trends of conflict-affected species (Daskin & Pringle, 2021), elucidation of the various pathways linking conflicts to conservation threats (Gaynor et al., 2016), and examination of how the prevalence

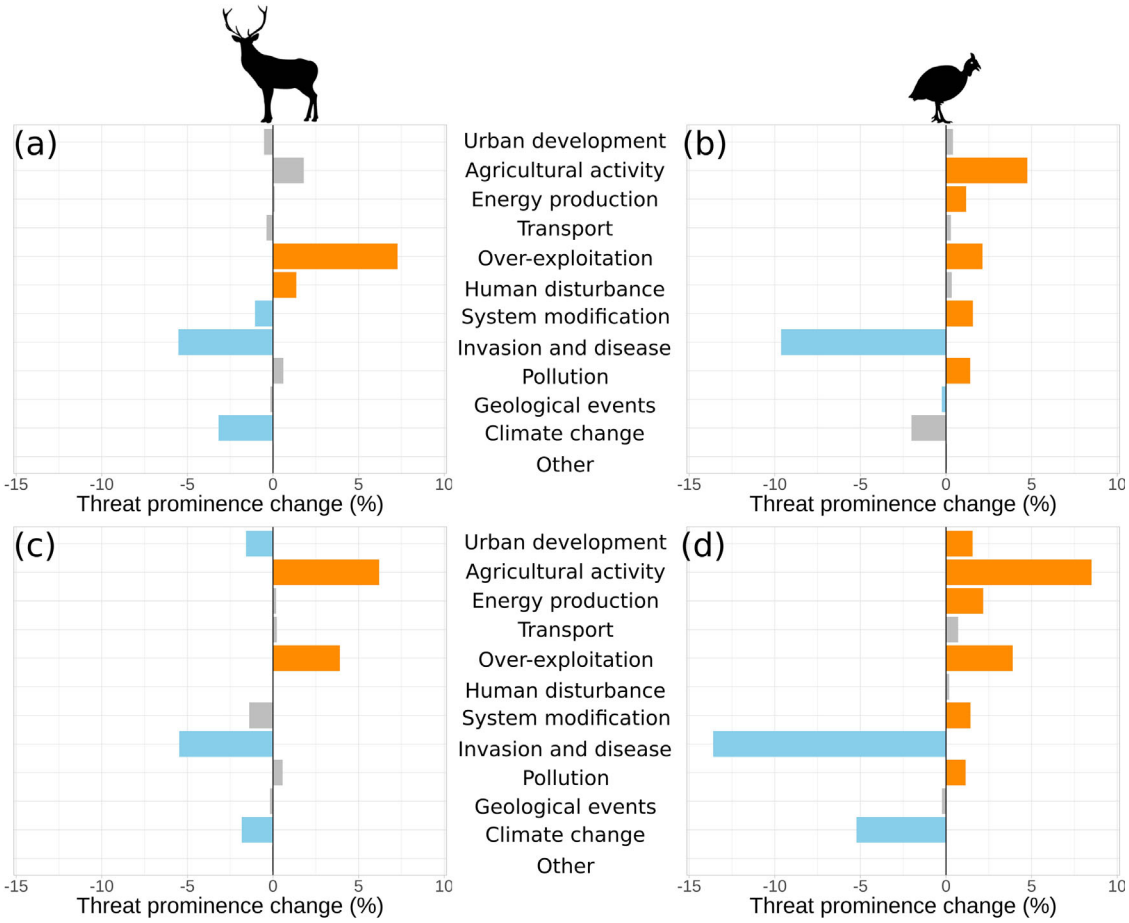

FIGURE 4 Increases (consistently positive, orange), decreases (consistently negative, blue), or no differences (grey) in the prominence of different threats associated with species that overlap with conflict, relative to species that do not overlap with conflict, for all mammal (A) and bird (B) species, and threatened mammal (C) and bird (D) species, based on binomial generalized linear models. See Table S3 for model details

and relative importance of these pathways differ among species and functional trait groups (Stalmans et al., 2019).

Collectively, and data limitations notwithstanding, our findings highlight armed conflicts as a potential conservation threat—and/or threat multiplier—for a wide suite of species globally. Given that the numbers of species identified by this study as having widespread and frequent overlap with armed conflicts substantially exceed the numbers for which conflicts are currently listed as a threat, our findings call for greater recognition of this threat in species conservation assessments and plans. Our coarse-scale population trend analysis also suggests an elevated concern for threatened species, highlighting that while it can be practically challenging, empirical research and monitoring of species populations over space and time within armed conflict landscapes are urgently needed (Daskin & Pringle, 2021). Finally, we highlight that armed conflicts are associated with and potentially exacerbate (directly and indirectly) other major conservation threats such as hunting and habitat loss (Gaynor et al., 2016), which is an essential consideration in the design of conservation programmes for species threatened by armed conflicts.

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AUTHOR CONTRIBUTIONS

U.M., A.H., and A.M.O. conceived the study. U.M., S.J.S., A.M.O., and A.H. collected and analyzed the data. U.M.,

A.M.O., and A.H. drafted the manuscript. All authors provided feedback and approved the final manuscript.

ETHICS STATEMENT

No primary data were collected in this study. All data presented in the manuscript are from publicly available datasets not requiring additional ethical considerations.

DATA ACCESSIBILITY STATEMENT

Data were downloaded from public-access datasets cited in the references section. Derivatives of these datasets used in this study along with the R script used for data processing, analysis, and preparation of figures and tables are provided in the Appendix.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

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

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