Conservation Biology

Mammalian megafauna in an uncertain world: ex situ management as insurance against extinction

Journal:	*Conservation Biology*
Manuscript ID	19-658.R1
Wiley - Manuscript type:	Contributed Paper
Keywords:	Conservation planning, Mammals < Animals, Asia, Captive breeding, Reintroduction

Abstract:	Many large-bodied mammalian species are experiencing collapses in range or numbers due to escalating threats, mainly triggered by humans. The persistence of species with populations reduced to precarious levels may be heavily dependent on the fate of a very small number of individual animals. Although in situ conservation aimed at mitigating current threats is important, it may sometimes be insufficient on its own. In these instances, the International Union for Conservation of Nature provides guidelines for ex situ management and the Convention on Biological Diversity (Article 9) indicates how it can support the convention's objectives as an 'insurance' policy for conserving species. The circumstances that justify its use are uncertain. We evaluated current in situ extinction risk and ex situ management of 43 species of Critically Endangered mammalian megafauna, and the geopolitical variables related to governance, economics, and national policy within their extant ranges. We showed that almost one third of the world's terrestrial mammalian megafauna are not the subject of any ex situ management. Most of these taxa occur in Africa and the Middle East, especially in areas characterized by political uncertainty, such as border zones or areas affected by armed conflicts. A further 23% of these taxa in ex situ programs do not meet sustainability criteria. Strategic conservation planning, such as the One Plan approach, is recommended for improving ex situ management for these taxa. Given the escalating trend in threats afflicting megafauna, ex situ management should be considered more rigorously in conservation decision-making, particularly for those in politically unstable regions to achieve Target 12 of the Convention on Biological Diversity on preventing the extinction of threatened species.

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Abstract

Many large-bodied mammalian species are experiencing collapses in range or numbers due to escalating threats, mainly triggered by humans. The persistence of species with populations reduced to precarious levels may be heavily dependent on the fate of a very small number of individual animals. Although *in situ* conservation aimed at mitigating current threats is important, it may sometimes be insufficient on its own. In these instances, the International Union for Conservation of Nature provides guidelines for *ex situ* management and the Convention on Biological Diversity (Article 9) indicates how it can support the convention's objectives as an 'insurance' policy for conserving species. The circumstances that justify its use are uncertain. We evaluated current *in situ* extinction risk and *ex situ* management of 43 species of Critically Endangered mammalian megafauna, and the geopolitical variables related to governance, economics, and national policy within their extant ranges. We showed that almost one third of the world's terrestrial mammalian megafauna are not the subject of any *ex situ* management. Most of these taxa occur in Africa and the Middle East, especially in areas characterized by political uncertainty, such as border zones or areas affected by armed conflicts. A further 23% of these taxa in *ex situ* programs do not meet sustainability criteria. Strategic conservation planning, such as the One Plan approach, is recommended for improving *ex situ* management for these taxa. Given the escalating trend in threats afflicting megafauna, *ex situ* management should be considered more rigorously in conservation decision-making, particularly

for those in politically unstable regions to achieve Target 12 of the Convention on Biological Diversity on preventing the extinction of threatened species.

Introduction

Although the maintenance of biodiversity *in situ* is the main objective for contemporary global conservation, this focus alone may not ensure the survival of species on the brink of extinction. Nonetheless, the utility of *ex situ* management for species conservation remains unclear and there are differing perspectives on its value as a meaningful approach (Balmford et al. 1996; Snyder et al. 1996; Conde et al. 2011; Pritchard et al. 2012; Fa et al. 2014; Brichieri-Colombi et al. 2019). The potential of *ex situ* management to support *in situ* conservation of species is, however, recognized in Article 9 of the Convention on Biological Diversity (CBD). The Convention text, drafted in 1992, states, crucially, that *ex situ* management should support *in situ* conservation measures (Convention on Biological Diversity 1992), indicating that there should be a relationship between what is happening in the wild and in captivity (Convention on Biological Diversity 1992).

Ex situ is defined as conditions under which individuals are spatially restricted with respect to their natural movement patterns or those of their progeny, are removed from many of their natural ecological processes, and individuals are managed on some level by humans (see also Williams & Hoffman 2009; IUCN/SSC 2014; McGowan et al. 2017). Besides buying time, addressing the causes of primary threats and offsetting their effects, *ex situ* management can be used for population restoration or conservation introduction within or outside the species' indigenous range (IUCN/SSC 2013, 2014). The primary purpose of an *ex situ* program is most often claimed to be an "insurance policy", maintaining options for future conservation strategies (Zimmermann 2010; McGowan et al. 2017).

There had been limited, if any, guidance proposed as to what such links between *in situ* and *ex situ* managements might consist of, until IUCN's Species Survival Commission adopted *ex situ* management guidelines in 2014 (IUCN/SSC 2014; see also McGowan et al. 2017). These provided a decision-making process for determining whether *ex situ* management was appropriate for a particular species, given its conservation needs, biological requirements and available resources (McGowan et al. 2017).

In recent times, there has been a sharply increasing concern about species extinction risk (e.g. Brondizio et al. 2019) and recognition of significant challenges in maintaining viable wild populations of large-bodied mammals. For example, conservation efforts are struggling to arrest the decline of various Critically Endangered taxa that have small and decreasing populations, such as Sumatran rhino *(Dicerorhinus sumatrensis)* (Havmøller et al. 2016), Asiatic cheetah (*Aconinyx jubatus venaticus*) (Farhadinia et al. 2017) and hirola *(Beatragus hunteri)* (Ali et al. 2018), suggesting that even intensive actions can be associated with ambiguous outcomes.

Here we explore whether there is a particular set of circumstances where *ex situ* management is likely to be of special value to an overall species recovery program for some of the most conservation-dependent taxa, i.e. Critically Endangered terrestrial mammalian megafauna. We excluded marine megafauna because they are difficult, if not impossible, to manage *ex situ* for conservation purposes (Klinowska 1991; Zimmermann 2010). Terrestrial mammalian megafauna are particularly valuable in economic, ecological and societal terms, yet are challenging and expensive to conserve (Ripple et al. 2014; Lindsey et al. 2017). We assumed that species insurance policy (*ex situ* management variables) should be formulated based on *in situ* extinction risk (demographic variables) and its association with uncertainty in governance, economics, and national policy (geopolitical variables) and so we explored this within the range of 43 species of mammalian megafauna. We were particularly interested in understanding the effect of political uncertainty, such as in border zones or other areas with armed conflicts, where *in situ* conservation is likely to be compromised. Although these variables are informative as to when an *ex situ* management population is potentially appropriate as a hedge against extinction, other factors relating to feasibility and risk will also need to be considered in practice. Our analyses may inform *ex situ* policies for Critically Endangered megafauna in such areas, and demonstrate a strategic approach for identifying *ex situ* management as a potential priority for highly threatened species.

Methods

Species and geographic regions

We defined as megafauna any mammalian species with adult body masses over 40 kg (for ungulates and primates Stuart 1991) or ≥15 kg (for carnivores Ripple et al. 2014). The megafauna in this paper represent four mammalian orders: Carnivora, Primates, Cetartiodactyla and Perissodactyla. We included only Critically Endangered taxa (see IUCN 2017 for details on criteria). The latest list of Critically Endangered mammals was obtained from the IUCN's Red List of Threatened Species (with assessment date of 2015 to 2017 for different taxa). In total 43 taxa of Critically Endangered megafauna were identified, including 18 species, 23 subspecies and two sub-populations (Table S1). The two gorilla species (*Gorilla* spp.) were Critically

Endangered at both species and subspecies levels; we therefore included all four gorilla subspecies with associated variables.

We defined five geographic regions: 1) African sub-Saharan, 2) Middle East/ Sahara-Sahel, 3) Asia (excluding the Middle East), 4) Europe and 5) North America. We assumed three *a priori* dimensions to fragility of situations in which *ex situ* management can be considered: extinction risk (*in situ* demographic variables), insurance policy (*ex situ* management variables) and uncertainty in governance, economics, and national policy (geopolitical variables; Table 1).

In situ demographic and ex situ management variables

Demographic stochasticity, environmental stochasticity and random catastrophes can increase extinction risks in small populations (Lande et al. 2003). As a proxy for these extinction risks, we derived two *in situ* demographic variables from the IUCN Red List. They include the total population size of the taxa and its number of subpopulations. Accordingly, subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (www.redlist.org).

In addition, we collated four variables concerning *ex situ* management. An *ex situ* program was defined only by the presence of least two pairs of the species within the same facility, either inside (national *ex situ* program) or outside (international *ex situ* program) the range country. Although our evaluation is limited to the presence of *ex situ* founding populations, we acknowledge that case histories that involve too few individuals, or that lack effective management or infrastructure do not necessarily constitute a successful *ex situ* program. Accordingly, we queried the species' studbook managers, Association of Zoos and Aquariums (AZA; https://www.aza.org), the European Association of Zoos and Aquariums (EAZA;

https://www.eaza.net) and Pan-African Association of Zoos and Aquaria (PAAZA; http://www.zoosafrica.com). We also reviewed data on the presence of *ex situ* individuals within the species range countries, mainly using IUCN's Red List of Threatened Species. Data on *ex situ* numbers were obtained from Species360 Zoological Information Management Software (ZIMS; www.species360.org) as well as local accredited experts in range countries. We also asked the Southeast Asian Zoos and Aquariums Association (SEAZA) and the Pan-African Association of Zoos and Aquaria (PAAZA) for information concerning study taxa within their zoos, but none was forthcoming. Thus, we acknowledge that our paper could underestimate the prevalence of *ex situ* populations for some taxa, particularly in Asia. To evaluate the sustainability of *ex situ* populations, we used the inbreeding-avoidance criterion of $N_e > 50$, known as the minimum viable effective population size, which prevent the dramatic short term consequences of inbreeding depression (Franklin et al. 2014). The last *ex situ* management variable was the endorsement of *ex situ* management as part of the conservation actions drafted for each taxon as part of its corresponding IUCN Red List assessment.

Geopolitical variables

Management practices do not occur in a vacuum; instead they are part of a wider context of international politics and multiscalar networks of social, cultural, political, economic and environmental factors (Hodgetts et al. 2019). Border zones and armed conflicts can compromise conservation resources, actions and outcomes (Hanson et al. 2009; Dallimer & Strange 2015). Likewise, governance, economics and political support are associated with conservation performance of countries with regard to conserving their megafauna (Dickman et al. 2015; Lindsey et al. 2017). Accordingly, we included a geopolitical perspective to our analysis through four metrics as: 1) occurrence of the main population nucleus in a border zone (binary data); 2) political instability within the taxon's main extant range in terms of recent armed conflict (binary data); 3) National Conservation Likelihood (NCL) (Dickman et al. 2015) and 4) Megafauna Conservation Index (MCI) (Lindsey et al. 2017).

We defined a population as being a 'border' population if the species' main extant range intersects with international borders and where the population nucleus persists in the country's border zones, both assessed based on demographic and distributional data in the IUCN Red List. To assess the spatial overlap between species ranges and armed conflicts, we compared the geographic extant range of species within each country with the locations of armed conflicts between 2008 and 2017. We adopted the Uppsala conflict database definition of armed conflict as "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths in one calendar year (Gleditsch et al. 2002)." We extended the above definition to non-state based violence as well, e.g. between religious or ethnic groups. The geo-referenced data on occurrence of armed conflict were obtained from Uppsala Conflict Data Program (http://ucdp.uu.se).

Finally, we obtained an index of National Conservation Likelihood (NCL) from Dickman et al. (2015) for each range country. The NCL was calculated based on 16 variables considered as important indicators of likely conservation effectiveness in a country, based on governance, economics and welfare, human population pressures, and conservation policy (see Table S2 for more details). We also used the Megafauna Conservation Index (MCI) that assessed the spatial, ecological and financial contributions of each country towards conservation of the world's terrestrial megafauna (Lindsey et al. 2017). This is based on three metrics: 1) ecological contribution, defined as megafauna cumulative distribution based on the number of extant megafauna within each country's borders, 2) protected area contribution measured by the percentage of megafauna habitat that is strictly protected and 3) financial contribution represented by the percentage of each country's national gross domestic product (GDP) allocated to conservation (see Table S3 for countries' MCI).

Data analysis

We used Non-metric Multidimensional Scaling (NMDS) to explore patterns of variation among the taxa in their demographic and geopolitical characteristics. As a method for exploring multivariate patterns, NMDS has several advantages compared to other options, including a reduced arch effect, gradient recovery enhancement, and the ability for the user to specify the number of dimensions in which to represent n-dimensional raw data (Podani 2005).

NMDS is an iterative procedure which seeks to represent the rank orders of dissimilarity between entities in the derived ordination space. Each ordination started with 20 random configurations, and proceeded through 400 iterations for each of four dimensions. We chose the Bray-Curtis dissimilarity index which has a good rank order relation to ordering species along different variables. The data were transformed to their square roots to reduce the influence of outlying values. The transformed values were then submitted to Wisconsin standardization (Oksanen et al. 2013).

We used a Shepard plot where ordination distances are plotted against observed dissimilarities, and two statistics of goodness of fit, referred to as non-metric fit R^2 and linear fit R^2 (Figure S1) to assess the performance of the ordination. The stress value on species position was also optimized, representing the difference between the distances in the reduced dimension compared to the complete multidimensional space. Hence low values of stress indicate that the species rank differences are faithfully reproduced by the ordination. As a rule of thumb, stress <0.05 and <0.1 give an 'excellent' and 'good' representation, respectively. Stress <0.2 can still lead to a usable picture, although for values at the upper end of this range there is potential to mislead (Clarke 1993). We also fitted a smooth surface using a generalized additive model (GAM) to assess the contribution of each variable to the NMDS ordination with restricted maximum likelihood (REML) estimation (Oksanen et al. 2013). For each variable, we calculated adjusted R^2 and the approximate significance of smooth terms to check the linearity hypothesis of relationship between the species composition.

Analysis of similarity (ANOSIM) using the Bray–Curtis distance index was used to test the statistical significance of differences in the ordination scores with respect to geographic regions. This nonparametric permutation procedure is based only on the rank order of the similarity matrix values underlying an ordination plot to calculate an *R* test statistic. Both NMDS and ANOSIM were run using the 'vegan' package (Oksanen et al. 2013). We conducted all analyses in *R* (R Development Core Team 2013).

Results

There are 43 Critically Endangered terrestrial mammalian megafauna (Table S1), spanning 57 countries across Asia (n=10), Sahelo-Sahara/Middle East region (n=17), and sub-Sahara Africa (n=26). Outside Africa and Asia, the Balkan lynx (*Lynx lynx balcanicus*) persists across three east European countries, while the red wolf (*Canis rufus*) is the only representative of Critically Endangered megafauna in North America (Figure 1).

Current *in situ* population sizes differ substantially among species, with 55.8% (n=24) of populations estimated to comprise fewer than 250 individuals, whereas a few others (n=8) comprise more than 1,000 individuals (Table S1). Except from six taxa, all other species (86.0%) are declining in numbers. In total, 44.2% (n=19) of the evaluated taxa mainly occur along international boundaries (Table S1). Armed conflicts have recently occurred within the range of 30.2% (n=13) of the Critically Endangered megafauna, predominantly in Sahelo-Sahara or sub-Saharan Africa.

We found that 14 taxa (32.6%) lack any *ex situ* programs, either within or outside their ranges. Additionally, 23.3% of the *ex situ* populations (n=10) do not meet the inbreeding-avoidance criterion of $N_e > 50$ as a proxy for population suitability. There are international *ex situ* programs for 44.2% (n=19) of the species while more species (67.4%, n=29) are associated with a national *ex situ* program within at least one range country. *Ex situ* management was explicitly endorsed during the Red List assessment for only 15 taxa (34.9%), almost exclusively belonging to herbivores (n=14). Those taxa without any *ex situ* endorsement tend to have ranges in Africa or the Middle East (Figure 2), whereas the rest of Asian species usually have *ex situ* support, either inside or outside the range countries.

Apart from rehabilitation efforts, eight species were associated with reinforcement or reintroduction programs, i.e. enhancing population viability or re-establishing a viable population within the species' indigenous range, respectively (IUCN/SSC 2013, 2014), such as red wolf *Canis rufus*, Addax *Addax nasomaculatus*, Sumatran orangutan *Pongo abelii*, Bornean orangutan *Pongo pygmaeus*, Dama gazelle *Nanger dama*, black rhinoceros *Diceros bicornis*, western lowland Gorillas *Gorilla gorilla gorilla* and western chimpanzee *Pan troglodytes verus*.

There was no evidence that the taxa in different geographic regions differed with respect to our demographic and geopolitical predictors (ANOSIM R = -0.01546, P = 0.54). However, when the two regions with the highest abundance of taxa were examined in isolation, the composition of demographic and geopolitical predictors were significantly different (ANOSIM R = 0.2059, P = 0.03). Four variables, NationalExsitu, InternationalExsitu, BorderZone and Instability, accounted for the highest proportion of explained deviance, varying between 66.2 and 88.9% (see Table 1 for variable description). In contrast, the population size of each taxon, either in the wild or captivity as well as NCL and MCI made only minor contributions to the ordination of the species with nonlinear fitted surface ($P > 0.05$; Table 1).

The two key variables describing geopolitical uncertainty, i.e. BorderZone and Instability were ordinated far from those variables in favor of the *ex situ* management, such as NationalExsitu, InternationalExsitu and ExSituEndorsed.

Discussion

Around one third of the world's Critically Endangered terrestrial mammalian megafauna are not supported by any *ex situ* management. These taxa without *ex situ* management mainly persist in uncertain situations such as border zones or regions experiencing armed conflicts, particularly in Africa and the Middle East (Figure 2). Importantly, another 23% of taxa are not sustainably represented in *ex situ* programs. Considering the current trends of dynamic threats to these megafauna, *ex situ* management, endorsed in the Article 9 of the CBD, may merit more attention as an option in conservation decision-making, particularly in politically uncertain situations, acknowledging the extra challenges its implementation presents.

Border zones and armed conflicts have compromising effects on conservation resources, actions and outcomes (Hanson et al. 2009; Dallimer & Strange 2015; Gaynor et al. 2016). They can sometimes serve as refugia for rare species due to restrictions on human access (Lee et al. 2007; Melovski et al. 2019) or halt hunting or extractive industries (Lindsell et al. 2011). However, more often socio-political boundaries impose substantial costs on biodiversity and ecosystem conservation by fragmenting ownership, governance, and management (Dallimer & Strange 2015; Brito et al. 2018; O'Kelly et al. 2018). Likewise, armed conflicts often lead to withdrawal of conservation funding by international development programs (Hanson et al. 2009; Gaynor et al. 2016). Yet sustained conservation efforts in conflict zones, incorporating conservation issues into military, relief, and reconstruction planning and rapid interventions following ceasefires, may help to save many at-risk populations (Hanson et al. 2009; Hanson 2011; Daskin & Pringle 2018). However, the effective population size may drop so severely during the political instability that reversal is unlikely without *ex situ* management.

Although the attention of CBD contracting Parties is drawn, in Article 9 of the convention text, to adopting *ex situ* measures, as far as possible and as appropriate, and predominantly for the purpose of complementing *in situ* actions (Convention on Biological Diversity 1992), conservationists generally do not consider *ex situ* interventions until *in situ* approaches are thought to have low prospects of success (Zimmermann 2010; Pritchard et al. 2012). For example, action plans generally have not considered *ex situ* management as part of the conservation solutions, even for Critically Endangered megafauna with decreasing population trends existing in geopolitically fragile regions (Hillman-Smith et al. 1986; Emslie & Brooks 1999; IUCN/SSC 2012; Antelope Specialist Group 2017). *Ex situ* management cannot reverse the effect of failed *in situ* conservation if implemented too late (Martin et al. 2012). We therefore propose that, as far as possible, *ex situ* management should be incorporated within conservation action plans of the Critically Endangered megafauna in politically uncertain situations. We note, however, that this requires a careful approach so that investments in *ex situ* management do not detract from investments in *in situ* strategies.

Where the *ex situ* approach is deemed advisable, there will be some important issues to consider, including where the program should be sited. This will require balancing the security of the animals, which will comprise a significant proportion of the remaining extant population, and staff who may be at risk in conflict zones. When political instability occurs within the range of species but the central states cannot be described as 'failed', as is the case of the majority of taxa evaluated here, investment and capacity building within range countries is a more promising approach, and likely to attract more widespread support, rather than moving individuals outside the range states which could be perceived as having elements of neocolonial conservation, and therefore not attract the support of public and scholars (Hayward et al. 2018). Likewise, some species perhaps do not need *ex situ* management. A clear example of this is the African wild donkey *Equus africanus*. There are large populations of this species outside their native range that are argued to contribute to biodiversity conservation (Lundgren et al. 2018; Schlaepfer 2018). Other conservationists believe that the origin of the animals matters (Pauchard et al. 2018).

To take into account constraints and uncertainties about when and how to implement *ex situ* management, the IUCN SSC has proposed a five-step process: 1) status review; 2) potential roles of *ex situ* management; 3) how the *ex situ* population can meet identified roles; 4) appraisal of the feasibility and risks and 5) decision-making in the interests of transparency about the cultural, values and knowledge frameworks that are used (IUCN/SSC 2014; McGowan et al. 2017). Therefore, if a Critically Endangered taxon does not pass this five-step decision-making process, it suggests that the constraints and uncertainties of implementing an *ex situ* management may be non-beneficial to the overall recovery. For example, endorsed *ex situ* plans during the Red List assessment almost exclusively belong to herbivores. In contrast, *ex situ* management is a resource intensive endeavor and reinforcement/reintroduction programs can experience high chance of failure in large carnivores (Snyder et al. 1996; Jule et al. 2008; Hayward & Somers 2009; Zimmermann 2010). Therefore, further research is desirable to enhance the success rate of reinforcement, reintroduction and translocation attempts for carnivorous megafauna, which is increasingly encouraged by governments (Breitenmoser et al. 2014; Qin et al. 2015; Chestin et al. 2017; Farhadinia et al. 2017; Gray et al. 2017).

The management of at-risk species, particularly in less-stable parts of the world, requires a spectrum of interventions that can range from habitat protection to the *ex situ* programs with the eventual aim of reinforcement/reintroduction into the wild (Conde et al. 2013; Canessa et al. 2016). Consequently, some have argued that the boundary between *ex situ* and *in situ* management is becoming blurred (Pritchard et al. 2012; Redford et al. 2012). To bridge between conservation interventions holistically, the IUCN SSC Conservation Planning Specialist Group advocates the One Plan approach (Byers et al. 2013; Conde et al. 2013). This is the development of unified management strategies and conservation actions by all responsible parties for all populations of a species, whether inside or outside their natural range (Byers et al. 2013).

In an ideal world, we might wish that *in situ* strategies would be sufficient to guarantee that no megafauna species goes extinct. However, there are cases where this is doubtful and properly implemented *ex situ* programs have arguably contributed to the recovery of several megafauna (Hedrick & Fredrickson 2010; Stanley-Price 2016). *Ex situ* measures could complement *in situ* protection if it is well targeted and resources used effectively and efficiently. Given the reported poor progress towards achieving Aichi Target 12 of the CBD to reversing the declines of the most threatened species (Tittensor et al. 2014), it is clearly vital that all potential responses are considered and that they are deployed strategically where they will have the biggest positive impact. As human armed conflicts are predicted to increase in association with the effects of global climate change (Burke et al. 2009), mammalian megafauna, particularly those with small populations inhabiting politically non-stable regions, can benefit from such strategic and holistic support.

Data availability The data that support the findings of this study are provided in the manuscript.

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Figure legends

Figure 1 Global distribution of critically endangered megafauna. (A) Asia, (B) southeast Asia, (C) Sahelo-Sahara/Middle East, and (D) Sub-Saharan Africa. Only the red wolf living in the US is not shown. The Balkan lynx is shown with other species on the Sahelo-Sahara/Middle East map. See Table S4 for the courtesy of species silhouette.

Figure 2 Non-metric multi-dimensional scaling (NMDS) ordination of the demographic and geopolitical variables for critically endangered megafauna. Color points represent taxa connected to the geographic group centroid; those that are more similar to one another are ordinated closer together. See Table 1 for the full species names.

Table 1 Description of demographic, *ex situ* management and geopolitical variables evaluated for 43 critically endangered mammalian megafauna. The contribution of each variable to the NMDS ordination (adjusted R^2, the approximate significance of smooth terms and the percentage of deviance described by each variable) was estimated after fitting a smooth surface using a generalized additive model (GAM).

Variable type	**Variable name**	**Description**	**Reference**	R^2	P	**Deviance explained**
Demographic	InsituPopulation	The in situ population size	IUCN Red List	0.012	0.32	2.2%
	SubpopulationNumber	The number of in situ subpopulation(s)	IUCN Red List	0.099	< 0.01	16.5%
Ex situ management	ExsituPopulation	The *ex situ* population size	IUCN Red List/AZA/EAZA/ ZAA/ZIMS	0.208	0.04	28.8%
	ExSituEndorsed	Is *ex situ* management endorsed in the corresponding IUCN Red List assessment?	IUCN Red List	0.330	< 0.01	36.9%
	NationalExsitu	Is there any *ex situ* population within range countries?	IUCN Red List/AZA/EAZA/ZIMS	0.858	< 0.01	88.9%
	InternationalExsitu	Is there any *ex situ* population outside range countries?	IUCN Red List/AZA/EAZA/ZIMS	0.652	< 0.01	70.9%
Geopolitical	BorderZone	Is the main population nucleus occurs along border zone?	IUCN Red List	0.595	< 0.01	66.2%
	Instability	Is there recent armed conflict within the taxa's main range?	Uppsala Conflict Data Program	0.811	< 0.01	85.5%
	MCI	Megafauna Conservation Index	(Lindsey et al. 2017)	0.044	0.19	6.9%
	NCL	National Conservation Likelihood	(Dickman et al. 2015)	0.081	0.11	11.5%

Figure 1A

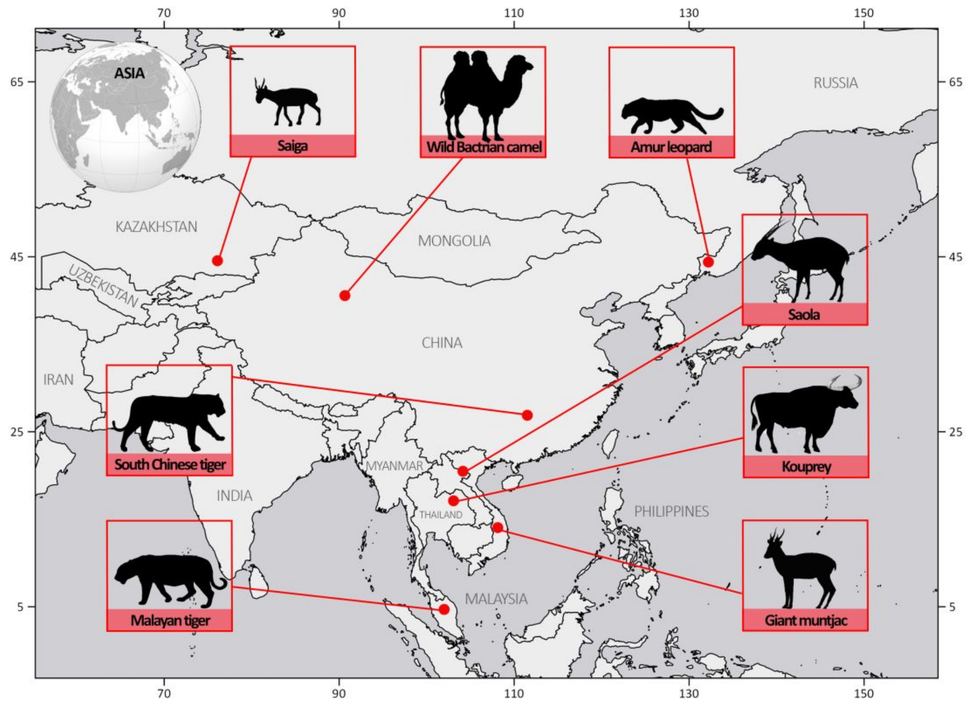


Figure 1B

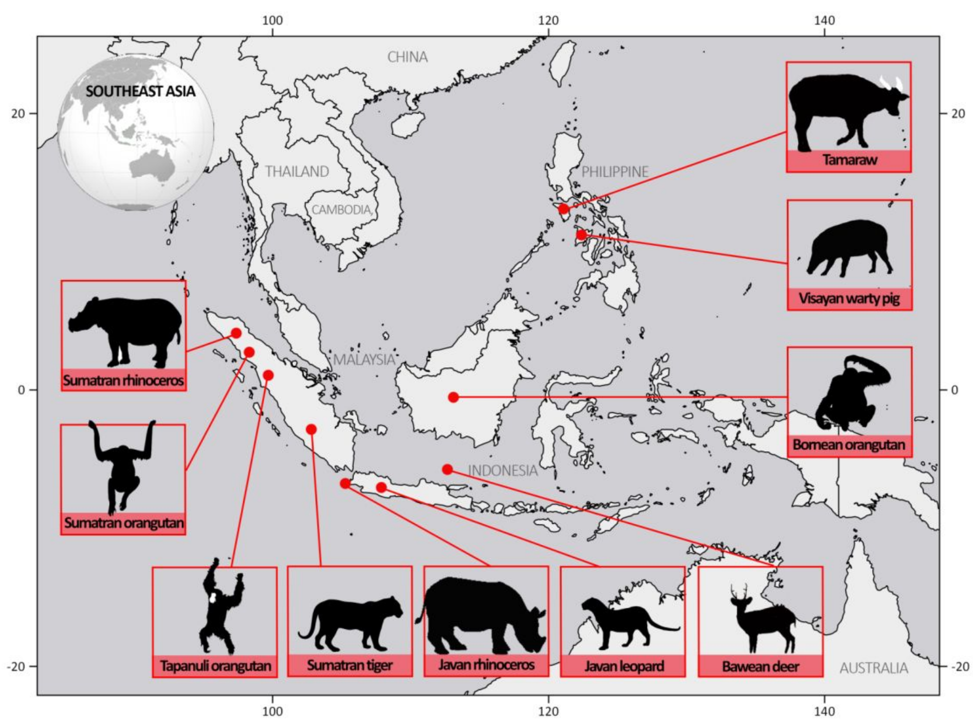


Figure 1C

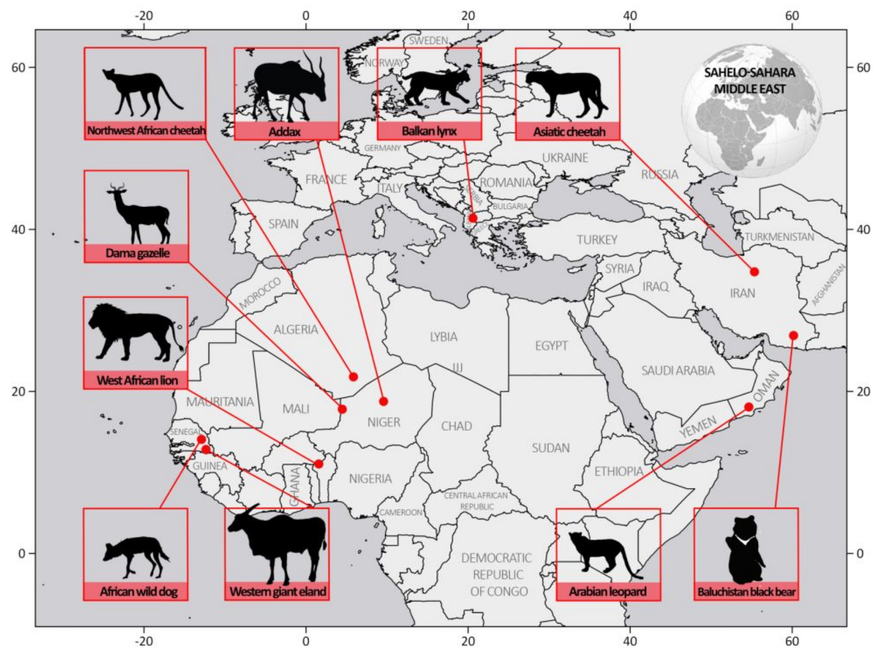


Figure 1D

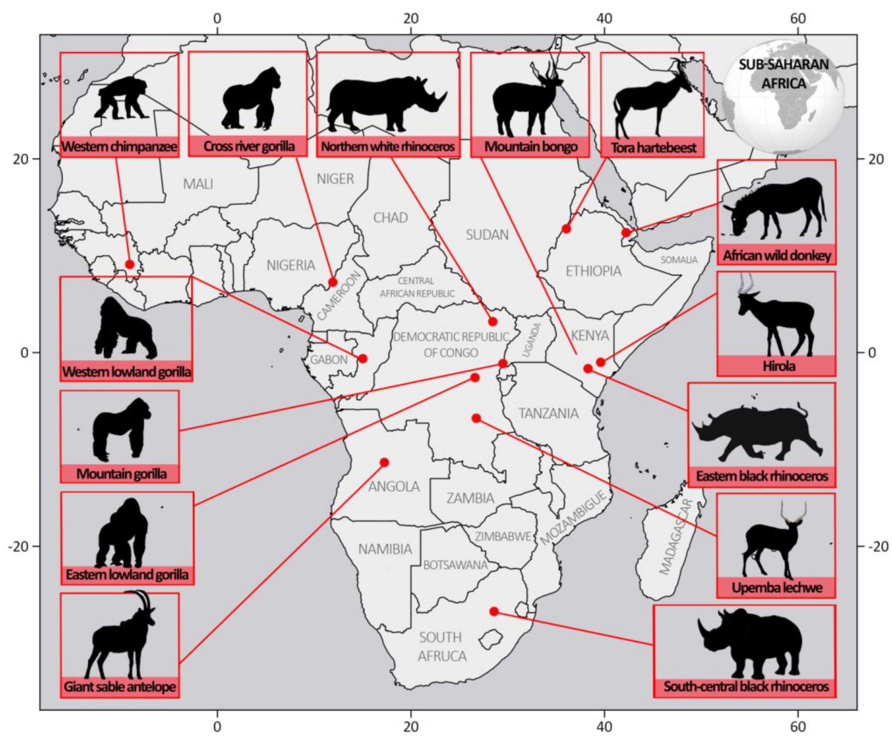
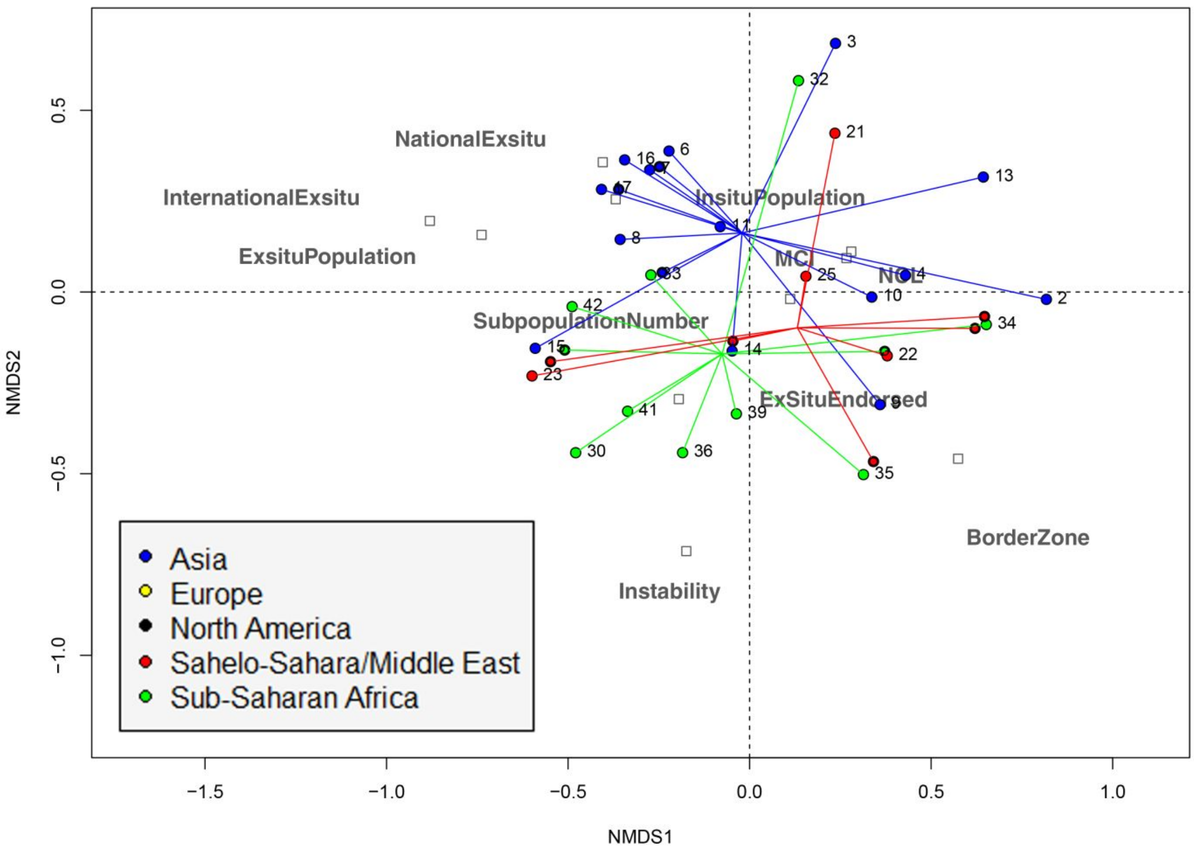


Figure 2


NationalExsitu
InternationalExsitu
ExsituPopulation
InsituPopulation
MCI
NCL
SubpopulationNumber
ExSituEndorsed
Instability
BorderZone
Asia
Europe
North America
Sahelo-Sahara/Middle East
Sub-Saharan Africa
NMDS1
NMDS2
−1.5
−1.0
−0.5
0.0
0.5
1.0
−1.0
−0.5
0.0
0.5