



Applying best practice to feasibility assessment and strategic planning for great ape translocation: A case study of Grauer's gorilla (*Gorilla beringei graueri*)

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ARTICLE INFO

Keywords:

Precautionary principle
Reinforcement
Reintroduction
Tshiaberimu
Virunga

ABSTRACT

We outline the feasibility and risk assessments that are essential prerequisites to conservation translocation of great apes, while upholding the precautionary principle to avoid harms to conspecifics, sympatric taxa and ecosystems. As part of a strategic planning process, we addressed key questions on the costs and benefits of a translocation of Grauer's gorillas in Democratic Republic of Congo. We reviewed published and gray literature to compile data on Grauer's gorilla ecology and potential release sites in the subspecies' geographic range. Taking into account ecological dimensions of the habitats, impacts on conspecifics, sympatric great apes and other wildlife, and existing threats, we formulated recommendations on whether and where translocation could benefit conservation of this taxon. We concluded that one site assessed is compatible with key IUCN criteria. At Mt. Tshiaberimu in Virunga National Park, the resident Grauer's gorilla population is non-viable, no sympatric great ape species is present and the site is actively protected against poaching and habitat encroachment. Conservation translocations are widely used for species recovery; however, detailed accounts of the analyses and planning required to adhere to IUCN best practice are rare. Our approach enabled evidence-based determination of feasibility despite some initial information gaps. The process is widely applicable and could encourage improved compliance with IUCN guidelines when risks to wild conspecifics might be high, yet ecological knowledge of the target population is limited. The Grauer's Gorilla Conservation and Reinforcement Project is a partnership between the Gorilla Rehabilitation and Conservation Education Center, Virunga National Park and Re:wild.

1. Introduction

Conservation translocation is the deliberate movement of a wild organism and its release in another habitat for the purpose of species or ecosystem conservation (IUCN/SSC, 2013). Conservation translocation is used to reinforce existing species populations, reintroduce species to areas from which they have been extirpated, or to introduce individuals into areas outside the species range. Well-planned carefully executed translocations with suitable safeguards can result in conservation gains that include re-establishing species in former habitats, supplementing non-viable populations, restoring ecosystem functions, and incentivising habitat protection and anti-poaching activities (e.g., Goossens et al., 2005; Novak et al., 2021). Translocation conducted without appropriate safeguards can have significant negative consequences for released

individuals, wild conspecifics, other interacting native taxa and humans. For example, infectious disease introduced through translocation has been catastrophic for some species (e.g., Lockwood et al., 2019; Pimentel et al., 2005). Translocation can cause excessive social disruption or exacerbated competition for resources among wildlife (e.g., Ancrenaz et al., 2021; Sherman et al., 2020), and mixing of different subspecies or subpopulations of the same taxon can lead to harmful genetic issues and reduced fitness (e.g., Banes et al., 2016; Benjamin-Fink and Reilly, 2017). Sociopolitical complexities or lack of local community support often lead to difficulties or failure in translocation projects (Berger-Tal et al., 2020). Definitions of translocation success vary widely and are often based on numbers of individuals released regardless of survival or impacts on resident wildlife and the ecosystem (e.g., Morris et al., 2021). To help decision makers and practitioners

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<https://doi.org/10.1016/j.biocon.2024.110521>

Received 22 February 2023; Received in revised form 16 February 2024; Accepted 27 February 2024

Available online 15 March 2024

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achieve positive outcomes and reduce negative impacts of translocation, the International Union for the Conservation of Nature (IUCN) developed global (IUCN/SSC, 2013) and taxon-specific (Beck et al., 2007) best practice guidelines for wildlife translocation. These guidelines use the “precautionary principle”, which stipulates that actions with the potential to cause harm to wildlife or the environment should be avoided (IUCN, 2007).

We carried out a translocation feasibility assessment and comparative site risk analysis on behalf of the Gorilla Rehabilitation and Conservation Education (GRACE) Center — a rehabilitation facility for orphaned Grauer's gorillas (*Gorilla beringei graueri*) in eastern Democratic Republic of Congo (DRC). The goals of the translocation project are to: 1) improve conservation of the taxon through supplementation of wild Grauer's gorilla population(s) with the release of rehabilitated individuals from the sanctuary, and 2) to improve the protection of wild gorillas and their habitat through management activities associated with such a release. For this study, we adopted a precautionary approach, whereby a great ape translocation must not endanger resident great apes, other native taxa or ecological integrity of the area (Beck et al., 2007). Thus, any site with a viable great ape population would be considered unsuitable for translocation due to the threat of disease transmission, genetic hybridization, social disruption or natural resource competition posed by a release of formerly captive great apes. Equally unsuitable are sites where a sympatric great ape species is present (i.e., eastern chimpanzees *Pan troglodytes schweinfurthii* in the region of focus), as they would face the same risks as conspecifics with the additional threat of lethal interspecies aggression (e.g., coalitionary attacks by chimpanzees on gorillas, as witnessed in Gabon by Southern et al., 2021).

The precautionary principle also applies to the health and welfare of the released and resident individuals. While releasing captive animals into natural habitats may be perceived as intrinsically valuable for their welfare (Browning and Veit, 2021), translocation can compromise rather than promote welfare (Harrington et al., 2013). Adverse stress may occur during all stages of the release process, from capture, handling, examination and transport, to holding, release, and post-release monitoring (Berg, 2018; Teixeira et al., 2007). Specifically regarding great apes, some released individuals have failed to thrive due to inadequate physical or psychological rehabilitation or resilience, being released into unsuitable habitats, and/or not receiving the support they need to adapt to natural conditions pre- or post-release (Grundmann, 2006; Sherman et al., 2020). Encounters with wild conspecifics exacerbated by competition over resources have resulted in deaths of released chimpanzee males (Goossens et al., 2005). In addition, some formerly captive great apes lost their fear of humans and were more likely to crop forage or pose a threat to humans, and were themselves at greater risk of capture or killing post-release (Beck, 2019; Hockings and Humle, 2009; McLennan and Hockings, 2016). The popular portrayal of translocation as “opening the cage door” to give captive animals their “freedom” distracts from the complex reality.

Translocation requires meticulous planning, assessments of costs and benefits, post-release monitoring, and significant long-term funding (Berger-Tal et al., 2020; IUCN/SSC, 2013), as well as competent staff and oversight (Maggs et al., 2021). Detailed feasibility assessments, planning processes and methodologies for translocations are rarely shared (Batson et al., 2015), and translocation initiatives that share such information often do not address the key considerations outlined in IUCN guidelines (Pérez et al., 2012). This study presents a rarely published perspective of feasibility and consideration of comparative risks for potential conservation translocations following IUCN guidelines (Beck et al., 2007; IUCN/SSC, 2013). It is also the first translocation to be formally planned for Grauer's gorillas.

Grauer's gorillas are listed as Critically Endangered on the IUCN Red List of Threatened Species and are endemic to eastern DRC (Plumptre et al., 2016a). Even though it is illegal throughout their range to kill, capture or trade live gorillas or their body parts, Grauer's gorilla

numbers have crashed during the past 20 years, due mainly to illegal hunting for bushmeat associated with artisanal mining and commercial trade (Plumptre et al., 2016b). High demand for bushmeat stems from the growing human population, the destabilising impact of armed groups, illegal mining in protected areas, and scarcity of affordable domestic protein in rural areas (Plumptre et al., 2015b; Spira et al., 2019). When female great apes with dependent offspring are killed for meat, their infants may be captured alive and trafficked illegally and opportunistically (GRASP and IUCN, 2018), albeit mostly locally rather than internationally. Gorilla infants confiscated by government authorities and confirmed by genetic testing to be the Grauer's subspecies are taken to GRACE. The orphaned gorillas at GRACE were all wild-born and are candidates for translocation, referred to here as the source population. Although the IUCN conservation action plan for Grauer's gorillas (Maldonado et al., 2012) does not list translocation as a priority action, it highlights the potential value of releasing gorilla orphans to bolster small, isolated subpopulations in well protected habitats.

Our approach was grounded in the IUCN *Best Practice Guidelines for Re-introduction of Great Apes* (Beck et al., 2007) and *Guidelines for Reintroductions and Other Conservation Translocations* (IUCN/SSC, 2013). We addressed five overarching questions: 1) Do suitable release sites for Grauer's gorillas exist in the subspecies' geographic range that comply with the precautionary principle of protecting wild great ape populations? 2) What information is critical to guide decision-making on the feasibility of a Grauer's gorilla translocation to the habitats identified? 3) What are the key risks and benefits posed by a potential translocation? 4) Given available information, is translocation feasible and a suitable conservation tool for Grauer's gorillas? and 5) What variables should be used to inform selection of appropriate release candidate gorillas? This process is replicable for other threatened species and provides an example of a systematic approach to translocation feasibility and risk-benefit analyses when baseline data are initially incomplete or lacking.

2. Methods

2.1. Study area

The area of interest was the geographic range of Grauer's gorilla as modelled and mapped by Plumptre et al. (2015b) and Plumptre et al. (2016b), upon which the IUCN Red List distribution map for the subspecies was based (WCS, 2019). Fig. 1 is a map of the Grauer's gorilla landscape that shows the locations of the sites we assessed, together with protected areas and community concessions.

2.2. Data needs, feasibility and risk assessment tools

Based on requirements stipulated in the IUCN/SSC, 2013 guidelines, and combined with information extracted from the great ape-specific decision tree (Beck et al., 2007), we tabulated standards and questions for the assessment of any great ape release site (Table A1) and of candidates for release (Table A2). We then elaborated a detailed checklist of the key information needed to guide any gorilla translocation (Table A3). We also created a diagrammatic tool using Miradi software (Foundations of Success, 2019) to assist project planners to make decisions based on key feasibility and risk variables (Fig. A1) and, in consultation with gorilla and other wildlife health experts, we produced a bespoke disease risk analysis template (not presented in this paper).

2.3. Identification and assessment of potential release sites

Initially, release sites for consideration were proposed by two of the project partners (GRACE and Virunga National Park): one because of its proximity to the source population (Tayna Nature Reserve); the other because the resident gorilla population had declined to a few individuals (Mt. Tshiaberimu). We then consulted the scientists who led a comprehensive reassessment of Grauer's gorilla conservation status, for which

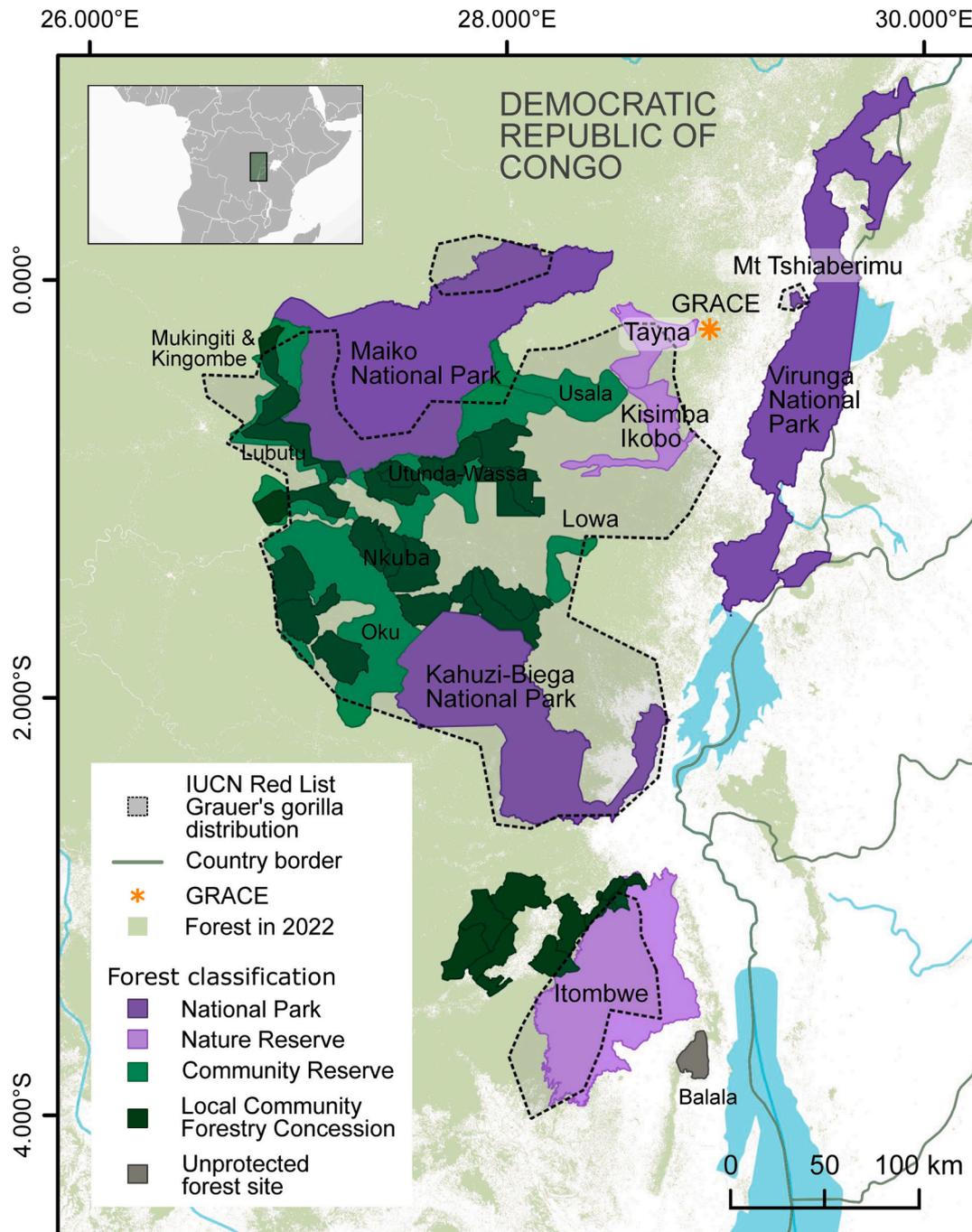


Fig. 1. Map of Grauer's gorilla geographic range and forest classification, showing locations of Mt. Tshiaberimu in Virunga National Park, Tayna Nature Reserve, Balala forest and the Gorilla Rehabilitation and Conservation Education (GRACE) Center. IUCN Red List Grauer's gorilla distribution is represented by dashed lines and gray shade (WCS, 2019). National Park (dark purple) and Nature Reserve (light purple) borders from World Database of Protected Areas (UNEP-WCMC and IUCN, 2024). Local Community Forestry Concessions (dark green) from Community Forest Database of DRC (Ministry of Environment and Sustainable Development, 2023), Fauna & Flora International, Strong Roots and Wildlife Conservation Society. Community reserves (light green) and Balala forest (gray) delineated by authors. Tropical moist forest in 2022 is shown in pale green (Vancutsem et al., 2021), Country borders (black) and rivers (light blue) from Natural Earth. Map created using QGIS 3.24 (QGIS, 2023). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

they consolidated all available data on the current density and distribution of great apes in eastern DRC (Plumptre et al., 2015b; Plumptre et al., 2016b). They were asked to identify any additional sites that they would consider for a Grauer's gorilla translocation using their detailed first-hand knowledge of the landscape. These experts recommended one further site – Balala – a forest in South Kivu where gorillas no longer occur, which is within the subspecies' historic range (Plumptre et al., 2015b) and has been identified as a biodiversity conservation priority

(Plumptre et al., 2015a). During a site visit to North Kivu in DRC, we interviewed people knowledgeable about the sites proposed, and later followed up by remote discussions with experts on Grauer's gorillas, their habitats and translocation opportunities (see Acknowledgements).

We collated almost 370 documents and online resources relevant to this assessment, including peer-reviewed literature, IUCN publications, World Heritage and UN Security Council reports, plus unpublished reports and other gray literature produced by Berggorilla & Regenwald

Direkthilfe, Dian Fossey Gorilla Fund Europe, Dian Fossey Gorilla Fund International, the Gorilla Organization, Mountain Gorilla Veterinary Project, Virunga National Park and the Wildlife Conservation Society (bibliography available upon request). We also extracted data on threatened species occurrence from the IUCN Red List of Threatened Species (IUCN, 2024).

Having first considered the three sites proposed against the critical issues for release sites listed in Table A1, we used the information gathered to review: protected area status and management in place (including law enforcement); ecology (fauna and flora); knowledge about resident great apes; threats (poaching of wildlife and non-timber forest products; encroachment; civil conflict); and tourism aspirations. Finally, we formulated recommendations based on the best data available, and applied the precautionary principle to exclude unsuitable release sites. This principle assumes that translocation is more likely than not to pose risks to wild great apes and ecosystems unless there is good evidence to the contrary, hence sites with viable conspecific or

sympatric great ape populations were considered unsuitable.

2.4. Release candidate assessment

Judgements about a great ape's suitability for release should be made on an individual basis and, during a site visit to GRACE in 2017, we presented animal caregivers with a series of questions in order to rank each female gorilla's position in the hierarchy, their affinity to humans (i.e., which gorillas prefer the company of people over conspecifics), and about which individuals they thought would survive best without human support (see Appendix 4). Table A2 covers the behavioral and physiological variables, such as age, body condition, biomechanical skills and reproductive health, that are listed as IUCN standards for translocation. An animal must also be psychologically healthy to maximise their chances of not only surviving but also thriving after release. Behavioral traits that will favor successful release include whether an individual gorilla is feeding and nest-building

Table 1

Summary analysis of suitability of three proposed release sites per IUCN guidelines (Beck et al., 2007; IUCN/SSC, 2013). This table represents the situation prior to 2021 and circumstances may have changed since. Data sources are given in footnotes. Details of enforcement activities are not provided due to their sensitive nature of anti-poaching measures. Traffic light key: green – meets IUCN criterion; yellow – more data or caution needed in order to meet IUCN criterion; red – does not meet IUCN criterion.

IUCN translocation criteria		Mt. Tshiaberimu, Virunga NP	Tayna Nature Reserve	Balala forest
A1/A9	Are gorillas absent or is resident population non-viable without reinforcement? Is population below carrying capacity?	Yes. Resident gorilla population is non-viable ¹ . Based on historical data, the population was previously much larger and is now below carrying capacity of the habitat ¹	No. Gorillas present (population presumed viable ²). Chimpanzees also present ³ , making site unsuitable for translocation	Yes. Gorillas have been extirpated; however, chimpanzee presence ⁴ makes site unsuitable
A2	Is release appropriate and cost effective, or would habitat protection, law enforcement, and/or community activities be more appropriate and cost effective?	Yes. Habitat protection, law enforcement and community projects are in place ^{5,6} and would be strengthened as part of a planned release. Without supplementation, these actions alone would not enable the population to recover to a viable level ¹	No. Protecting gorillas and habitat through law enforcement and community engagement would be more appropriate and cost effective than translocation	No. Creating a reserve and developing birding tourism would be more appropriate given lack of protection and desire for tourism ⁷
A5	Can the precautionary principle be upheld?	Yes. Translocation would not endanger resident gorillas or ecological integrity of the area	No. Translocation could pose risks to resident gorillas and chimpanzees	No. Translocation could pose risks to chimpanzees
A6	Is there a compilation of socioecological and behavioral information about the population?	Yes ⁸ , although additional information needed on home-range size, habitat use and feeding behavior of resident gorillas	Partially. Contemporary data needed on both gorilla and chimpanzee ecology	No. Nothing known about extirpated gorilla population
A8	Is site in suitable habitat in historic range? Has food availability been assessed?	Yes. Habitat is suitable and within geographic range of Grauer's gorilla subspecies ⁹ , although quantitative information on seasonal availability of food is needed	Yes. Habitat is suitable; however, presence of viable gorilla and chimpanzee populations makes site unsuitable	Yes. Habitat is suitable; however, chimpanzee presence makes site unsuitable
A10/C6	Have original causes of decline of the taxon been addressed and are animals and site adequately protected?	In part. Poaching and encroachment are being actively managed ⁵ . Significant long-term funding and resources are in place to ameliorate risks ¹⁰	No active law enforcement to prevent poaching and/or habitat destruction at time of assessment ¹¹ (but see ¹²)	No active management or legal protection in place ⁴
A13	Do governments of the nation and district support the release? Is there local community support?	Yes. Government entities are supportive. Protected Area Authority (PAA) has agreed not to allow tourism when translocated gorillas are released ¹⁰	In part. Designated a Nature Reserve ¹³ . Lacking local community support at time of assessment (but see ¹²)	No formal protected area designation ⁸
B5/C5	Would the action jeopardise the conservation/welfare of other endangered animals/plants at site?	No. Additional site protection conferred by reinforcement is likely to benefit rare wildlife and plants present. There is no known incompatibility with other species as gorillas are native to this site	No. Protection would benefit other species. No known incompatibility with other species as gorillas are native to site	No. Protection would benefit other species. No known incompatibility as gorillas were native

Data sources: 1. Iyer et al. (2023), 2. Nixon (2013), Plumptre et al. (2016b), 3. Nixon (2013), Plumptre et al. (2015b), 4. Plumptre et al. (2015b), Plumptre et al. (2016b), A.J. Plumptre (pers. comm. 2021), 5. Virunga Foundation (2023), Virunga NP (unpubl. reports), 6. Overall guard density in Virunga NP is above the threshold considered best practice for effective protected area management (Bruner et al., 2001; Henson et al., 2016), 7. A.J. Plumptre & D. Kujirakwinja (pers. comm. 2021), 8. Saa-Sita et al. (2022), Syaluha (2018), Dian Fossey Gorilla Fund Europe (unpubl. reports), Virunga NP (unpubl. data), 9. Plumptre et al. (2016b), 10. E. de Merode, Virunga NP (pers. comm. 2017), 11. Nixon (2013), 12. GRACE (2022), 13. Ministerial Decree No. 942/CAB/MIN/2005.

independently, and perhaps beginning to display sexual behavior. Prior to assessing the translocation suitability of each gorilla at GRACE, we reviewed published literature on eastern gorilla (*Gorilla beringei*) socio-ecology (e.g., Sicotte, 1993; Yamagiwa et al., 2012), and interactions between released great apes and humans (e.g., Beck, 2019; Russon et al., 2016). We then proposed additional variables, including competence measures and temperament, and incorporated them into Table A3.

3. Results

3.1. Data needs, feasibility and risk assessment tools

Table A1 lists the IUCN standards that release sites should meet. Table A3 is a detailed checklist of key information requirements for gorilla translocation that includes site and candidate selection, and for preparation and management at the pre-release, release and post-release stages of translocation. The data needs specified represent an ideal set of data required to make informed decisions about each critical aspect of a translocation. In practice, some baseline data were not available for our feasibility assessments (see Section 3.2).

Fig. A1 outlines the risk assessments to be undertaken as the reinforcement project proceeds. Conservation goals, such as enhanced population viability, secure and protected habitat, and conserved biodiversity in the region, can be ranked using this diagram and a stoplight system applied to prioritise the threats to these targets. It should be emphasized that risk analysis is an iterative process to be incorporated into the full management cycle of a translocation program, ensuring that new and emerging risks are identified, assessed and mitigated. For the Grauer's gorilla translocation, risk assessments will be carried out by the site managers in collaboration with other project partners.

3.2. Identification and assessment of potential release sites

We summarise the outcome of our site assessments in Table 1, which shows that releases at two of the three sites would have violated aspects of the precautionary principle for great ape translocation. On one hand, Tayna Nature Reserve is unsuitable because the extant gorilla population is not in need of reinforcement. Also, the gorillas (and chimpanzees) present are not genetically isolated from other gorilla (and chimpanzee) populations, so translocating gorillas from GRACE to this site could put both resident and adjacent great ape populations at risk of introduced diseases, and increased competition for resources. Furthermore, at the time of our assessment, the site lacked active law enforcement (Nixon, 2013).

On the other hand, the Balala forest is now geographically isolated from other great ape habitats and hence would pose no risk to those wild populations; however, chimpanzees are still found here (Plumptre et al., 2015b). A lack of ecological data, absence of anti-poaching measures and no formal protected area status (A.J. Plumptre & D. Kujirakwinja pers. comm. 2021) point to alternative conservation strategies being more appropriate for this site than translocation. In addition, habitats such as Balala forest that once formed part of the geographic range of Grauer's gorillas, but where there is no longer an extant population, are likely to be high-risk locations unless adequate protection can be put in place to prevent whatever caused the extirpation.

At Mt. Tshiaberimu, the resident Grauer's gorilla population is non-viable, no sympatric great ape species is present and the site is actively protected against poaching of wildlife and habitat encroachment. While some IUCN criteria were met only partially, active efforts by project partners are underway to address these issues (Table 1). The isolation and distance of Mt. Tshiaberimu from other forests where gorillas (or chimpanzees) exist will ensure against gorillas moving between populations. Reinforcement will not, therefore, present a risk of disease transmission or social disruption to other gorillas, or to chimpanzees. We then considered the ecological dimensions of this site in more detail,

including the gorillas' use of the habitat, likely carrying capacity, food availability, and changes in the gorilla population over time. For comparison, we reviewed studies of two eastern gorilla populations that reside at similar altitude to Mt. Tshiaberimu: Grauer's gorillas in the highland sector of Kahuzi-Biega National Park (e.g., Casimir, 1975; Yamagiwa et al., 2005), where elevation is 2000–3308 m (Inogwabini et al., 2000), and mountain gorillas (*Gorilla beringei beringei*) in the Virunga Massif (e.g., McNeilage, 2001; Watts, 1984), which range between 1850 and 3800 m (Williamson and Butynski, 2013). The area of forest cover remaining at Mt. Tshiaberimu is about 40 km² (Iyer et al., 2023). This is larger than estimates of the area of habitat used habitually by a Grauer's gorilla group in the Kahuzi-Biega highlands – referred to as a home range – which varied between 13 and 31 km² accumulated over eight years (Yamagiwa, 1999). Studies of the plant species eaten by the Mt. Tshiaberimu gorillas (cumulatively, over 80 taxa listed by Saa-Sita et al., 2022; Syaluha, 2018; Dian Fossey Gorilla Fund Europe and Virunga National Park, unpubl. data) indicate that their diet is diverse for a high altitude habitat (2000–3011 m asl).

In the 1960s, Mt. Tshiaberimu supported roughly 30–40 gorillas (estimated by Schaller, 1963). For the past decade, the number of gorillas remaining at this site has hovered between five and seven individuals (Berggorilla & Regenwald Direkthilfe, Gorilla Doctors, Gorilla Organization and Virunga National Park, unpubl. data). The magnitude of the decline (80 % decrease) has mirrored that recorded elsewhere in the Grauer's gorillas range (Plumptre et al., 2016b). Since the current population of only seven gorillas (two adult males, three adult females, one juvenile female, and one infant of unknown sex; Virunga National Park unpubl. data) is now well below carrying capacity, the habitat is likely to produce adequate quality, quantity and diversity of food and, theoretically, the area of habitat remaining is sufficient to sustain growth and dispersal of the gorilla population for the foreseeable future. Nonetheless, additional data on the habitat and the feeding ecology of the resident gorillas are needed to ascertain whether the gorillas face food shortages at particular times of year. Also, home-range size for the Mt. Tshiaberimu gorillas is not known and must be assessed before any gorillas are released.

3.3. Release candidate assessment

The 11 female and three male gorillas at GRACE are 9–23 years old (as of late 2023) and have been managed with translocation as a goal since their confiscation. They have access to a large forested enclosure with natural vegetation during the day, sleep inside a dormitory overnight, and are provided with some supplementary food (Leeds et al., 2024). The females are nulliparous and have contraceptive implants, to be removed after transfer to an interim facility at the release site. Through consultation with caregivers, 10 of the 11 female gorillas were judged to be physically and behaviorally healthy, and rated suitable for release, pending health examinations. This was despite having been captured at a young age and deprived of their mothers before they were of weaning age. Not being mother-reared can have adverse impacts on the behavior and reproductive success of western lowland gorillas (*Gorilla gorilla gorilla*) in zoos (Ryan et al., 2002), so it was reassuring to observe one of the females displaying maternal behavior towards an infant that was introduced to the group in 2016 (see also Leeds et al., 2024). One individual has a physical handicap that would affect her ability to cope in a more challenging environment and she will not be considered for translocation.

4. Discussion

When considering the feasibility and risks of any translocation project, it is important to learn lessons from previous successes and failures. Attempts to translocate gorillas have ranged from the addition of a few individuals to resident groups, to the release of established groups into new areas (Beck, 2019). Here, we review the outcomes of

some previous gorilla translocations. Eastern gorilla releases involving two Grauer's gorillas and four mountain gorillas have had a very poor success rate. Four of these individuals died or disappeared within weeks of release (Beck, 2019; Gray et al., 2005; Shalukoma, 2000); however, three of them were too young to survive without a lactating mother. Notably, two of the mountain gorillas were reintegrated when returned to their natal groups within days of separation (Morris, 1995; Mudakikwa, 2002) and one survived into adulthood. Translocation of western lowland gorillas (*Gorilla gorilla gorilla*) in Congo and Gabon had higher survival rates. Beck (2019) summarised five of those releases: whilst annual birth rate and other demographic parameters (annual survival rate, first year survival of infants) of the translocated population did not differ significantly from wild gorillas, survival rates were improved in later releases by the involvement of project personnel experienced in planning and implementation. Latterly, gorillas were encouraged into the forest as soon as possible to prevent continued dependence on humans and subsequent aggression towards humans, which had occurred in some earlier releases (King et al., 2012). Beck (2019) attributed the high survival rate of these gorillas to intensive and extended pre-release preparation, post-release monitoring and post-release support. The experience of King and Courage (2008) when introducing subadult females to other released gorillas is also informative. They suggested that the following factors were important: monitoring the oestrus cycles of rehabilitant females to time introductions, minimising the presence of people familiar to the released gorillas at the time of release to avoid defensive aggression by the silverback, and adequate time to adapt to the release site.

Crucial to translocation planning is understanding the natural behavior and ecology of a species, namely the characteristics that may help or hinder adaptation. Gorillas are gregarious and several aspects of their socioecology will be advantageous to translocation outcomes: i) they live in stable, polygynous groups led by a dominant male and are not territorial (Harcourt and Stewart, 2007); ii) they are among the few primates characterised by female transfer and most female mountain gorillas transfer from one group to another at least once during their lifetime (Watts, 1996); iii) emigration from her natal group is the female gorilla's dispersal mechanism, so a translocated female will have a good chance of being accepted by an unfamiliar group if she behaves appropriately; and iv) as female gorillas seek the protection of a mate, translocated individuals are more likely to try to join a group than to remain alone. In addition, once socially integrated, a released individual will not only be protected by the male group leader, but she will also benefit from his knowledge of the habitat in general and home range in particular, including food sources and potential dangers. Furthermore, gorilla groups are socially cohesive and coordinate their daily activities, which will enhance a released female's chances of survival. On the other hand, if adult male gorillas reside at a release site, physical aggression between resident and released males could result in death (lethal aggression between adult males has been documented in mountain gorillas; Williamson, 2014; Rosenbaum et al., 2016). Given that two adult males currently reside at Mt. Tshiaberimu, and that sexually mature females are needed to boost immediate breeding opportunities, no males should be translocated into this population in the near future (see also Appendix 4).

Based on behavioural considerations, and to facilitate management of the process and limit risks, we recommend that three or four female gorillas form the first cohort to be translocated. This recommendation is supported by population viability modeling, which determined that supplementing the Mt. Tshiaberimu population with just two or three females could limit the risk of extinction of these gorillas (Iyer et al., 2023). To foster the GRACE gorillas' release potential, we recommend several management actions, which include monitoring their nest-building competence, feeding behavior and use of outdoor enclosures. Safety and management systems permitting, providing opportunities for the gorillas to stay out overnight will be important physical and psychological preparations for the move. Likewise, the introduction of

bamboo to the diet will be important as bamboo is a major food source at Mt. Tshiaberimu (Syaluha, 2018). The gorillas' health and welfare will be central to translocation planning and success, and in deciding which individuals to release and which will remain at the sanctuary. The translocated gorillas will have to adapt to significant changes when they are taken from a safe environment to one that is much less predictable. Hence the transition will need to be a 'soft' release (Beck et al., 2007), involving pre- and post-release strategies, such as pre-release acclimatization in an environment similar to the release site, timing the move to take into account seasonal changes in food availability and climate, observational health monitoring, and initially supplementary feeding to support the gorillas' adjustment to Mt. Tshiaberimu. Selection of the individuals to release will involve future consultations between gorilla caregivers, GRACE managers and technical advisors. Further consultation and planning will help management to decide when and how to separate translocation candidates from the other gorillas at the sanctuary, and to put in place transportation protocols (for transfer to an interim facility at the release site), post-release monitoring and contingency planning. Given the urgency of assisting recovery of the Mt. Tshiaberimu population, it will be most beneficial if the translocated gorillas are capable of conceiving soon after their social integration; hence, reproductive females should be the first priority for release.

Population viability analysis has shown that the isolated Mt. Tshiaberimu population is currently too small to become viable without reinforcement (Iyer et al., 2023); therefore, ensuring the gorillas' survival cannot be achieved through alternative conservation measures alone. Conversely, reinforcement of this population is unlikely to succeed without significant investment in other conservation activities to control poaching and human encroachment of the habitat. Rescue of this Grauer's gorilla population could trigger additional resources, multiply efforts and benefit a number of other rare and endemic species (e.g., owl-face monkeys *Cercopithecus hamlyni*, Shelley's crimsonwing *Cryptospiza shelleyi*), adding to the overall ecosystem health and ecological services, and supporting the local economy by creating jobs for protected area management and gorilla monitoring, and community development initiatives. These benefits will accrue only if the translocation succeeds. Sadly, insecurity in eastern DRC will be a significant challenge to the success of this program. Reinforcing active protection through effective law enforcement and the constant presence of rangers will be crucial to ensuring the gorillas' survival, including carrying out rigorous and regular risk assessments before plans for reinforcement are pursued. If, when evaluated, the risks are judged too high, the translocation will not go ahead.

Critically, strong government commitment already exists for a gorilla reinforcement at Mt. Tshiaberimu, and a partnership between Virunga National Park, GRACE and Re:wild is in place, together with financial commitments for the translocation and long-term protection of both gorillas and habitat. Therefore, our assessment of translocation opportunities for the Grauer's gorillas at GRACE is that there is strong potential for a reinforcement at Mt. Tshiaberimu to have a positive conservation outcome without posing undue risk to wild conspecifics or other great ape taxa.

Translocating Grauer's gorillas to any other protected site in the subspecies' geographic range would pose unacceptable risks to resident gorillas and – where they are sympatric – to chimpanzees. However, our analyses highlighted that the other sites we assessed, Balala and Tayna, harbor rare and endemic species, and are of immense value for their biodiversity and ecosystem services (e.g., Greenbaum and Chifundera, 2012; Plumpton et al., 2015a; UGADEC and ICCN, 2008) and thus merit strengthened protection. Regardless of the suitability of these sites for translocation, it is of utmost importance that efforts are strengthened to protect Grauer's gorillas throughout their range.

5. Conclusions

This paper highlights the complex but vitally important due

diligence required when considering any translocation, particularly in gathering and assessing the data necessary to safeguard wild populations and habitats. The extent of planning conducted here may seem out of reach for many projects, especially those involving species that attract less funding, or which will be released in greater numbers. We were able to collate enough information to answer key questions about the release sites proposed, and about likely risks and benefits of supplementing a wild population. Although some baseline data were not available during the site assessments (e.g., seasonal fluctuations of food availability at Mt. Tshiaberimu and the gorillas' use of the habitat), these knowledge gaps must be addressed before any gorillas are released. Many species and habitats are not well documented, and practitioners will face challenges assembling a robust dataset to analyse feasibility and risks. Nonetheless, it is critical that translocations are not poorly planned experiments—the risks to wild populations and their habitats, other resident wildlife and ecosystems, the released animals, program staff, other support personnel and neighboring human communities are too great. Where translocation is feasible and can uphold the precautionary principle, it is important that the upscaling of the human and financial resources that will be needed for effective implementation is not underestimated. We urge organizations considering translocation to focus on conservation goals and to build strategic partnerships to ensure that they will be able to meet the precautionary principle and, if this will not be possible, to forego translocation in favor of alternative conservation actions with lower risks.

Funding

We gratefully acknowledge the Arcus Foundation (Grant number G-PGM-2012-3348) and Re:wild for their support of this project.

CRediT authorship contribution statement

Elizabeth A. Williamson: Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Kay H. Farmer:** Writing – original draft, Methodology, Investigation, Conceptualization. **Julie Sherman:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Conceptualization, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Most data will be made available upon reasonable request; some of the data are confidential.

Acknowledgements

For their input throughout the assessment and planning process, the authors are indebted to Sonya Kahlenberg, Katie Fawcett, Tommi Wolfe and the GRACE DRC team, especially Jackson Kabuyaya Mbeke and Dalmas Kakule, and to Emmanuel de Merode and Virunga National Park staff, especially Laura Parker, Jacques Katutu and Benoit Ishaba. We also thank Dirck Byler and Mary Brown of Re:wild. For generously sharing their knowledge and experience, our sincere appreciation goes to Paul Aczel, Dominique Bikaba, Dan Bucknell, Damien Caillaud, Simon Childs, Mike Cranfield, Christina Ellis, Marc Fourrier, Deo Kujirakwinja, Jean Claude Kyungu, Boo Maisels, Oscar Maldonado, Angela Meder, Dario Merlo, Urbain Ngobobo, Stuart Nixon, Omer Paluku, Andrew Plumptre, Glenn Raynor, Claude Sikubwabo, Charles Sadi Simbi, Casey Slaughter, Eddy Kambale Syaluha, Angeliq Todd and the GRACE

advisors. For input at the early stages of planning, we thank Wildlife Impact's Ape Reintroduction Committee members Susan Cheyne, Tatyana Humle, Liz Macfie, Anne Russon and Serge Wich. The authors are grateful to Maria Voigt for producing the map in Fig. 1. Thanks are also extended to Christine Caurant, Thalia Liokatis, David Lucas and Steve Unwin for their reviews and contributions to the analyses. The manuscript was greatly improved by feedback from the editor and an anonymous reviewer.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.biocon.2024.110521>.

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