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1 **Title:**

2 Promoting ex-situ management risks being a dangerous and costly distraction from conserving
3 species in the wild: Response to Farhadinia et al. 2020

4

5 **Article:**

6 Conservation of endangered species may include establishing ex-situ populations to provide
7 insurance against extinction in the wild. Farhadinia et al. (2020) looked at the use of ex-situ
8 management for 43 species, subspecies and subpopulations of mammalian megafauna, finding that
9 approximately a third of these taxa currently have no ex-situ populations and for 23% that do, the
10 ex-situ population is not currently viable. They argue that bringing these species, particularly those
11 found in “politically unstable” regions, into captivity should be “considered more rigorously”.

12 Whilst we agree that, in certain cases, ex-situ management can provide an important safety
13 net to prevent species extinctions, it is not a panacea. Negative conservation impacts may arise
14 throughout the establishment of ex-situ populations, and species-specific biological factors influence
15 whether ex-situ management (and ultimately reintroduction/reinforcement) is appropriate.
16 Although these considerations should be central to decisions about initiating ex-situ management,
17 they were disregarded by Farhadinia et al. Here, we address this gap and identify issues that may
18 arise during the establishment, management, and release of ex-situ populations.

19 *Initiating captive populations*

20 Of 43 taxa included in the original paper, 15 were assessed as having no ex-situ management,
21 with a further 10 where their current ex-situ population is too small to avoid risks of inbreeding
22 depression. Consequently, effective ex-situ management of these 25 species would require
23 individuals to be captured from wild populations. Farhadinia et al. used an effective population size
24 of >50 individuals to indicate a viable population, without considering the difference between actual

25 population size (N) and effective population size (N_e) in captive populations. The average ratio of
26 $N:N_e$ is 0.26 (max 0.7; Lees & Wilcken 2009), for an N_e of 50, the ex-situ population would need 70 –
27 190 individuals; therefore, at least 5 additional taxa do not currently have sustainable captive
28 populations. For half of these 30 taxa, creating a sustainable ex-situ population would require
29 capturing 50% to 100% of their wild population. When wild populations are very small, as is the case
30 for many Critically Endangered (CR) taxa, they are vulnerable to stochastic events and inbreeding
31 depression. Therefore, removing enough individuals from these populations to avoid inbreeding in
32 ex-situ populations poses an additional threat to their survival in the wild, and in the case of some
33 CR taxa, would make them extinct in the wild, as was the case for red wolf (*Canis rufus*; Hinton et al.
34 2017).

35 The practicality of establishing effective ex-situ populations in “politically unstable” regions is
36 another key concern. Ex-situ management is substantially more expensive than in-situ management
37 (Balmford et al. 1995) and many countries have insufficient resources to effectively manage and
38 maintain captive populations, especially during armed conflicts where local resources and foreign
39 aid are likely to be diverted elsewhere. Moving endangered species to other countries can be
40 appropriate and effective when undertaken in collaboration with range governments and wildlife
41 authorities. However, amidst political turmoil and/or periods of unrest, these agencies are likely to
42 be stretched in their capacity to adequately engage with these initiatives; removing biodiversity
43 under such circumstances may raise legitimate allegations of exploitation and neocolonialism
44 (Hayward et al. 2018).

45 *Maintaining a captive population*

46 Ex-situ management is extremely complex, with species often having complicated husbandry
47 requirements for survival, health, and reproduction. These requirements are usually identified over
48 many years of experience in captive management, often through trial and error. For example,
49 although all female cheetahs (*Acinonyx jubatus*) breed in the wild (Laurenson et al. 1992), a

50 substantial proportion do not successfully breed in captivity, even when kept in optimal conditions
51 (Wachter et al. 2011). Thus ex-situ management is unlikely to serve as comprehensive insurance for
52 two CR subspecies of cheetah (*A. j. hecki* and *A. j. venaticus*), particularly as moving individuals into
53 captivity will reduce their effective population size and further threaten their viability in the wild.

54 Difficulties in providing appropriate conditions to foster natural behaviour and reproduction in
55 captivity hinders the maintenance of genetic diversity. Moving large mammals between institutions
56 for breeding has welfare implications and is very expensive, with no guarantee of successful
57 reproduction. Assisted reproduction is becoming more widely used but it is an invasive, expensive
58 procedure which is, for many endangered species, untested and experimental (Weise et al. 2014).

59 *Reintroduction/reinforcement*

60 The ultimate objective of ex-situ conservation should be reintroduction/reinforcement of wild
61 populations, however preparing animals for release is a complicated process particularly for species,
62 such as large carnivores, that rely on complex and learned behaviours to survive in the wild. Young
63 predators learn many of their skills from their mothers; whilst some hunting related behaviours may
64 be innate, predator and human avoidance behaviours are usually learnt (e.g., in cheetahs; Durant
65 2000), yet have a direct impact on the likelihood of an animal surviving post-release (Tetzlaff et al.
66 2019). Training animals to hunt and forage effectively in a captive setting is difficult, time-
67 consuming, and expensive, with no guarantee of success. In addition, reintroductions ultimately
68 depend on the timely cooperation of ex-situ institutions making their, often valuable, captive
69 populations available for release into the wild, which is not guaranteed.

70 Finding suitable areas for release is also challenging, particularly when concurrent in-situ
71 conservation efforts are absent or limited, as the original threats to the species may persist.
72 Reinforcing extant populations with captive individuals will put additional pressure on available
73 resources, and may result in intraspecific competition (Hayward et al. 2007), exacerbate human-
74 wildlife conflict and erode potential goodwill (Qin et al. 2015). Equally, if the species has been

75 extirpated at reintroduction sites, then local human populations may have lost coping mechanisms
76 for living alongside the species leading to human-wildlife conflict (Linnell & Cretois 2018).

77 *Additional considerations*

78 Several inconsistencies in the approach used by Farhadinia et al. are cause for concern. Most
79 importantly, their “43 critically endangered species” includes some subspecies, but not others (e.g.,
80 all subspecies of *Gorilla beringei* and *Gorilla gorilla* were included but not all subspecies of *Pongo*
81 *pygmaeus*); as well as two subpopulations, which are not recognised as subspecies (the West African
82 subpopulations of the African wild dog (*Lycaon pictus*) and the African lion (*Panthera leo*)). These
83 inconsistencies have a substantial impact on the figures reported in the paper, depending on which
84 definition of (sub)species is used (Table 1; Appendix Table S1).

85 The existence of armed conflict within a species range was suggested as a reason for
86 implementing ex-situ management. However, as acknowledged in the original paper, periods of
87 conflict do not inevitably lead to conservation harm (Collar et al. 2017). Using conflicts to justify
88 diverting funding from in-situ conservation towards ex-situ management is clearly inappropriate.
89 Likewise, the paper claims that border zones can compromise conservation, but there is no
90 justification given for this generalisation. For 15 taxa, having transboundary ranges was the sole
91 indicator of “political instability” (Table 1), but no evidence was provided showing they are at
92 greater risk because of this. It should also be noted that ex-situ populations are also susceptible to
93 political instability, with captive animals vulnerable to being mistreated and/or killed (Kinder, 2013).

94 *Conclusion*

95 Farhadinia et al. suggest using “ex-situ management as an insurance against extinction”, but
96 insurance does not always pay out: for example the northern white rhino (*Ceratotherium simum*
97 *cottoni*) is effectively extinct in the wild despite years of intensive ex-situ management, costing
98 substantial amounts of money (Gibbens 2018).

99 Whilst we agree that ex-situ management can be an important aspect of species conservation,
100 which has been effective for certain species, its use should be considered on a species-by-species
101 basis, incorporating biological, ecological and socioeconomic information rather than broad-stroke
102 generalisations based on threat levels and inferences about range country governance. The
103 difficulties associated with ex-situ management and reintroduction/reinforcement discussed here
104 are not exhaustive, with multiple species-specific issues affecting different taxa. Such difficulties may
105 explain why very few of these species have been the subject of successful releases.

106 Ex-situ management is very resource intensive and often depletes limited in-situ resources
107 and efforts, with no guarantee of success, particularly for species with complex behaviours and/or
108 threats. Where sufficient species-specific data are available, robust decision trees, using input from a
109 range of stakeholders and experts, can be useful tools for determining whether ex-situ management
110 may be appropriate (e.g., Canessa et al. 2016). The five-step process proposed by IUCN Species
111 Survival Commission (IUCN SSC 2014) provides best practice guidelines on when ex-situ
112 management is likely to augment conservation efforts, but mammalian megafauna (especially large
113 carnivores) often do not meet these conditions due to their intrinsic characteristics.

114 Generalised endorsement of ex-situ management as an insurance against the extinction of
115 megafauna, in the absence of more pragmatic recommendations, risks being an expensive
116 distraction from addressing the real threats faced by many species in the wild. We, therefore, argue
117 that in-situ conservation should remain the primary focus of species conservation; ex-situ
118 management as a tool to recover a species should only be initiated as a last resort after using IUCN
119 SSC best practice guidelines.

120

121 **Supporting Information**

122 Detailed species data (Appendix S1), Notes on the inconsistencies observed in species data from
123 Farhadinia et al. 2020 (Appendix S2) are available online. Authors are solely responsible for the
124 content and functionality of these materials. Queries (other than absence of the material) should be
125 directed to the corresponding author.

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- 173

Tables

Table 1. Differences in the figures obtained based on the species definition used. (ssp: subspecies). Alternative's detailed data are available in Supporting Information.

	From Farhadinia et al. 2020: includes some Recognized ssp, but not all and subpopulations that are not recognised ssp	Alternative 1: Recognized ssp used where possible, if no Red List entry for the ssp then the parent species Red List is used	Alternative 2: Recognized ssp used where possible, if no Red List entry for the ssp then it is inferred from information in the parent species Red List	Alternative 3: Exclude all ssp, use only the Red List entry for parent species
Number of taxa	43	38	42	21
Number of range countries	54	49	55	32
Number of taxa with total in-situ population <250	24	20	22	8
Number of taxa with total in-situ population >1000	8	9	9	7
Percentage of taxa where population trend is decreasing	86.05	86.84	80.95	90.48
Percentage of taxa where ranges cross national boundaries	48.84	42.11	38.1	38.1
Percentage of taxa with armed conflict in range	30.23	28.95	28.57	28.57
Number of taxa with no ex-situ population – international	23	19	21	9
Number of taxa with no ex-situ population – national	15	12	13	6

Percentage of taxa with no ex-situ and ranges crossing international boundaries & conflict zones	73.33	66.67	75	57.14
Percentage of taxa with no ex-situ and ranges crossing conflict zones	26.67	25	33.33	14.29
