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Analysis of rhino (*Rhinoceros unicornis*) population viability in Nepal: impact assessment of antipoaching and translocation strategies

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Small populations with restricted geographic ranges such as rhinoceros (*Rhinoceros unicornis*) are prone to extinction due to anthropogenic factors. The identification of factors underpinning the survival of such species is of critical importance for population persistence. We used VORTEX population viability analysis (PVA) to assess rhino population viability in Nepal. We simulated deterministic single-population models under different scenarios to assess viability of two distinct rhino populations in Nepal: a source population in Chitwan National Park and an augmented population in Bardia National Park. The impacts of poaching on the populations and the potential for rhino translocation from one population to another were assessed under the PVA framework. Population and demographic data were obtained from censuses and from published literature. The model output suggested that the Chitwan population is stable and capable of supplying at least 10 rhinos every 3 years for translocation provided poaching is restricted (≤15 animals per 3 years). However, the Bardia population is more vulnerable and unable to persist without supplementation even at the lowest poaching rate (2 animals per year). Supplementation of at least 10 animals every 3 years for 30 years is crucial for establishing a viable population of rhinos in Bardia. This level of supplementation can withstand the poaching rate of ≤2 animals per year. Our study demonstrates that poaching is the major factor determining rhino population viability in Nepal. The supplementation of the Bardia rhino population with animals from the Chitwan population and increased effort to reduce poaching are expected to enhance the viability of rhino populations in Nepal.

Siaurai paplitusių mažų populiacijų, pavyzdžiui, indinio raganosio (*Rhinoceros unicornis*), išlikimui didelę grėsmę kelia antropogeniniai veiksniai. Nepale esančių Chitwan Nacionalinio Parko ir Bardia Nacionalinio Parko *R. unicornis* populiacijų gyvybingumo analizė atlikta VORTEX programa, naudojant deterministinį modelį su skirtingais scenarijais. Buvo įvertintas brakonieriavimo poveikis ir raganosių perkėlimo iš vienos populiacijos į kitą galimybės. Naudoti apskaitų ir literatūriniai duomenys apie raganosių skaičių ir populiacijų struktūrą. Gauti rezultatai rodo, kad Chitwan raganosių populiacija yra stabili; ji gali papildyti gretimas populiacijas ne mažiau 10 individų per 3 metus (su sąlyga, kad per tą laiką brakonieriai eliminuoja ne daugiau 15 individų). Bardia Nacionaliniame Parke raganosių populiacija yra labiau pažeidžiama. Ji negali išlikti be individų papildymo iš Chitwan populiacijos net esant minimaliam brakonieriavimui (2 gyvūnai per metus). Bardia raganosių populiacijos gyvybingumui būtina 30 metų papildyti ją bent 10 gyvūnų kas trejus metus. Mūsų tyrimas parodė, kad Nepale raganosių populiacijų gyvybingumą lemia brakonieriavimas.

Keywords: rhino; population viability analysis (PVA); VORTEX; Chitwan National Park; Bardia National Park; poaching; translocation

Introduction

Species persistence in a geographic area depends on a diverse set of natural and anthropogenic factors. For instance, species-specific demographic structure, predation, habitat availability and suitability, density dependence and poaching may individually or collectively determine the fate of a population (Shaffer 1981; Lande 1987, 1998). Anthropogenic factors are the primary deterministic causes of species extinction (Lande 1998). Poaching has been one of the major anthropogenic factors that have led to the decline in large mammal species (Borner and Severre 1986; Barnes et al. 1991; Chapron et al. 2008). However, active management interventions such as poaching control and supplementation of breeding populations have demonstrated significant success in counterbalancing these declines and allowing populations to recover (Strum and Southwick 1986; Griffith et al. 1990; Bonal, Talukdar, and Sharma 2008).

Evaluation of imminent threats facing populations is an important conservation issue. Quantitative assessment of threats faced by a population, or potential remedial measures to maintain viable populations (Thapa et al.

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2013) may aid in identifying appropriate management interventions. Population viability analysis (PVA) greatly contributes to wildlife conservation policy for endangered species restoration and management (Lindenmayer et al. 1993). PVA is extensively used for the quantitative evaluation of threats to populations, identification of quantitative targets for species recovery, estimation of the required magnitude of restoration efforts and evaluation of management strategies using species-specific data and models (Lindenmayer et al. 1993; Akçakaya and Sjögren-Gulve 2000). It uses computer simulation modelling to estimate extinction vulnerabilities of small populations. PVAs are most useful when relative (comparative) rather than absolute results are desirable (Akçakaya and Sjögren-Gulve 2000). Thereby, the effect of different management interventions can be compared and relative merits of alternative options assessed.

While scientific literature is replete with theoretical and empirical studies of the biology and habitat associations of the greater one-horned rhinoceros (*Rhinoceros unicornis*) in its natural habitat in Nepal, the ability of the population to persist for a long time has received surprisingly little attention (Thapa et al. 2013). Greater one-horned rhinoceros (hereafter rhinos) predominantly live in the flood plain ecosystem in Nepal and India (Dinerstein 2003). Current populations of this species are restricted to a few protected areas of Nepal and India (Foose and van Strien 1997), and populations of >80 individuals are recorded just in two national parks: Chitwan National Park in Nepal and Kaziranga National Park in India (Dinerstein, Shrestha, and Mishra 1990). The understanding of the potential long-term viability of these populations and factors affecting population persistence is crucial for adopting appropriate management interventions.

In Chitwan, the highest densities of rhinoceros are found along flood plain grasslands and riverine forests that account for only 30% of the park area (Seidensticker 1976; Mishra 1982; Dinerstein and Wemmer 1988; Kafley, Khadka, and Sharma 2008). The analysis of rhino habitat suitability adopting Maxent modelling and using remote sensing and GIS tools (Kafley, Khadka, and Sharma 2008), and habitat suitability index model (Thapa, Acevedo, and Limbu 2014) demonstrates habitat use by rhinos primarily along riparian grassland habitats in the park. This predictable pattern of animal occurrence might have been a reason for rhinos being frequently victimized by poachers in Chitwan and elsewhere. Prior to malaria eradication and the massive influx of hill people in 1950s, the rhino population in the Chitwan valley numbered approximately 1000 individuals. By around 1960, massive habitat destruction and poaching led to the plunge in population size below 100 individuals (Laurie 1978). Strict protection measures undertaken since the establishment of Chitwan National Park proved efficient in saving this species from extirpation. The population recovered reaching 270–310 individuals (Laurie 1978) in 1975 and in 1988 the population size was estimated at 358–376 individuals (Dinerstein 2003). Chitwan reached a peak of 544 individuals in 2000, but thereafter a 32% decline over 5 years reduced the population to 372 individuals in 2005 (DNPWC 2006). This decline might be due to the fact that the population size exceeded the carrying capacity of the habitat as suitable habitat for rhinos is in decline (Kafley, Khadka, and Sharma 2008; Thapa, Acevedo, and Limbu 2014) or due to the surge in poaching recorded between 2000 and 2005 (DNPWC 2006; Thapa et al. 2013). Therefore, direct loss of animals either through organized hunting (Rookmaaker 2004) (in the historical past) or poaching (in the present context) appears to be a major factor determining the rhino population size in Chitwan (Rothley, Knowler, and Poudyal 2004).

For over three decades, the Chitwan population has also served as a source population to restock the potential rhino habitat in Bardia National Park and Suklaphanta Wildlife Reserve (Thapa et al. 2013). A total of 87 rhinos were translocated to Bardia National Park and Suklaphanta wildlife reserve between 1986 and 2003. However, the ability of the Chitwan population to sustainably donate animals without negatively affecting Chitwan's rhino persistence probability has not yet been adequately studied. A total of 83 individuals were translocated to Bardia (Thapa et al. 2009) from 1986 to 2003 and Dinerstein (2003) reports the birth of 27 calves from translocated individuals. Yet during the 2008 Rhino Count in Bardia, only 21 rhinos were recorded (DNPWC 2009). The decimation of the Bardia population has been primarily attributed to poaching (Thapa et al. 2013). This scenario suggests that the viability of the small rhino population can be largely affected by poaching (Dinerstein 2003; Baral and Heinen 2005; Mainali 2005; Subedi 2012) in addition to fluctuations due to demographic characteristics of the population and stochasticity in environmental, genetic and ecological processes (Miller et al. 1999; Subedi 2012). Unfortunately, in the short term, at least some level of rhino poaching seems unavoidable due to increasing prices of illegally harvested rhino horn. Hence, the identification of poaching level that can be compensated by natural population growth is essential for determining resilience of the population.

PVA models have been widely employed for quantifying the effect of factors that adversely impact on wild populations and hence for assessing existing uncertainties in population persistence. The objective of this paper is to examine the viability of rhino populations under scenarios of different levels of poaching and translocation. Specifically, this paper quantifies the effect of varying poaching intensities on the Chitwan population and the ability of the population to serve as a donor of animals for the Bardia population supplementation. We also identify and recommend strategies for the maintenance of the desired population size in Bardia National Park. The goal of this study is to recommend quantities of animals for translocation from Chitwan to Bardia and to inform the management about the intensity of poaching that the populations might sustain before sustainable populations in both protected areas are attained.

Materials and methods

Data collection

The Chitwan rhino population data that were used for the PVA were collected during the *Rhino Count 2008* (DNPWC 2009) (Table 1). In brief, the count of rhinos was conducted employing the opportunistic search method. A team of 25–40 observers mounted on elephants conducted the survey using a sweeping technique (DNPWC 2009). The resultant number of recorded rhinos was based on direct sighting (DNPWC 2009). We used a combination of census data and demographic data to parameterize the model. Information on the current population structure and pattern was obtained from the census data and demographic data (Table 1) on reproduction patterns, fecundity and mortality rate were obtained from secondary sources (Dinerstein and Price 1991; Dinerstein 2003) and unpublished data of the Department of National Parks and Wildlife Conservation and from other conservation stakeholders such as WWF Nepal and National Trust for Nature Conservation.

Data analysis

VORTEX 9.5 software (Miller and Lacy 2005) was used to examine viability of the rhino population over 100 years to get information on the management intervention measures to be necessarily undertaken in pursuance of self-sustaining populations. Data in Table 1 were used to create a baseline scenario. The majority of the demographic parameters and information on environmental uncertainties were obtained from Dinerstein and Price (1991) and Dinerstein (2003). We performed sensitivity analysis to inform management on potential thresholds associated with animal removal due to poaching and translocation. Each model was run for 1000 iterations. PVAs were also carried out for the rhino population in Bardia National Park that has been considered to be the second potential habitat for rhinos in Nepal (DNPWC 2006). As information concerning the Bardia population was scarce, we modelled its baseline population viability using demographic data on the Chitwan population.

We varied parameters of the baseline scenario to examine whether different combinations of poaching intensity and translocation would affect viability of the Chitwan population. Similarly, combinations of poaching and animals received through translocation were used to assess viability of the Bardia population. Potentially realistic scenarios used for the Chitwan and Bardia populations are described in Tables 2 and 3, respectively. We modelled the effect of poaching alone at different levels in both protected areas. Poaching data from 1997 to 2006 were used to calculate baseline poaching rates for both parks. For Chitwan (Table 2), scenarios included baseline removal levels (15 animals poached per year with no removals for translocation), and increased and decreased poaching levels (5–36) that occurred with and without translocations of varying numbers of animals (0–15). Translocations were set to occur every three years and occurred as a single event. For Bardia (Table 3), scenarios involved a no-poaching and no-supplementation (via translocation) baseline as well as varying levels of poaching (2–8 rhinos per year) combined with the release of 10–15 translocated animals every three years. As the current management requires that translocated animals originate from Chitwan, for the sake of the modelling exercise, where Chitwan and Bardia populations are ecologically separated (Figure 1), the two populations were modelled independently.

We examined the number of rhinos that can potentially be translocated from Chitwan to supplement the reintroduced populations elsewhere. Although translocated animals are expected to have lower survivorship and different breeding and demographic characteristics compared to native individuals (Dinerstein 2003), our modelling was based on the assumption that demographic profiles of the two populations are similar. The PVA for the Bardia population was carried out to examine whether translocation efforts will ultimately lead to a viable population. The criterion for considering a population

Table 1. Demographic parameters used in rhino population simulation in Chitwan (Dinerstein and Price 1991; Dinerstein 2003; DNPWC 2009).

Initial population size: 408
Age and sex distribution
15 male and 18 female juveniles (3 years old)
16 male and 19 female sub-adults (4–6 years old)
61 non-breeding male and 81 breeding female young adults (6–12 years)
85 breeding male and 113 breeding female adults (>12 years) distributed equally among all age groups from age 12 to 40
Mortality
0–3 years old: 2.8 ± 0.9%
4–6 years old: 2.2 ± 0.7%
>6 years old: 2.9 ± 0.5%
Reproduction
Age of first breeding for females: 6 years
Age of first breeding for males: 7 years
Litter size: 1
Interbirth interval: 48 months (4 years)

Table 2. Parameters used for testing different scenarios in VORTEX for the Chitwan population.

Scenario	Description
15Poach_Mean_Baseline	15 rhinos poached per year, No removal for translocation
Low_Poach5 Per yr	5 rhinos poached per year, No removal for translocation
12Poach_Yr	12 rhinos poached per year, No removal for translocation
18Poach_Yr	18 rhinos poached per year, No removal for translocation
36Poach_Yr	36 rhinos poached per year, No removal for translocation
Translocate10per3year	No poaching, 10 rhinos translocated to other reserves per 3 years
Trans10 poach15per3year	15 animals poached and 10 rhinos translocated per 3 years
Trans10 poach30per3year	30 animals poached and 10 rhinos translocated per 3 years
Trans15 Poach15per3Yr	15 animals poached and 15 rhinos translocated per 3 years

Table 3. Parameters used for testing different scenarios in VORTEX for the Bardia population.

Scenario	Description
Baseline	No poaching, No supplementation
2PoachperYr	2 rhinos poached per year
2PoachperYr_Supply10per3Yr	2 rhinos poached per year and 10 supplemented per 3 years
5PoachperYr_Supply10per3Yr	5 rhinos poached per year and 10 supplemented per 3 years
5PoachperYr_Supply15per3Yr	5 rhinos poached per year and 15 supplemented per 3 years
8PoachperYr_Supply15per3Yr	8 rhinos poached per year and 15 supplemented per 3 years
7PoachperYr_Supply15per3Yr	7 rhinos poached per year and 15 supplemented per 3 years
6PoachperYr_Supply15per3Yr	6 rhinos poached per year and 15 supplemented per 3 years
6PoachperYr3M3F_Supply15per3Yr	6 rhinos poached per year and 15 supplemented per 3 years

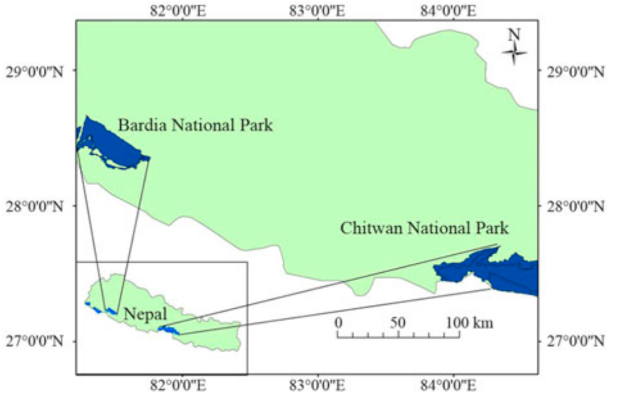

Figure 1. Chitwan and Bardia National Parks in Nepal. Source: Author.

viable was the mean population size of all replicates (extinct and extant) higher than 100 individuals (Foose and van Strien 1997) after 100 years and the positive stochastic growth rate.

Results

Chitwan population

The deterministic growth rate of the Chitwan population was 0.049 in all scenarios as none of the parameters contributing to deterministic growth rate varied between models. According to the baseline scenario, which included the mean poaching level of 15 rhinos per year, the Chitwan population is unlikely to go extinct within 100 years. However, the population has substantially decreased from 408 (base population) to 105 (the mean across both extant and extinct populations) and 244 (mean across extant populations only), with the median time until extinction of 89 years (Table 4). Increasing of the poaching intensity level to the level that is slightly higher than the mean level (18 animals poached per year), however, rendered the population highly susceptible to destruction with the median time of 50 years until extinction. The performed simulation clearly indicated that the poaching rate of 36 rhinos per year (maximum poaching intensity faced by the Chitwan population) was the worst scenario that led to population collapse (Table 4) due to highly negative stochastic growth. Decreasing of poaching intensity from 15 to 12 animals per year also resulted in a negative stochastic growth rate. However, this level of poaching in the absence of rhino removal for translocation allowed 277 animals to persist in 100 years. A decline in poaching intensity to just 5 ind. per year resulted in a 5% decline in the Chitwan population but with positive stochastic growth.

Models with different combinations of animal removal through translocation and/or poaching at 3-year intervals (Table 4) never resulted in population extinction. Models that included translocation of 10 animals and poaching of 30 animals every 3 years allowed the population to persist over 100 years. However, the high negative stochastic growth of −0.019 resulted in >50% of the simulated population going extinct in 100 years. The model that allowed the translocation of 15 animals and removal of 15 animals through poaching every 3 years projected that the Chitwan population will persist

Table 4. Simulation of the Chitwan population output in different scenarios (Stoc-r – stochastic growth rate; PE – probability of extinction; N-extant – population size across extant populations in simulation; N-all – population size across all extant and extinct populations in simulation; MedianTE – median time for extinction; MeanTE – mean time for extinction).

Scenario	Stoc-r	PE	N-extant	N-all	MedianTE	MeanTE
15Poach_Mean_Baseline	–0.019	0.57	243.81	104.86	89	64.9
Low_Poach5Peryear	0.038	0	387.42	387.42	0	0
12Poach_Yr	–0.004	0.342	276.84	182.19	0	70.5
18Poach_Yr	–0.072	0.979	134.24	2.82	50	51.4
36Poach_Yr	–0.198	1	0	0	18	18.2
Translocated10per3years	0.04	0	381.13	381.13	0	0
Trans10poach15per3year	0.023	0.035	343.33	331.32	0	81.5
Trans10poach30per3year	–0.019	0.507	223.05	109.98	100	70.4
Trans15Poach15per3year	0.012	0.133	309.42	268.27	0	72.5

with positive stochastic growth though the resulting population size will be smaller than the baseline population. When the number of translocated animals was 10 and 15 animals were removed through poaching every three years, there was no deleterious impact on population persistence. The population had strongly positive stochastic growth (0.023), insignificant probability of extinction (3.5%) and none of the simulated populations went extinct.

Bardia population

The baseline scenario of the Bardia population that included no poaching in simulations shows that despite the small initial size, the population may be viable. However, the introduced annual poaching of just 2 rhinos per year resulted in extirpation within the median time of 13 years (Table 5). Thus, to ensure persistence of the Bardia population, either poaching must be virtually completely eliminated, or translocations must be maintained at levels that counterbalance losses due to poaching.

The simulation with 2 poaching events per year and population supplementation with 10 rhinos every 3 years for a period of 30 years shows the resultant population to be viable in 100 years with the population size very similar to that of the baseline model. However, increasing of poaching from 2 to 5 animals per year at the same level of supplementation led to population extinction. If during a 30-year period, poaching intensity was maintained at 5 animals per year and supplementation level at 15 animals every 3 years, the population would remain viable. The level of supplementation being the same, the population would be viable if loss of rhinos due to poaching did not exceed 6 animals per year (Table 5).

Discussion

Viability of Chitwan population

VORTEX-based modelling results clearly show that the Chitwan population is stable. The scenario that included the mean poaching rate (15 animals per year), calculated from years of intensive poaching during the Maoist insurgency period in Nepal (Poudyal 2002), revealed that the Chitwan rhino population could still persist over 100 years. Though this scenario is not typical, the results demonstrate the resilience of rhino population to poaching in the long term. However, it is important to note that removal of 15 animals resulted in negative stochastic growth and hence population cannot be regarded as viable at this poaching rate. Similar results were obtained even when 12 animals were removed through poaching per year. The model reveals that if poaching exceeds 18 animals per year, it is likely that the Chitwan population cannot persist beyond about 50 years. Thus, annual poaching appears to be the determining factor for the persistence of rhinos in Chitwan. This is in agreement with Dinerstein's (2003) observation that poaching for rhino horn outweighs the natural ability of rhinos to

Table 5. Simulation of the Bardia population output under different scenarios (Stoc-r – stochastic growth rate; PE – probability of extinction; N-extant – population size across extant populations in simulation; N-all – population size across all extant and extinct populations in simulation; MedianTE – median time for extinction; MeanTE – mean time for extinction).

Scenario	Stoc-r	PE	N-extant	N-all	MedianTE	MeanTE
Baseline	0.047	0	255.58	255.58	0	0
2PoachperYr	–0.153	1	0	0	13	12.9
2PoachperYr_Supply10per3Yr	0.055	0	249.95	249.95	0	0
5PoachperYr_Supply10per3Yr	–0.013	1	0	0	31	31.1
5PoachperYr_Supply15per3Yr	0.045	0.01	242.77	240.34	0	54.5
8PoachperYr_Supply15per3Yr	–0.051	1	0	0	31	28.9
7PoachperYr_Supply15per3Yr	–0.041	1	0	0	37	36.5
6PoachperYr_Supply15per3Yr	0.026	0.506	238.35	117.75	81	49.9
6PoachperYr3M3F_Supply15per3Yr	−0.019	0.892	202.86	21.92	46	47.9

recover quickly and it is impossible to ignore the issue of poaching when determining whether the rhino is prone to extinction. Here, we have added a quantitative nuance to this observation, revealing a threshold at which poaching results in extirpation of the Chitwan and Bardia populations.

Our model scenarios (Tables 2 and 3) reflect three plausible management options that can prompt decisions for rhino population management in Chitwan: (1) translocation of 10 animals and removal of 15 animals by poachers every 3 years; (2) translocation of 10 animals and removal of 30 animals by poachers every 3 years and (3) translocation of 15 animals and removal of another 15 animals by poachers every 3 years. Scenario 2 represents a seemingly extreme poaching rate, but during periods of political or administrative instability it is likely to happen and therefore cannot be totally ignored (DNPWC 2009). Even in this scenario the model predicted that the Chitwan population could withstand removal of 10 more animals for translocation to other reserves. The more likely scenarios 1 and 3 involve poaching of 15 rhinos every approximately 3 years. Model outcomes for both scenarios revealed that despite high poaching pressure, 15 additional rhinos could be available for translocation without impairing the viability of the Chitwan population. Thapa et al. (2013) argue that the translocation of animals from Chitwan, in fact, may also help avoid inbreeding depression in the Chitwan population.

The simulations in this study did not involve any catastrophic events that can dramatically reduce the ability of the population to recover and can be a major cause of extinction of the small population (Shaffer 1981; Lacy and Clark 1990). For example, flooding in Kaziranga National Park killed over 40 animals (Dinerstein 2003). However, rhino populations in Nepal have not suffered any major (natural) catastrophic events in recent history. In Chitwan, frequent monsoon flooding invigorates the habitat, supplementing silt for better growth of preferred forage grass *S. spontaneum* (Dinerstein 2003). During the flood, rhinos take refuge in the adjoining elevated forest, minimizing casualties. However, a few deaths are always possible, although losses of approximately 5% due to such flooding do not have significant adverse effects on Chitwan's rhinos (Subedi 2012). Similarly, we did not include disease and other unforeseen casualties due to the lack of baseline information on those parameters. However, we should always be aware of the possibility of such calamities. Taking these possibilities into consideration, and given the results of different scenarios, we propose that the translocation of 10 animals every three years for a period of 30 years is a viable management option.

Viability of Bardia population

The small rhino population of Bardia National Park could attain viable size provided no poaching incidents happen. However, this scenario is not ideal. Poaching in Bardia was less than 2 animals per year for over a decade from 1986 to 1998. A surge in poaching during the Maoist insurgency period decimated the population (Martin 2004) and only 21 animals remained in 2008 (DNPWC 2009). Given this population size, even if poaching rate is maintained at 2 animals per year, our results show that the population will not persist.

The alternative for boosting the Bardia population is to supplement it with animals translocated from Chitwan National Park (DNPWC 2006). Our results show that supplementation of 10 animals every 3 years for a period of 30 years will successfully restock the population. This level of supplementation, however, restores the viable population only when the loss due to poaching can be arrested to ≤2 animals per year. The population will not remain viable if poaching intensity reaches 5 animals per year. Beyond this level of poaching, translocation rates must be increased with supplementation of 15 animals every 3 years for a period of 30 years. If poaching surges to >6 animals per year, even supplementation of 15 animals every 3 years is insufficient to restore the viable population in Bardia.

To conclude, we suggest supplementing the Bardia population with at least 10 rhinos every 3 years for a period of 30 years on the optimistic assumption that the level of poaching could be maintained at ≤2 animals per year. Nepal has achieved a significant progress in rhino poaching control as evidenced by countrywide 'zero-poaching' years 2011 and 2013 and only 1 rhino poached in 2012 (Unpublished government data). This scenario makes additional animals available for translocation from Chitwan and might assure a viable population in Bardia if a well-managed translocation schedule is maintained and poaching is curbed as at present. Depending on changes in poaching level and natural population growth in Chitwan and Bardia, the models presented here can be revised to suit existing circumstances. Furthermore, monitoring of the translocated animals' performance and the number of animals removed through poaching is highly recommended for adjusting the target number for periodic supplementation through translocation. The technique adopted here can be readily applied to assess population viability of other endangered species that are thriving in small populations. Hence, the simple yet rigorous technique of PVA using VORTEX is immensely useful for identifying appropriate management actions to safeguard small populations of endangered species against extinction risk.

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