SPATIALLY EXPLICIT STRATEGIC ACTION PLAN FOR THE RECOVERY OF THE NORTHERN LION IN AFRICA 2023–2027

PART A:

TECHNICAL AND SCIENTIFIC REVIEW

Lion Recovery Fund

SPECIES SURVIVAL COMMISSION
CAT SPECIALIST GROUP

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GLOSSARY

Core area	Core area of suitable habitat and management effectiveness (typically within a Key Lion Area)
EAZA	European Association of Zoos and Aquaria
Hybridisation zones	Regions where genetically distinct populations meet, mate, and produce at least some offspring of mixed ancestry
Genetic lineages (or pedigree)	A series of mutations that connect an ancestral genetic type (allele, haplotype, or haplogroup) to derivative (original) type
Key Lion Area	Areas with significant potential for lion recovery
Mitochondrial DNA	The circular chromosome found inside the cellular organelles called mitochondria
Nuclear DNA	The genetic material from two patents, the nucleus therefore contains pairs of chromosomes
Panmictic	Random mating within a breeding population of a subspecies
Paper Park	Protected area with little to no management effectiveness or capacity often overrun by pastoralists, resident agriculturalist, or fishermen, and often deforested and used for mining
Pastoralism	Extensive livestock production system that involves the tracking and use of grazing and water across a given landscape (normally a “rangeland”). Normally practiced in dryland areas, mobility is key to this system
Pastoralists	People who practice pastoralism as a livelihood system
Phylogeographic	The study of the link between geography and intraspecific genetic diversity, focuses on the temporal and spatial scales between the evolution of new species and the establishment of current ecological patterns, such as species’ geographic ranges
Precision of estimates	A measure of how close an estimate is expected to be to the true value of a population parameter. This measure is based on the degree of similarity among estimates of a population parameter if the same sampling method were repeated
Subspecies	A category in biological classification that ranks just below a species and includes a physically recognizable and geographically separate group of individuals whose members can breed successfully with members of other subspecies of the same species where their ranges overlap
Transhumance	Seasonal movement of livestock from summer to winter rangeland and may include temporary invasion of protected areas by pastoralists

EXECUTIVE SUMMARY

Chapter 1: Introduction. In Africa, the northern lion (*Panthera leo leo*) predominantly occurs in West and Central Africa. The subspecies also extends eastwards into an overlap zone with *Panthera leo melanochaita* in North-East Africa (→ Fig. 1.1). Lions occurring further south in Gabon and southern Democratic Republic of Congo are believed to be *Panthera leo melanochaita* (→ Section 1.1 and 1.2). The 2006 IUCN regional strategy for West and Central Africa identified a key need for additional lion surveys and status assessments (→ Section 1.3.1). In West Africa, intensive surveys conducted over the next 5–10 years indicated that in many of the identified Lion Conservation Units (LCUs) lion populations were already extirpated (→ Table 1.1 and Fig. 1.2a). In Central Africa, it is not feasible to estimate lion numbers in some of the large-sized Lion Conservation Units. Survey efforts in core areas, however, indicated that some lion populations are not faring better than in West Africa. In the North-East, most population estimates remain guesses due to limited surveys of certain core areas (→ Table 1.1).

We propose Key Lion Areas (→ Section 1.3.2) that describe: (1) core areas of current conservation efforts that have a good chance of lion recovery, (2) core areas that lack conservation efforts but have a good chance of leading to lion recovery, (3) core areas where lions could be reintroduced, and (4) corridors between core areas. A Key Lion Area thus is typically a landscape or part of an ecosystem with a core area of suitable habitat and management effectiveness that favours lions, often surrounded by areas of lower conservation designation and less effective conservation management or is linked to other Key Lion Areas by existing or potential corridors. For each Key Lion Area, the presence of lions was mapped (→ Fig. 1.2b) using the classification of the IUCN Red List (Extant, Possibly Extant, Possibly Extinct, Extinct, and Presence Uncertain, → Section 1.3.3). Across most of the extant range of the northern lion, the situation has become critical in terms of numbers and probability of persistence (→ Table 1.1). In West Africa, the population is estimated at 220 individuals, with 91% of them living in the W-Arly-Pendjari complex (→ Section 1.4.1 and 1.4.2). As such, with a population of less than 250 individuals with more than 90% of the population belonging to a single subpopulation, it is listed as Critically Endangered. In India, on the other hand, northern lions are doing better due to improved protection and better habitat management (→ Section 1.4.3).

Chapter 2: Lion biology and ecology in West and Central Africa. Across Central and West Africa, lions tend to prey on medium-sized prey (<200 kg) about as often as they prey on large prey (→ Section 2.1). However, based on scat-based studies rather than carcass-based ones, a different prey pattern emerged with lions also predating on small to very small-sized prey, and large prey predominating lions' diet throughout much of their range. Livestock (predominantly cattle) comprised part of the diet in a few studies. This is known to result in retaliatory persecution by herdsmen. However, as with most protected areas in Central and West Africa, livestock attacks were strongly influenced by herders driving their cattle into the park for forage and water. Lions did, however, prefer wild prey over livestock when relative abundances were considered (→ Section 2.1). In this report, potential ecological thresholds (carrying capacity) for lions were estimated based on available resources at the time using the preferred prey species approach (→ Appendix A-1). Reaching these estimated ecological thresholds, however, is unlikely in most northern lion populations due to significant human influences. The estimated ecological thresholds are thus only a guide to potential for lion populations if all human influences could be adequately addressed. Studies on lion's home range and habitat use are quite rare in Central and West Africa (→ Section 2.2). Most home range

estimates are for Bénoué and Waza National Parks in Cameroon and Pendjari National Park in Benin. When compared with lion home range estimates for Pendjari and Bénoué, those in Waza National Park were about three times larger. Lion home ranges in Waza are most likely so much larger because of different habitat types and lower prey densities. Throughout Central and West Africa, lions live at low to very low densities relative to area size, typically <3 lions/100 km² (→ Section 2.3). One of the reasons for this is that throughout the region, there is generally low lion prey biomass due to poor quality soils. Although one might assume that northern lions are socially and ecologically different from Eastern and Southern lions, their social composition and prey selection do not support this (→ Section 2.4). Further studies will be needed at sites where prey biomass and species composition has recovered with improved management when lions are once again at higher densities.

Chapter 3: Threat and gap analysis. During the IUCN 2006 lion strategy workshops, Lion Conservation Units were categorised as viable (I), potentially viable (II) or significant but of doubtful viability (III; → Fig. 1.2a and Table 1.1). This was based on expert knowledge on population size, prey base, level of threats, habitat quality and area size. The results were useful for the defining of the strategy as they provided insights into threats and opportunities for strategic intervention and population recovery (→ Table 3.1). In Central and West Africa, national governments and statutory authorities often lack the required financial resources and technical capacity to successfully mitigate threats against lions and their prey. Seeking and facilitating collaborative management partnerships has become a vital short- to medium-term solution. However, the longer-term goal must also be to increase financial support and capacity development for park management services within the governments of the region (→ Section 3.1).

The predominant reasons for the decline of northern lions include most of the threats that lions face elsewhere. The most prevalent of these in the region include depletion of their prey base, encroachment into protected areas (mostly by livestock being driven into and residing in protected areas), and various reasons for illegal killing (capturing in traps, hunting for body parts, killing over livestock depredation; → Section 3.2, Fig. 3.1 and Table 3.2). These threats are heightened in West Africa, and parts of Central Africa, by very high human densities outside protected areas. Failure to adequately mitigate these threats is generally the result of critical underfunding of protected area management needs, and lack of capacity in government departments. Throughout the region, an inability to limit damage to protected areas by pastoralist or fundamentalist groups, as well as over-hunting wildlife, has resulted in a virtual collapse of wildlife populations, resulting in particularly severe declines of lions, cheetahs, and African wild dogs.

Throughout its range, the northern lion is generally poorly monitored in terms of population size. Mostly, the methods presently used to survey northern lions are not suitable to reliably detect population change (→ Section 3.3). As is often the case in wildlife conservation in Africa, there has been a much greater investment in aerial surveys done to determine status and trend of herbivores in West and Central Africa. There are, however, still several gaps (→ Section 3.3.2) and surveys have not always been repeated systematically over time. Across most of the protected areas in West and Central Africa, there are significant institutional and organisational capacity shortfalls for protected area management (→ Section 3.4). Thus, many protected areas in the northern lion's range are either 'paper parks' or, if a management presence is apparent, the resources and capacity available is often marginal. This lack of resources and capacity to secure protected areas leads to the expression of the threats described above. These shortcomings, and the need to address them, were highlighted in the

2006 IUCN Lion Conservation Strategies with Lion Conservation Units being identified to prioritise action and recover lion and prey populations.

The result of these threats and shortcomings is that, some time ago, northern lions became largely restricted to core areas inside protected areas within which weak management effectiveness generally continues to result in depleted prey bases and persecution of lions by pastoralists (→ Section 3.5). Protected areas in West and Central Africa that have retained lions are typically larger than protected areas without lions, and often support lion populations in better protected core parts. It is likely that the presence of pastoralists, and the associated density of cattle around many protected areas, are a greater source of illegal killing of lions than is poaching of lions and their prey.

Chapter 4: Enabling factors. Enabling factors to conserve the northern lion population include the protected area network, the *ex-situ* population, (inter)national and regional NGOs, and conservation initiatives and projects supportive of lion conservation. Protected areas in West and Central Africa tend to be smaller than in other parts of Africa, with most being no more than several thousand square kilometres (→ Section 4.1, Fig. 4.1 and Appendix A-1). In many instances formal protected areas such as national parks or game reserves are surrounded by a range of lower designation protected areas such as hunting areas, faunal reserves, etc. Together, these often form a 'complex' (e.g. W-Arly-Pendjari, Bénoué). Transboundary conservation is not a strong focus yet in Central and West Africa, with the only significant transboundary conservation areas being W-Arly-Pendjari and the recently named Bouba Njida-Sena Oura transboundary complex. In the eastern Overlap Zone, two important transfrontier areas include the Badingilo-Boma-Gambella and Alitash-Dinder complexes between South Sudan and Ethiopia and Sudan and Ethiopia, respectively, and well as the Kidepo Valley complex between Ethiopia and Uganda.

The Critically Endangered lions in West and Central Africa are at least in part represented genetically in the captive population in EAZA zoos. Efforts for more targeted breeding of the present captive individuals representing northern lions from Africa are presently undertaken by the EAZA and its lion holders and could ultimately lead to a West and Central African population in captivity (→ Section 4.2).

The NGOs active in the area tend to engage in park support or delegated management partnerships with statutory authorities (→ Section 4.3 and Table 4.1). As far as we can determine, about 650 (74%) of the approximately 855 northern lions estimated to occur in West and Central Africa (→ Table 1.1) currently occur in protected areas with cooperative or delegated management partnerships (→ Table 4.1). Thus, the NGO community has a huge role to play in the management of PAs important for the conservation of the northern lion. The Spatially Explicit Conservation Action Plan (SECAP, Part B) will assist in galvanising this effort, and realising a coordinated and integrated approach, with different players working together to save the northern lion, their prey, and their vital habitats.

As with lion conservation initiatives in most parts of Africa, the three key lion conservation strategies required in the region include: (1) Securing and recovering prey and lion populations in Key Lion Areas, also known as core areas, (2) Securing and maintaining corridors between various Key Lion Areas or simulating connectivity through translocation ('assisted dispersal'), and (3) Effectively mitigating intense human killing and persecution of lions by communities living adjacent to or alongside lions (→ Section 4.5).

Chapter 5: Involvement of local people, national institutions, and transboundary cooperation. Having the right set of actors and enablers together to develop plans at the appropriate scale, and being as

inclusive enough as possible, is vital. Throughout West and Central Africa, a review of community-based programmes outside protected areas needs to be done. In areas surrounding Key Lion Areas, there are often community programmes in place. However, they generally have different funding streams and are not aligned with park support projects. NGOs engaged in park support and management are generally not closely involved with community development or upliftment projects in the areas surrounding the protected areas (→ Appendix A-1, Section 5.1). It is vital to develop and maintain communication forums around all the Key Lion Areas in West and Central Africa. Without the engagement, support and buy-in from all stakeholders, it will be very difficult for governments and park support NGOs to secure protected areas from excessive resource use, even if such is illegal. Each step in the park management and development process should be engaged upon with as broad a base of stakeholders as is possible (→ Section 5.2). National institutions, especially university and other education institutions, should play an important guiding, mentoring, and training leadership role, and be brought into the stakeholder engagement group of each protected area (→ Section 5.3). Generally, protected area management staff in West and Central Africa are challenged by inadequate resources, which is predominantly a financial issue. However, lack of financial resources also affects the abilities and aspirations of staff in terms of desire to develop further (→ Section 5.4). There is a clear need for greater international cooperation and investment in addressing the challenges of park management and community upliftment for most Key Lion Areas. In some cases, these efforts need to be transboundary to be successful (→ Section 5.5). Keeping corridors as functional ecological units without the intrusion of transhumance (→ e.g. TANGO Approach; Fig. 5.1), agriculture, or deforestation, is vital to keep corridors as attractive areas for wildlife to use, and for lions to move through. Key corridors need to be gazetted and have adequate legal status (→ Section 5.6).

Chapter 6: Monitoring the recovery of the northern lion. Tracking population abundance or density is critical for understanding ecological processes, population dynamics, and for effective target-driven conservation planning. However, obtaining robust and repeatable density estimates of animals in natural settings is often practically and technically difficult. This is particularly the case for large carnivores because they naturally occur at low densities and are wide-ranging and often cryptic (→ Chapter 6). Perhaps more so than for any other large carnivore, a wide array of methods has been used to estimate lion density, including direct counts and long-term individual monitoring, camera trapping, distance sampling, and genetic surveys. However, because these techniques are costly and time-consuming index-based approaches, typically track surveys or call-up surveys are the most frequently used methods to estimate lion density and are still recommended in lion management guidelines. Currently, both index-based and spatially explicit mark-capture survey techniques seem set to persist in the region. Practitioners of either approach need support and guidance in how to do these as precisely as possible. Combining all approaches, and looking at each site in turn, it is possible to implement a long-term, spatially explicit, or index-based, monitoring framework for lions across Central and West Africa. During a transition period, it would be advisable to apply index-based surveys and more robust approaches in the same study areas, in order to have a direct comparison, and to demonstrate the pros and cons of both approaches directly (→ Chapter 6). A framework to adapt and utilise for surveys and monitoring of lions across West and Central Africa is presented in Appendix A-2. The results of such surveys need to be conveyed to park managers to guide and refine the actions to secure these populations, including the herbivore prey species. The outputs of multiple replicated lion monitoring initiatives across Central and West Africa (including the overlap zone) would be invaluable in planning, revising and fine-tuning conservation initiatives.

Chapter 7: Summation and conclusions. As lions, other large carnivores, and herbivore prey populations continue to decline in West and Central Africa, we encourage that all interested and affected parties involve themselves in its conservation and recovery. Importantly, governments, non-government organisations, and scientific and conservation institutions need to work together in a coordinated manner towards halting biodiversity loss and ensuring that conservation goals are met. Lions, and large carnivores more broadly, are good surrogate species against which to monitor and evaluate conservation efforts.

The distribution range of the northern lion in Africa is severely fragmented and populations are small, especially in West Africa. Some of these populations are now so isolated and small that – even if further anthropogenic losses could be suppressed immediately – these isolated populations may genetically or demographically no longer be viable. It is therefore important to maintain these small populations as a part of an overall metapopulation of northern lions in Africa. As the exchange of lions with neighbouring populations through dispersal is unrealistic for many of these isolated populations, assisted dispersal will be needed for a shorter or longer period, until natural migration corridors can be established again. Hence, the most promising approach for the time being is to maintain the northern lion population in Africa as a managed metapopulation.

The approaches should integrate lion monitoring and community sensitisation teams employed from local communities with park managers, supported by academics from in country universities and guided by global scientific expertise. This needs to be replicated across as many Key Lion Areas as possible. This is a model that could work and if implemented could eliminate many of the current inadequacies. Many of the extant populations are situated in areas of severe insecurity and implementing conservation programmes there might be difficult (→ Appendix A-1). On the other hand, several protected areas in the region where lions have been extirpated during the past decades today offer ecological and anthropogenic conditions allowing to bring lions back. The approach therefore should be to create and maintain a mosaic of small to medium sized lion populations through strict protection of the remaining source populations, reinforcement of the sink populations, and reintroducing lions to areas that could host (small) populations and so enlarge the overall metapopulation of northern lions.

To achieve the goal to conserve northern lions in Africa as a managed metapopulation, very close transboundary and international, but also cross-sectoral cooperation will be needed. This requires not only an agreement on a common strategy, but also the implementation of coordinated and concerted action and the regular exchange of experiences and sharing data. A platform for all institutions to meet could be the Joint CITES CMS African Carnivores Initiative, under which for instance the hereafter proposed Spatially Explicit Conservation Action Plan (SECAP; Part B) for the northern lion in Africa could be advanced. A common approach with close cooperation between all range countries and partners is an important requirement for the recovery of the northern lion in Africa. Working together and synergistically will also allow time to be saved avoiding replication of effort. Finally, the recovery of the northern lion will require substantial funding. Working together under one strategy will facilitate the generation of the means needed for implementation of all of these conservation projects.

RÉSUMÉ EXÉCUTIF

Chapitre 1 : Introduction. En Afrique, le lion du nord (*Panthera leo leo*) se trouve principalement en Afrique de l'Ouest et centrale. La sous-espèce s'étend également vers l'est dans une zone de chevauchement avec *Panthera leo melanochaita* en Afrique du Nord-Est (→ Fig. 1.1). Il semblerait que les lions présents plus au sud, au Gabon et dans le sud de la République démocratique du Congo, soient des *Panthera leo melanochaita* (→ Section 1.1 et 1.2). La stratégie régionale de l'UICN de 2006 pour l'Afrique de l'Ouest et centrale a identifié un besoin essentiel de suivis supplémentaires et d'évaluations du statut du lion (→ Section 1.3.1). En Afrique de l'Ouest, des suivis intensifs menés au cours des 5 à 10 années suivant la publication de la stratégie ont indiqué que dans de nombreuses Unités de Conservation du Lion (UCL) identifiées, les populations de lion avaient déjà disparu (→ Tableau 1.1 et Fig. 1.2a). En Afrique centrale, il n'est pas possible d'estimer le nombre de lions dans certaines des Unités de Conservation du Lion de grande taille. Les efforts de suivi dans les zones cœurs de ces Unités ont toutefois indiqué que certaines populations de lions ne se portent pas mieux qu'en Afrique de l'Ouest. Dans le Nord-Est, la plupart des estimations de population restent des suppositions en raison des suivis qui sont limités à certaines zones cœurs (→ Tableau 1.1).

Nous proposons des Zones Clés pour le Lion (→ Section 1.3.2) qui représentent : (1) les zones cœurs des efforts de conservation actuels avec une bonne chance de rétablissement des lions, (2) les zones cœurs qui manquent d'efforts de conservation mais qui ont une bonne chance de mener au rétablissement des lions, (3) les zones cœurs où les lions pourraient être réintroduits, et (4) les corridors entre les zones cœurs. Une Zone clé pour le lion est donc typiquement un paysage ou une partie d'un écosystème avec une zone cœur d'habitat favorable et une gestion efficace qui favorise la présence des lions. Celle-ci est souvent entourée de zones où le niveau de conservation est plus faible et la gestion conservatoire moins efficace, ou est reliée à d'autres Zones Clés pour le Lion par des corridors existants ou potentiels. Pour chaque Zone clé pour le lion, la présence des lions a été cartographiée (→ Fig. 1.2b) en utilisant la classification de la Liste rouge de l'UICN (persistant, possiblement persistant, possiblement éteint, éteint et présence incertaine, → Section 1.3.3). Dans la majeure partie de l'aire de répartition où le lion du nord subsiste, la situation est devenue critique en termes d'effectifs et de probabilité de persistance (→ Tableau 1.1). En Afrique de l'Ouest, la population est estimée à 220 individus, dont 91% vit dans le Complexe W-Arly-Pendjari (→ Section 1.4.1 et 1.4.2). À ce titre, avec une population de moins de 250 individus dont plus de 90 % de la population appartient à une seule sous-population, le lion est inscrit dans la catégorie « En danger critique d'extinction ». En Inde, en revanche, les lions du nord se portent mieux grâce à une meilleure protection et une meilleure gestion de l'habitat (→ Section 1.4.3).

Chapitre 2 : Biologie et écologie du lion en Afrique de l'Ouest et centrale. Dans toute l'Afrique centrale et de l'Ouest, les lions ont tendance à prédater aussi bien des proies de taille moyenne (<200 kg) que des proies de grande taille (→ Section 2.1). Cependant, d'après des études basées sur les fèces plutôt que sur les carcasses, un autre modèle de prédation est apparu : les lions prédatent également les proies de petite à très petite taille et les grandes proies prédominent leur régime alimentaire sur la plupart de leur aire de répartition. Quelques études ont mis en évidence que le bétail (principalement les bovins) faisait partie du régime alimentaire. On sait que cela a des répercussions en termes de représailles de la part des bergers. Cependant, dans la plupart des aires protégées d'Afrique centrale et de l'Ouest, les attaques sur le bétail étaient fortement liées à la conduite du bétail dans les parcs par les bergers pour y trouver du fourrage et de l'eau. Les lions préféraient toutefois les proies

sauvages au bétail lorsque les abondances relatives étaient prises en compte (→ Section 2.1). Dans ce rapport, les seuils écologiques potentiels (capacité de charge) pour les lions ont été estimés sur la base des ressources disponibles au moment de l'écriture, en utilisant l'approche de la préférence des proies (→ Annexe A-1). Atteindre ces seuils écologiques estimés est toutefois peu probable dans la plupart des populations de lions du nord en raison d'influences humaines importantes. Les seuils écologiques estimés ne constituent donc qu'un guide du potentiel des populations de lions si toutes les influences humaines pouvaient être traitées de manière adéquate. Les études sur le domaine vital et l'utilisation de l'habitat du lion sont assez rares en Afrique centrale et de l'Ouest (→ Section 2.2). La plupart des estimations de domaines vitaux concerne les parcs nationaux de la Bénoué et de Waza au Cameroun et le Parc National de la Pendjari au Bénin. Comparées aux estimations des domaines vitaux des lions à la Pendjari et à la Bénoué, celles au Parc National de Waza étaient environ trois fois plus importantes. Les domaines vitaux des lions à Waza sont probablement beaucoup plus grands en raison de la différence entre les types d'habitats et du fait de densités de proies plus faibles. Dans toute l'Afrique centrale et de l'Ouest, les lions vivent à des densités faibles, voire très faibles par rapport à la taille de la zone, avec généralement <3 lions/100 km² (→ Section 2.3). L'une des raisons de cette situation est la faible biomasse en proies, en général, en raison de la mauvaise qualité des sols dans toute la région. Bien que l'on puisse supposer que les lions du nord sont socialement et écologiquement différents des lions d'Afrique de l'Est et australe, leur composition sociale et leur sélection de proies ne confirment pas cette hypothèse (→ Section 2.4). D'autres études seront nécessaires sur les sites où la biomasse des proies et la composition des espèces ont été restaurées grâce à une meilleure gestion, lorsque les lions seront à nouveau présents à des densités plus élevées.

Chapitre 3 : Analyse des menaces et des lacunes. Au cours des ateliers sur la stratégie du lion organisés par l'UICN en 2006, les Unités de Conservation du Lion ont été classées comme viables (I), potentiellement viables (II) ou importantes mais de viabilité douteuse (III ; → Fig. 1.2a et Tableau 1.1). Cette classification était basée sur les connaissances des experts de la taille des populations, des proies, du niveau de menaces, sur la qualité de l'habitat et la taille de la zone. Les résultats ont été utiles pour la définition de la stratégie, car ils ont donné un aperçu des menaces et des opportunités d'intervention stratégique et de restauration de la population (→ Tableau 3.1). En Afrique centrale et de l'Ouest, les gouvernements nationaux et les autorités statutaires ne disposent souvent pas des ressources financières et des capacités techniques nécessaires pour atténuer avec succès les menaces pesant sur les lions et leurs proies. La recherche et la facilitation de partenariats de gestion collaborative sont devenues une solution vitale à court et moyen terme. Cependant, l'objectif à plus long terme doit également être d'accroître le soutien financier et le développement des capacités des services de gestion des parcs au sein des gouvernements de la région (→ Section 3.1).

Les principales raisons du déclin des lions du nord correspondent à la plupart des menaces auxquelles les lions sont confrontés ailleurs. Les plus répandues dans la région sont la réduction de leurs proies, l'empiètement sur les aires protégées (principalement par le bétail conduit et résidant dans les aires protégées), et la destruction illégale pour diverses raisons (capture dans des pièges, chasse pour des parties du corps, destruction pour déprédation du bétail ; → Section 3.2, Fig. 3.1 et Tableau 3.2). Ces menaces sont renforcées en Afrique de l'Ouest, et dans certaines parties de l'Afrique centrale, par des densités humaines très élevées à l'extérieur des aires protégées. L'incapacité à atténuer ces menaces de manière adéquate est généralement le résultat d'un manque critique de financement des besoins de gestion des aires protégées et d'un manque de capacité dans les services gouvernementaux. Dans toute la région, l'incapacité à limiter les dommages causés aux zones protégées par les éleveurs ou les

groupes fondamentalistes, ainsi que par la chasse excessive de la faune sauvage, ont entraîné un quasi-effondrement des populations d'animaux sauvages, avec pour conséquence des déclins particulièrement graves des populations de lions, de guépards et de lycaons.

Dans toute son aire de répartition, la taille des populations de lions du nord est généralement mal suivie. En particulier, les méthodes actuellement utilisées pour recenser les lions du nord ne sont pas adaptées pour détecter de manière fiable les changements de population (→ Section 3.3). Comme c'est souvent le cas dans le domaine de la conservation de la faune en Afrique, on a beaucoup plus investi dans les suivis aériens réalisés pour déterminer le statut et la tendance des populations d'herbivores en Afrique de l'Ouest et centrale. Il existe cependant encore plusieurs lacunes (→ Section 3.3.2) et les suivis n'ont pas toujours été répétés systématiquement dans le temps. Dans la plupart des aires protégées d'Afrique de l'Ouest et centrale, il existe d'importantes lacunes en matière de capacités institutionnelles et organisationnelles pour la gestion des aires protégées (→ Section 3.4). Ainsi, de nombreuses aires protégées dans l'aire de répartition du lion du nord sont soit des "parcs sur le papier uniquement", soit, si une gestion existe bien, les ressources et les capacités disponibles sont souvent marginales. Ce manque de ressources et de capacités pour sécuriser les aires protégées conduit à l'expression des menaces décrites ci-dessus. Ces lacunes et la nécessité d'y remédier, ont été soulignées dans les 2006 Stratégies de conservation du lion de l'UICN, avec l'identification d'Unités de Conservation du Lion afin de donner la priorité à l'action et de rétablir les populations de lions et de proies.

Ces menaces et ces lacunes ont pour résultat que les lions du nord sont depuis quelque temps largement limités aux zones cœurs à l'intérieur d'aires protégées au sein desquelles la faible efficacité de la gestion continue généralement à entraîner un appauvrissement des proies et la persécution des lions par les éleveurs (→ Section 3.5). Les aires protégées d'Afrique de l'Ouest et centrale qui ont conservé des lions sont généralement plus grandes que les aires protégées sans lion et hébergent souvent les populations de lions dans des zones centrales mieux protégées. Il est probable que la présence d'éleveurs et la densité de bétail associée autour de nombreuses aires protégées, constituent une source plus importante de destructions illégales de lions que le braconnage des lions et de leurs proies.

Chapitre 4 : Facteurs de réussite. Les facteurs facilitant la conservation de la population de lions du nord incluent le réseau d'aires protégées, la population ex-situ, les ONG (inter)nationales et régionales, ainsi que les initiatives et projets de conservation qui soutiennent la conservation du lion. Les aires protégées en Afrique de l'Ouest et centrale ont tendance à être plus petites que dans d'autres régions d'Afrique, la plupart ne dépassant pas plusieurs milliers de kilomètres carrés (→ Section 4.1, Fig. 4.1 et Annexe A-1). Dans de nombreux cas, les aires formellement protégées, telles que les parcs nationaux ou réserves, sont entourées d'une série d'aires protégées de désignation inférieure, telles que des zones de chasse, des réserves fauniques, etc. Ensemble, elles forment souvent un « complexe » (par exemple, celui du W-Arly-Pendjari, de la Bénoué). La conservation transfrontalière n'est pas encore une priorité en Afrique centrale et de l'Ouest, les seules zones de conservation transfrontalières significatives étant le W-Arly-Pendjari et le récemment nommé Complexe transfrontalier de Bouba Njida-Sena Oura. Dans la Zone de chevauchement orientale, deux zones transfrontalières sont importantes et comprennent les complexes de Badingilo-Boma-Gambella et d'Alitash-Dinder entre le Soudan du Sud et l'Éthiopie et entre le Soudan et l'Éthiopie, respectivement, ainsi que le complexe de la vallée de Kidepo entre l'Éthiopie et l'Ouganda.

Les lions En danger critique d'extinction en Afrique de l'Ouest et centrale sont, au moins en partie, représentés génétiquement dans la population captive des zoos de l'EAZA. Des efforts pour une reproduction plus ciblée des individus actuellement captifs de lions du nord d'origine africaine sont actuellement entrepris par l'EAZA et ses détenteurs de lions et pourraient finalement aboutir à une population captive de lions d'Afrique de l'Ouest et centrale (→ Section 4.2).

Les ONG actives dans la région ont tendance à s'engager dans des partenariats de soutien aux parcs ou de gestion déléguée avec les autorités statutaires (→ Section 4.3 et Tableau 4.1). Pour autant que nous puissions le déterminer, environ 650 (74 %) des quelque 855 lions du nord dont la présence est estimée en Afrique de l'Ouest et centrale (→ Tableau 1.1) se trouvent actuellement dans des aires protégées avec des partenariats de coopération ou de gestion déléguée (→ Tableau 4.1). Ainsi, la communauté des ONG a un rôle majeur à jouer dans la gestion des aires protégées importantes pour la conservation du lion du nord. Le Plan d'actions de conservation géographiquement explicite (PACGE, partie B) aidera à galvaniser cet effort, et à réaliser une approche coordonnée et intégrée, avec différents acteurs travaillant ensemble pour sauver le lion du nord, ses proies, et ses indispensables habitats.

Comme pour les initiatives de conservation du lion dans la plupart des régions d'Afrique, les trois stratégies clés de conservation des lions requises dans la région comprennent : (1) la sécurisation et le rétablissement des populations de proies et de lions dans les Zones Clés pour le Lion, également appelées zones cœurs, (2) la sécurisation et le maintien des corridors entre les différentes Zones Clés pour le Lion ou la simulation de la connectivité par le biais de translocations (« dispersion assistée »), et (3) l'atténuation efficace des destructions humaines les plus intenses et de la persécution des lions par les communautés vivant à proximité ou aux côtés des lions (→ Section 4.5).

Chapitre 5 : Implication des populations locales, des institutions nationales et de la coopération transfrontalière. Il est vital de réunir le bon groupe d'acteurs et de facilitateurs pour développer des plans à une échelle appropriée, et d'être aussi inclusif que possible. Dans toute l'Afrique de l'Ouest et centrale, un examen des programmes communautaires en dehors des zones protégées doit être effectué. Dans les zones entourant les Zones Clés pour le Lion, des programmes communautaires sont souvent en place. Cependant, ils possèdent généralement des sources de financement différentes et ne sont pas alignés sur les projets de soutien aux parcs. Les ONG engagées dans le soutien et la gestion des parcs ne sont généralement pas étroitement associées aux projets de développement ou de dynamisation des communautés dans les zones entourant les aires protégées (→ Annexe A-1 et Section 5.1). Il est vital de développer et de maintenir des forums de communication autour de toutes les Zones Clés pour le Lion en Afrique de l'Ouest et centrale. Sans l'engagement, le soutien et l'adhésion de toutes les parties prenantes, il sera très difficile pour les gouvernements et les ONG de soutien aux parcs de sécuriser les aires protégées contre une utilisation excessive des ressources, même si celle-ci est illégale. Chaque étape du processus de gestion et de développement du parc doit faire l'objet d'un engagement avec un ensemble de parties prenantes aussi large que possible (→ Section 5.2). Les institutions nationales, en particulier les universités et autres établissements d'enseignement, devraient jouer un rôle important de leadership en matière d'orientation, de mentorat et de formation, et être intégrées au groupe d'engagement des parties prenantes de chaque aire protégée (→ Section 5.3). En général, le personnel de gestion des aires protégées en Afrique de l'Ouest et centrale est confronté à un manque de ressources adéquates, ce qui est principalement un problème financier. Cependant, le manque de ressources financières affecte également les capacités et les aspirations du personnel en termes de désir de se développer davantage (→ Section 5.4). Il existe

un besoin évident de coopération et d'investissements internationaux plus importants pour relever les défis de la gestion des parcs et de la dynamisation des communautés pour la plupart des Zones Clés pour le Lion. Dans certains cas, pour être couronnées de succès, ces efforts doivent être transfrontaliers (→ Section 5.5). Il est vital de conserver les corridors en tant qu'unités écologiques fonctionnelles, sans intrusion de l'élevage transhumant (→ par exemple, l'approche TANGO; Fig. 5.1), de l'agriculture ou de la déforestation, pour que les corridors restent des zones attrayantes pour la faune et pour les lions. Les corridors clés doivent être inscrits au journal officiel et bénéficier d'un statut juridique adéquat (→ Section 5.6).

Chapitre 6 : Suivre le rétablissement du lion du nord. Le suivi de l'abondance ou de la densité d'une population est essentiel pour comprendre les processus écologiques, la dynamique des populations et pour une planification efficace de la conservation axée sur des objectifs. Cependant, il est souvent difficile, d'un point de vue pratique et technique, d'obtenir des estimations robustes et reproductibles de la densité des animaux en milieu naturel. C'est particulièrement vrai pour les grands carnivores, car ils sont naturellement présents à de faibles densités, possèdent une vaste aire de répartition et sont souvent cryptiques (→ Chapitre 6). Peut-être plus que pour tout autre grand carnivore, un large éventail de méthodes a été utilisé pour estimer la densité des lions, incluant les comptages directs et le suivi individuel à long terme, le piégeage photographique, l'échantillonnage à distance et les suivis génétiques. Cependant, comme ces techniques sont coûteuses et prennent du temps, les approches basées sur des indices, notamment les suivis basés sur les traces ou les stations d'appel sont les méthodes les plus fréquemment utilisées pour estimer la densité des lions et sont toujours recommandées dans les directives de gestion du lion. Actuellement, les techniques de suivi basées sur les indices de présence et les techniques de marquage-capture-recapture spatialement explicites semblent persister dans la région. Les praticiens de l'une ou l'autre de ces approches ont besoin de soutien et de conseils pour les réaliser de la manière la plus précise possible. En combinant toutes les approches et en examinant chaque site tour à tour, il est possible de mettre en œuvre un cadre de suivi à long terme, soit spatialement explicite, soit basé sur les indices de présence, pour les lions à travers l'Afrique centrale et de l'Ouest. Pendant la période de transition, il serait conseillé de mener des suivis basés sur des indices de présence et sur des approches plus robustes dans les mêmes zones d'étude, afin d'avoir une comparaison directe, et de démontrer directement les avantages et les inconvénients des deux approches (→ Chapitre 6). Un cadre à adapter et à utiliser pour les suivis et la surveillance des lions à travers l'Afrique de l'Ouest et centrale est présenté en Annexe A-2. Les résultats de ces suivis doivent être transmis aux gestionnaires des parcs pour guider et affiner les actions visant à sécuriser ces populations, y compris les espèces proies herbivores. Les résultats de multiples initiatives de suivi des lions répliquées à travers l'Afrique centrale et de l'Ouest (y compris dans la Zone de chevauchement) seraient inestimables pour planifier, réviser et affiner les initiatives de conservation.

Chapitre 7 : Synthèse et conclusions. Alors que les lions, les autres grands carnivores et les populations de proies continuent à décliner en Afrique de l'Ouest et centrale, nous encourageons toutes les parties intéressées et concernées à s'impliquer dans leur conservation et leur rétablissement. Il est important que les gouvernements, les organisations non gouvernementales et les institutions scientifiques et de conservation travaillent ensemble de manière coordonnée afin d'enrayer la perte de biodiversité et de garantir la réalisation des objectifs de conservation. Les lions et plus largement les grands carnivores, sont de bons représentants permettant de suivre et d'évaluer les efforts de conservation.

L'aire de répartition du lion du nord en Afrique est fortement fragmentée et les populations sont petites, notamment en Afrique de l'Ouest. Certaines de ces populations sont aujourd'hui si isolées et si petites qu'elles pourraient ne plus être viables d'un point de vue génétique ou démographique, même si toutes pertes anthropiques additionnelles pouvaient être supprimées immédiatement. Il est donc important de maintenir ces petites populations dans le cadre d'une métapopulation globale de lions du nord en Afrique. Comme l'échange de lions avec les populations voisines par le biais de la dispersion n'est pas réaliste pour bon nombre de ces populations isolées, la dispersion assistée sera nécessaire pendant une période plus ou moins longue, jusqu'à ce que des couloirs de migration naturels puissent à nouveau être établis. Par conséquent, l'approche la plus prometteuse pour l'instant est de maintenir la population africaine de lions du nord comme une métapopulation gérée.

Ces approches doivent intégrer des équipes de surveillance des lions et de sensibilisation des communautés, recrutées au sein de celles-ci, avec les gestionnaires des parcs, soutenues par des universitaires du pays et guidées par une expertise scientifique internationale. Cette approche doit être répliquée dans autant de Zones Clés pour le Lion que possible. Il s'agit d'un modèle qui pourrait fonctionner et qui, s'il est mis en œuvre, pourrait éliminer bon nombre des insuffisances actuelles. De nombreuses populations existantes sont situées dans des zones de grande insécurité et la mise en œuvre de programmes de conservation pourrait y être difficile (→ Annexe A-1). D'autre part, plusieurs aires protégées de régions où les lions ont disparu au cours des dernières décennies offrent aujourd'hui des conditions écologiques et anthropiques permettant leur retour. L'approche devrait donc être de créer et de maintenir une mosaïque de populations de lions de petite à moyenne taille par une protection stricte des populations sources restantes, en renforçant les populations puits et en réintroduisant des lions dans des zones qui pourraient accueillir des (petites) populations. Cela permettrait ainsi d'élargir la métapopulation globale de lions du nord.

Pour atteindre l'objectif de conservation des lions du nord en Afrique en tant que métapopulation gérée, une coopération transfrontalière et internationale très étroite, mais aussi intersectorielle, sera nécessaire. Cela nécessite non seulement un accord sur une stratégie commune, mais aussi la mise en œuvre d'actions coordonnées et concertées, ainsi que l'échange régulier d'expériences et le partage de données. L'Initiative conjointe CITES-CMS pour les carnivores africains pourrait constituer une plateforme permettant à toutes les institutions de se rencontrer et dans le cadre de laquelle, par exemple, le Plan d'actions de conservation géographiquement explicite (PACGE ; Partie B) proposé ci-après pour le lion du nord en Afrique pourrait avancer. Une approche commune avec une coopération étroite entre tous les pays de l'aire de répartition et les partenaires est une condition importante pour le rétablissement du lion du nord en Afrique. Travailler ensemble et en synergie permettra également de gagner du temps en évitant la répétition des efforts. Enfin, la restauration du lion du nord nécessitera un financement important. Travailler ensemble dans le cadre d'une stratégie unique facilitera la génération des moyens nécessaires à la mise en œuvre de tous ces projets de conservation.

PART A: TECHNICAL AND SCIENTIFIC REVIEW

CHAPTER 1: INTRODUCTION

1.1. DELINEATION OF THE AREA

In Africa, the northern lion (*Panthera leo leo*) predominantly occurs in West and Central Africa. The subspecies also extends eastwards into an overlap zone with *Panthera leo melanochaita* in North-East Africa (Fig. 1.1). Historically, northern lions occurred in all biomes in Central and West Africa, except for the coastal Upper and Lower Guinean Forests and the interior of the Saharan Desert. To the south, the northern lion did not penetrate far into the equatorial forest zone. Thus, lions occurring further south in Gabon and southern Democratic Republic of Congo are believed to be *Panthera leo melanochaita* (Bertola et al. 2022a).

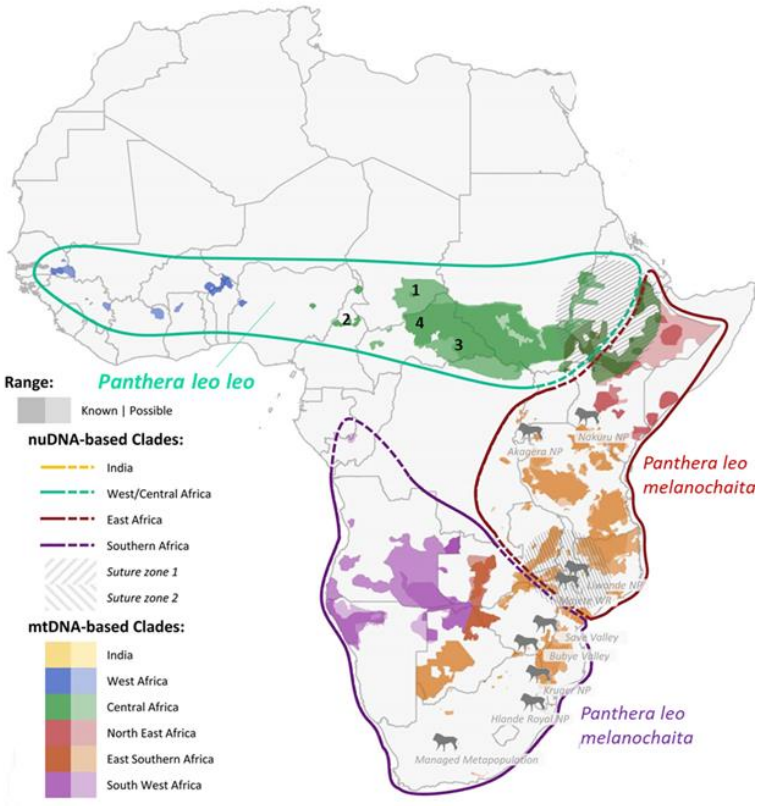

Fig. 1.1 The distribution of genetic variation in the lion, based on previous studies. Colours of the lion range indicate genetic lineages based on mitochondrial DNA; delineation indicates genetic lineages based on nuclear DNA. Natural potential overlap/hybridisation zones are indicated by shading. Dashed lines indicate uncertainty regarding the exact boundary, as this is inferred from available sampling localities and/or suture zones (reproduced from Bertola et al. 2022a). *Distribution de la variation génétique chez le lion d'après des études antérieures. Les couleurs de l'aire de répartition du lion indiquent les lignées génétiques basées sur l'ADN mitochondrial; la délimitation indique les lignées génétiques basées sur l'ADN nucléaire. Les zones de chevauchement/hybridation naturelles potentielles sont indiquées en grisé. Les lignes pointillées indiquent une incertitude concernant la délimitation exacte, celle-ci étant déduite des localités d'échantillonnage disponibles et/ou des zones de suture (reproduit de Bertola et al. 2022a).*

Lions once also ranged from Northern Africa through Southwest Asia, but they disappeared from most Asian countries within the last 150 years. Lions also once ranged west into Europe but became extinct there almost 2,000 years ago (Nowell & Jackson 1996, Sunquist & Sunquist 2002). Today, the only remainder of this once widespread northern population is a single isolated population in the Gir Forest National Park and Wildlife Sanctuary and other parts of the Gujarat State, India. Lions are extinct in North Africa, having perhaps survived in the High Atlas Mountains up to the 1940s (Nowell & Jackson 1996).

1.2 PHYLOGENETIC HISTORY AND TAXONOMIC POSITION

A phylogeographical study of lions by Bertola et al. (2011) indicated that the traditional split between Asian and African lions as distinct subspecies was not supported by mitochondrial DNA analysis. Thus, the IUCN SSC Cat Specialist Group's Cat Classification Task Force (Kitchener et al. 2017) proposed a split into two subspecies, *Panthera leo leo* of Asia and West, Central and North-East Africa, and *Panthera leo melanochaita* from South and East Africa (including eastern Ethiopia and Somalia). In support of this classification, several studies have been subsequently conducted, including samples from more populations and other genetic markers.

Several phylogeographic studies provided insights into the evolution and distribution of genetic variation in lion populations in Africa (subspecies *P. leo leo*) and its connection to the Indian population (formerly subspecies *P. leo persica*). Although the Africa-Asia split was used for a long time to inform management (e.g. there is a separate studbook for Asiatic lions in zoos), this taxonomic distinction has since been reconsidered. Phylogeographic studies have played an important part in this, providing improved understanding of the evolutionary history and relationships between populations. These studies have included data from mitochondrial DNA and described a northern group that includes populations from West and Central Africa as well as the Indian population and a southern group with populations from East and Southern Africa (Bertola et al. 2011, 2016, Barnett et al. 2014). Notwithstanding some challenges in the analyses, the newly described evolutionary relationships for lions were incorporated into the revised taxonomy, which now recognises a northern subspecies (*P. leo leo*) and a southern subspecies (*P. leo melanochaita*; Kitchener et al. 2017).

These challenges, including the fact that results retrieved from mitochondrial DNA represent only a very small and not necessarily representative part of the genome and are confounded by divergent dispersal patterns of either sex. Microsatellite data are useful for assessing within population diversity levels, but less suitable to infer deeper evolutionary lineages, even though also based on those data, a distinction between the northern and the southern subspecies can be inferred (Bertola et al. 2015).

To address this, Bertola et al. (2022a) used the most advanced genomic tools available by generating full genomes for lions throughout their natural range, and mine the genomes for variable sites (single nucleotide polymorphisms, SNPs) across each of the chromosomes. A subset of these variable sites was selected to form a standardised SNP panel that was then used to genotype more than 200 individual lions (samples) from 14 countries that represented almost the entire current distribution of the lion. Results from the whole genomes, as well as the SNP panel data aligned closely with previous studies, supporting the split between the northern populations and southern populations.

Based on the classification from the 2006 Lion Conservation Strategies (IUCN 2006a, b) and Riggio et al. (2013), Bertola et al. (2022b) created a list of 132 Lion Conservation Units (LCUs). They assigned each LCU to a phylogenetic clade based on DNA and mitochondrial DNA patterns, as observed in

previous studies. The resulting map clearly delineates the range of *Panthera leo leo* from that of *Panthera leo melanochaita* (Fig. 1.1). In mtDNA studies, it had already been shown that within the same region in Ethiopia, widely diverged mtDNA haplotypes occur (Bertola et al. 2016), and the presence of mixed individuals was confirmed with both microsatellites (Bertola et al. 2015) and SNP data (Bertola et al. 2022a). The exact geographic extent of the zone is unknown, as it can only be inferred from populations which were sampled in these studies and depends on the reliability of locality data for each of the samples. This overlap zone, and the lion conservation units within them, were incorporated by Bertola et al. (2022b) into a set of guidelines for translocations or re-introductions of lions across the range that would be deemed suitable and minimise loss of genetic heterozygosity and distinctiveness.

Lion range in Africa has gone through many rounds of regional expansions and contractions linked with the expansions and contractions of dense forests and hyper-arid deserts (Nobuyuki pers. comm.). When and where the natural barriers disappear formerly separated populations must have gradually merged initially forming "hybridisation" zone(s). However, as the division between "*leo*" and "*melanochaita*" is the deepest amongst the modern lion, the current and past hybridisation zones between the two have not merged two populations (Nobuyuki pers. comm.) This probably means that gene flows between *leo* and *melanochaita* through hybridisation zone(s) have been quickly diluted within each of the two populations in the past. But it is likely that due to the modern anthropogenic influence, the population of *leo* may nowadays not be strong enough to dilute gene flow from *melanochaita* any longer (i.e., *leo* has been reduced in number more than has *melanochaita*) (Nobuyuki pers. comm.).

1.3 STATUS OF THE NORTHERN LION

1.3.1 Introduction

In 2006, lion conservationists and country representatives met in Douala, Cameroon, to consider the strategic conservation needs of lions (mostly *Panthera leo leo*) in Central and West Africa (IUCN 2006a). This followed a similar workshop in 2005 in Johannesburg, South Africa, for lions in East and Southern Africa (IUCN 2006b). To illustrate current lion range, and to delineate areas for strategic lion conservation efforts, the participants defined ''Lion Conservation Units'' (LCUs) that included all known sites at that time for lions across the two regions in Africa. These were based on the outcomes of preceding technical workshops were experts defined regions classified as supporting lions (Fig. 1.2a; IUCN 2006a, b).

The IUCN (2006a) regional strategy for West and Central Africa identified a key need for additional lion surveys and status assessments. The aim was to assess lion presence in several protected areas where information was lacking. In West Africa, intensive surveys were then conducted over the next 5 to 10 years (e.g. Henschel et al. 2014). These surveys indicated that in many of the LCUs lion populations were already extirpated (Table 1.1). Survey results for Central Africa and the North-East overlap zone are not as prevalent in the published literature. However, recent NGO generated reports are a useful resource for most key lion areas (Table 1.1).

Table 1.1 Lion Conservation Units with as recent as possible survey estimates and literature sources for West, Central and North-East Africa. LCU type: * =areas not designated as LCUs by IUCN (2006a, b). #: identification numbers used in the maps. (Protected) areas: NP = National Park; bold = Proposed Key Lion Areas. Source: ALD = pers. comm. Estimates from the African Lion Database. *Unités de Conservation du Lion (UCL) avec les estimations aussi récentes que possible issues de suivis et de sources bibliographiques pour l'Afrique de l'Ouest, centrale et la Zone de chevauchement du Nord-Est. Type d'UCL : * =zones non désignées comme UCL par l'UICN (2006a, b). #: numéros d'identification utilisés dans les cartes. Zones (protégées) : PN = parc national; en gras = Zones clés proposées pour le lion. Source : ALD = comm. pers. Estimations d'après la Base de données sur le lion d'Afrique.*

LCU	LCU type	Country	#	(Protected) Area	Lion status	Pop. estimate	Source
West Africa							
Niokolo-Guinea	I	Guinea-Bissau	1	Boé and Dulombi NPs	Extinct	-	Henschel pers. comm.
		Senegal	2	**Niokolo Koba NP and Falémé hunting area**	Extant	29 (15–50)	Henschel pers. comm.
		Mali	3	Bafing-Falémé	Extinct	-	Henschel et al. 2014
		Guinea	4	Kankan Faunal Reserve	Extinct	-	Henschel pers. comm.
		Guinea	5	Haut Niger NP	Extinct	-	Henschel pers. comm
Boucle du Baoulé	III	Mali	6	Boucle du Baoulé NP	Extinct	-	Henschel pers. comm.
Comoé-Léraba	II	Côte d'Ivoire	7	**Comoé NP**	Extinct	-	Henschel et al. 2014
Bui-White Volta	II	Ghana	8	Bui NP	Extinct	-	Henschel et al. 2014
Mole	II	Ghana	9	Mole NP	Extinct	-	Henschel et al. 2014
Gbele Ecosystem	II	Ghana	10	Gbele Resource Reserve	Extinct	-	Henschel et al. 2014
Digya	III	Ghana	11	Digya NP	Extinct	-	Henschel et al. 2014
Nazinga-Sissili	*	Burkina Faso	12	Nazinga Game Ranch	Extinct	-	Henschel pers. comm.
Oti-Mandouri	II	Togo	13	Oti-Mandouri National Park	Extinct	-	Henschel pers. comm.
W-Arly-Pendjari	I	Benin, Burkin Faso, Niger	14	**W, Arly and Pendjari NPs and hunting areas**	Extant	155–187	African Parks 2019, 2021
Mt Kouffé/Wari Maro	II	Benin	15	Mt Kouffé/Wari Maro	Extinct	-	Henschel pers. comm.
Old Oyo	III	Nigeria	16	Old Oyo NP	Extinct	-	Henschel pers. comm.
Kainji Lake	II	Nigeria	17	**Kainji Lake NP**	Extant	10–20	Dunn pers. comm. (ALD)
Kamuku/ Kwiambana	II	Nigeria	18	Kamuku NP	Extinct	-	Henschel pers. comm.
				Approximate estimate		**215 (180–257)**	
Central Africa							
Lame-Burra/Falgore	II	Nigeria	19	Falgore and Lame-Burra GR	Extinct	-	Henschel pers. comm.
Yankari	II	Nigeria	20	**Yankari NP**	Extant	<10	Dunn pers. comm.
Waza	II	Cameroon	21	**Waza NP**	Extant	<15	Tumenta et al. 2021
Bénoué complex-Gashaka-Gumti-Sena Oura	I	Nigeria	22	Gashaka-Gumti NP	Extinct	-	Volker pers. comm. (ALD)
		Cameroon	23	**Bouba Njida, Bénoué and Faro NPs and hunting areas**	Extant	250	Bauer et al. 2015
	*	Chad	24	Sena Oura NP	Extant	2	Kirsten pers. comm. (ALD)
Melfi-Rokoum	*	Chad	25	Melfi-Rokoum (included below as part of the Zakouma	Extant	6	Fraticelli pers. comm. (ALD)

				Complex)			
Chad-RCA	II	Chad	26	**Zakouma NP, Siniaka Minia, Bahr-Salamat and Abou Telfan faunal reserves, and Aouk hunting area**	Extant	130	Olléová and Dogringar 2013
		Central African Republic (CAR) CAR	27	**Bamingui-Bangoran and Manovo-Gounda Saint Floris NPs, Vassako Bolo Wildlife Reserve and hunting sectors – Northern CAR**	Extant	20	WCS 2020
			28	**André Félix NP and Yata-Ngaya Faunal Reserve**	Extant	35	Mararv pers. comm. (ALD)
			29	**Greater Chinko Conservation Area**	Extant	108	Aebischer et al. 2020, African Parks 2022
Southwestern Sudan	I	South Sudan	30	Numatina, Chelkou and Boro Game Reserves and Bahr-al-Ghazal Swamp Wilderness	Poss. extinct	Unknown	Aebischer pers. comm.
			31	**Southern NP**	Extant	<20	FFI 2022
Garamba-Bili Uéré Complex	*	DRC	32	Bomu and Bili Uéré hunting areas	Extant	Unknown	Elkan pers. comm.
		DRC and South Sudan	33	**Garamba and Lantoto NPs and hunting zones**	Poss. Extant	43	African Parks (ALD)
				Approximate estimate		**640**	
North-East Africa – Overlap zone							
Sudd wetland	*	South Sudan	34	**Shambe NP and Zeraf Game Reserve**	Extant	Unknown	Elken pers. comm.
Boma-Gambella	I	South Sudan and Ethiopia	35	**Badingilo, Boma and Gambella NPs and the proposed Loelle protected area**	Extant	Unknown	Elken & Hunter pers. comm. (ALD), Yirga et al. 2021
Kidepo Valley South Sudan/Uganda	III	South Sudan and Uganda	36	**Kidepo Game Reserve and Kidepo NP**	Extant	132	Omoya et al. 2014 for Uganda
South Omo	II	Ethiopia	37	**Omo, Borana and Mago NPs, Tama and Chelbi wildlife reserves and hunting areas**	Extant	Unknown	Yirga et al. 2021
Kafa-Chebera-Maze-Nechisar	*	Ethiopia	38	**Kafa, Chebera Churchura, Maze and Nechisar NPs**	Extant	Unknown	Yirga et al. 2021
Bale	II	Ethiopia	39	Bale Mountains Area – Bale, Yabello and Gerale NPs	Extant	Unknown	Yirga et al. 2021
Welmel-Genale	III		40		Extinct		
Ogaden	II	Ethiopia	41	Ogaden region including Easter Hararge Controlled Hunting area and Shebelle-Somali	Extant	Unknown	Yirga et al. 2021
Babile	*	Ethiopia	42	Babile	Extant	Unknown	Yirga et al. 2021
Awash	II	Ethiopia	43	Awash NP and controlled hunting areas and game reserves	Extant	Unknown	Yirga et al. 2021
Dinder-Alitash	*	Sudan and Ethiopia	44	**Dinder, Alitash and Bejimiz NPs**	Extant	30–82	Mohammed et al. 2019
Mao-Komo	*	Ethiopia	45	Mao-Komo	Extant	Unknown	Yirga et al. 2021
				Approximate estimate		**Unknown**	

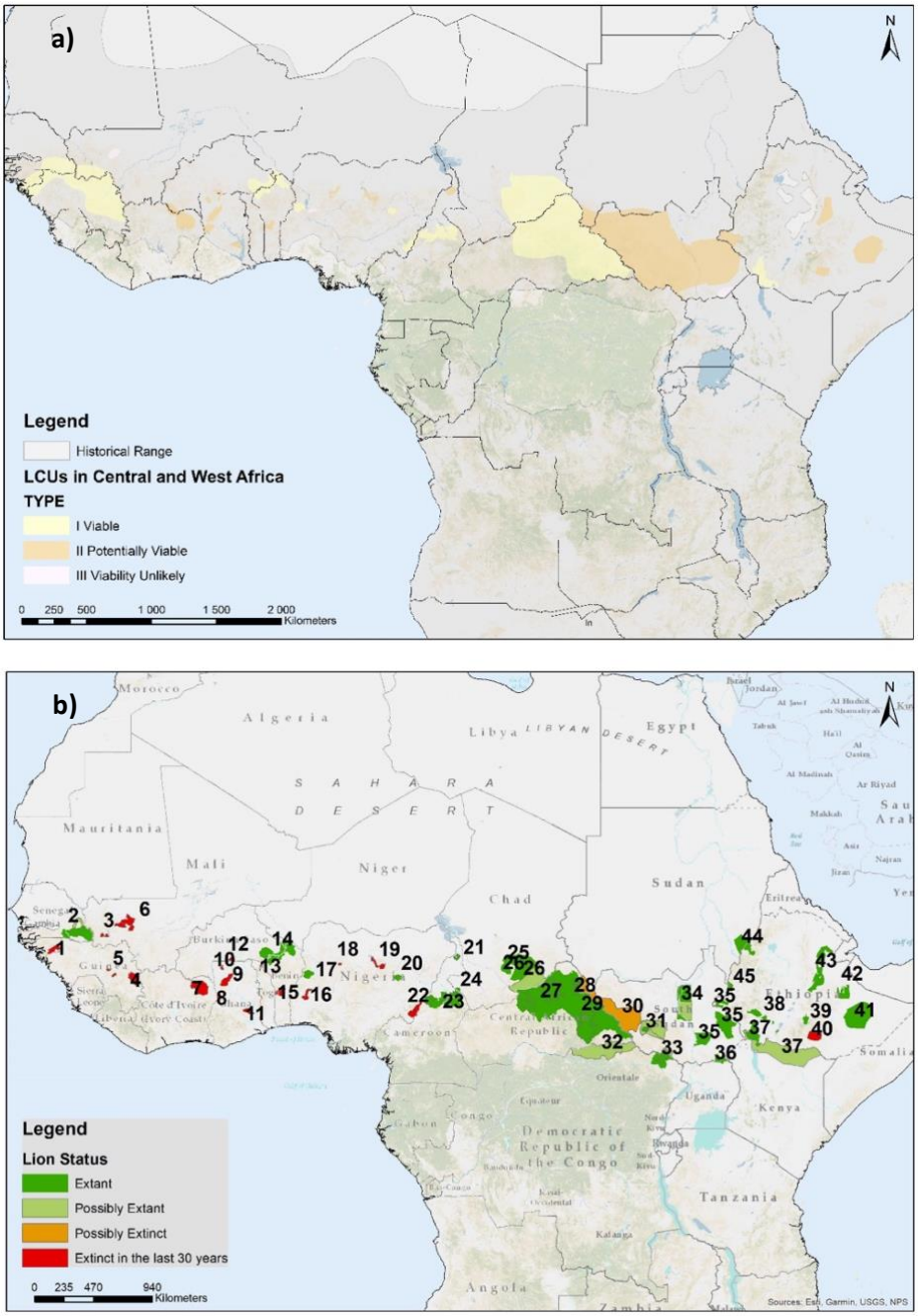

Fig. 1.2 a) Lion Conservation Units (LCUs) as defined for *Panthera leo leo* during the IUCN (2006a) lion strategy process across West and Central Africa and the North-East overlap zone. The viability of each LCU is depicted with pale yellow (viable), pale orange (potentially viable) and white (doubtfully viability), **b)** Key Lion Areas with current lion presence depicted as extant, possibly extant, or extinct within the last 30 years. Numbers correspond to the list of Key Lion Areas in Table 1.1. ***a)*** *Unités de Conservation du Lion (UCL) telles que définies pour Panthera leo leo au cours du processus d'élaboration de la stratégie pour le lion de l'UICN (2006a) à travers l'Afrique de l'Ouest et centrale et la Zone de chevauchement du Nord-Est. La viabilité de chaque UCL est représentée par du jaune pâle (viable), de l'orange pâle (potentiellement viable) et du blanc (viabilité douteuse),* ***b)*** *Zones Clés pour le Lion avec la présence actuelle du lion représentée comme persistante, possiblement persistante, possiblement éteinte ou éteinte au cours des 30 dernières années. Les numéros correspondent à la liste des Zones Clés pour le Lion du tableau 1.1.*

In Central Africa, some of the LCUs are so big that it is not feasible to estimate lion numbers across them. However, survey efforts in core areas indicate that some lion populations here are not fairing as badly as in West Africa. In the North-East, most lion population estimates remain 'guesses' with some limited surveys of certain core areas (Table 1.1). Although survey effort is still required to refine population estimates, these should not detract from a focus on conservation action on the ground. In some areas with no management focus, lion presence surveys would, however, be useful to assess their potential as future key lion areas.

1.3.2 Key Lion Areas

To clearly describe key areas with significant potential for lion recovery we thus propose a set of '**Key Lion Areas**' that describe areas of:

1) core areas of current conservation efforts that have a good chance of leading to lion recovery,
2) core areas that lack conservation efforts but have a good chance of leading to lion recovery,
3) core areas where lions could be re-introduced, and
4) corridors between core areas.

A **Key Lion Area** is thus typically a landscape or part of an ecosystem with a core area of suitable habitat and management effectiveness that favours lions, often surrounded by areas of lower conservation designation and less effective conservation management or is linked to other Key Lion Areas by existing or potential corridors (Fig. 1.2b). Key Lion Areas could equally be expressed as core areas, but as they are often large with core areas within them, they are thus designated as Key Lion Areas.

1.3.3 IUCN Status categories

The focus of this spatially explicit action plan is generally the recovery of lions in core areas, the reestablishment of lions in areas where they are absent, and the maintenance or recreation of corridors between these populations. For each Key Lion Area, the presence of lions was mapped (Fig. 1.2b) using the classification of the IUCN Red List for spatial data (IUCN 2021):

Extant – if lions were known to occur at a site within the last 20-30 years with recent evidence of their existence there;

Possibly extant – if there were no recent records due to the lack of surveys, but lions were likely to occur based on suitable prey and habitat;

Possibly extinct – lions were formerly known to exist in the area but the lack of confirmed records despite searches suggests that they are now likely extirpated due to habitat loss of other threats;

Extinct – lions were known to occur within the last 30 years, but exhaustive searches have confirmed that they are no longer present;

Presence uncertain – a record of lions in the area exists but the record requires verification.

The presence categories were assigned to the Key Lion Areas based on a comprehensive technical and scientific literature survey, engagement with species experts across the range, and cross referencing the latest lion estimates contained in the African Lion Database. The outcome is synthesised in Table 1.1. Each LCU or Key Lion Area site is discussed in greater detail in the Appendix A-I. Distribution maps and abundance estimates align with the new Red List Assessment for lions (Nicholson et al. in prep).

In summary, across most of the extant range of the northern lion, the situation has become critical in terms of numbers and probability of persistence (Table 1.1). This is especially the case in West Africa

where lions are now Critically Endangered (Henschel et al. 2014). Across its range, the northern lion has gone, or is near extinct, in 23 out of the 36 protected areas (63%) where they occurred in recent historical times (Brugière et al. 2015). The rate of extinction is significantly more pronounced in West Africa where there have been 15 extinctions out of 18 historical occurrences. In Central Africa there have been 8 extinctions out of 18 historical occurrences.

1.4 RED LIST ASSESSMENTS

1.4.1 Red list status of lions in Africa

Red List assessments for lions in Africa were done at the species level (Bauer et al. 2016). Throughout Africa, lion populations were estimated to have undergone a reduction of 43% from 1993 to 2014. This assessment spanned 21 years, which is approximately three lion generations. The assessment resulted in a listing as Vulnerable by the IUCN (Bauer et al. 2016).

The 2014 Red List classification did, however, mask an important dichotomy between stable to increasing lion populations in southern Africa, and declining lion populations elsewhere in Africa. This dichotomy is evident in listings of lion in different Red Lists. In South Africa, the lion was listed as Least Concern (Child et al. 2016), whereas in West Africa the lion is listed as Critically Endangered (Henschel et al. 2015).

The 2015 assessment inferred population change from 9 sites across 12 different countries in Central and West Africa (Henschel et al. 2015). These data suggested that lions here had declined by about 66% from about 1,304 individuals to about 439 individuals over three generations. During the same assessment period, *P. leo leo* was reported to have increased by about 55% from about 312 to 485 in the Gir region of India (Jhala et al. 2019).

Although it has not been done to date, if the northern lion was to be assessed in Africa, it would most probably be listed as Endangered. This would be based on Criteria 2a with an observed, estimated, inferred, or suspected population size reduction of ≥50% over the last three generations.

1.4.2 Red list status of northern lions in West Africa

Since 2004, lions in West Africa have been classified as a separate subpopulation (Bauer & van der Merwe 2004. This is because they are thought to be isolated from lions in Central Africa (Chardonnet 2002, Bauer & van der Merwe 2004). Previous assessments of the West African subpopulation used political boundaries to delineate its extent, incorporating populations from Senegal in the West to Nigeria in the East. However, molecular analyses established that lions in Yankari Game Reserve in central Nigeria are likely to be more closely related to lions in Cameroon (Central Africa), while lions from Kainji Lake National Park in western Nigeria, situated west of the lower Niger River, are more closely related to lions from Benin and Senegal (Bertola et al. 2015).

These findings suggest that the lower Niger River acts as a barrier to lion dispersal, separating lions in West Africa (west of the lower Niger River), from lions in central/eastern Nigeria and those of Central Africa. However, this still requires further verification as to certainty and relevance (Bertola pers. comm.). The 2015 regional IUCN Red List Assessment for the lion in West Africa (Henschel et al. 2015) therefore defines all populations west of the lower Niger River as belonging to an isolated West African subpopulation, even though the IUCN and other international organisations conventionally used national boundaries for regional delineation. Practically, however, conservation necessity may require

referring to all lions in West and Central Africa as one unit without considering the current haplotype distinction. The genetic and demographic status of the northern lion in Africa may suggest that we consider the entire range of *P. leo leo* in Africa as one conservation unit.

Surveys covering 17 protected areas throughout West Africa conducted from 2006 to 2013 confirmed the continued presence of lions in only three protected areas: Niokolo-Koba National Park in Senegal, the W-Arly-Pendjari Complex in Benin, Burkina Faso and Niger, and Kainji Lake National Park in Nigeria (Henschel et al. 2014). Lions were no longer recorded in Guinea-Bissau, Mali, Côte d'Ivoire, and Togo, with unsubstantiated reports of lions from Guinea's Haut Niger and Kankan Reserves, as well as from Mole National Park in Ghana (Henschel et al. 2014).

The total estimate was about 220 adult lions in West Africa, most of which (91%) were in the W-Arly-Pendjari population (Henschel et al. 2014). The surveys conducted between 2006 and 2013 across West Africa represented the first comprehensive assessment across the region with strong evidence of ongoing declines (Henschel et al. 2014). These results supported a listing of the West African lion subpopulation as Critically Endangered under criterion C2a(ii) where the adult population for the subspecies was estimated at less than 250 individuals and where at least 90% of the mature individuals existed in one population (Henschel et al. 2015).

1.4.3 Status of northern lions in India

For comparison with the status of the northern lion in Africa, we report on the status of Asiatic northern lions in India. At the time of last Red List review (Breitenmoser et al. 2008), lions existed as a single isolated population in India's Gujarat State in the Gir Protected Area. The population numbered about 175 adult individuals, with the population extending beyond the boundary of the lion sanctuary. Lion numbers were largely stable; however, the population was listed as Endangered based on population size as key criteria (Breitenmoser et al. 2008). Previously, however, the Asiatic lion was listed as Critically Endangered by the IUCN Red list in 1990 (Nowell & Jackson 1996).

Improved protection and better habitat management by the Gujarat Forest Department is what resulted in the lion population increasing to over 500 in the last total count in 2015 (Jhala et al. 2019). The result of the population expansion, and lions seeking new habitats, is that in the past two decades lions have dispersed into an agropastoral and coastal shrublands landscape totalling over 11,000 km² (Jhala et al. 2019).

1.5 GENETIC STATUS OF LIONS IN WEST AND CENTRAL AFRICA

Bertola et al. (2022a) found that the genetic diversity in Central and West African lions was similarly diverse to that of lions in East and Southern Africa. This is surprising, given the low population sizes of the northern lion across many of the protected areas in its range, it might be anticipated that signs of low population size might be evident in its genetics. However, to date this has not been found in any of the sampled populations (Bertola pers. comm.). Thus, until recently, it is likely that northern lions were connected and able to breed with individuals (panmictic) across their range. It is possible, however, that the catastrophic declines that have been recorded were likely to have occurred at such a rapid rate and too recently for genetic processes to take place that would induce genetic impoverishment (Bertola pers. comm.).

However, Bertola (pers. comm.) cautions that few sites, if any, in the northern lion's range have been (re)sampled either intensively enough, or over a short enough period, to realistically detect changes

in genetic diversity. It is therefore likely that some of the discreet lion populations that are very small, and that had their numbers reduced several decades ago, may already be genetically compromised. If so, these populations should ideally be genetically reinforced as part of recovery initiatives.

The situation in the overlap zone in north-eastern Africa remains the least clear. Some additional, not yet analysed samples do exist from Ethiopia that could be helpful to characterise the geography of the overlap zone (Bertola pers. comm.). Furthermore, partnerships are being established in Uganda in the south-western corner of the overlap zone to include samples from there; no data are currently available to reliably indicate where the country's lions fit biogeographically. This region is an interesting transition zone for many species and thus an important one to analyse (Bertola pers. comm.).

A current PhD study by Fleur Visser (University of Pretoria, South Africa, and University of Liège, Belgium) will generate more population-level datasets (Visser pers. comm.). It should then be possible to look at the genetic health for these vulnerable populations in Central and West Africa and to better assess diversity, inbreeding levels, and aspects of exposure and adaptive potential to pathogens.

CHAPTER 2:

LION BIOLOGY AND ECOLOGY IN WEST AND CENTRAL AFRICA

2.1 PREY SELECTION

Across Central and West Africa, lions tend to prey on medium-sized prey (<200 kg, 49%) about as often as they prey on large prey (>200 kg, 51%; Bauer et al. 2008). For example, a study in Waza National Park found that lions preyed on 14 different prey species, with five species that were either medium (50–200 kg) or large (>200 kg) in size forming most kills (Tumenta et al. 2013a). Similarly, in Pendjari National Park, lions preyed on a similar group of 13 different prey species, with medium-sized prey being predominant in the diet (60.7%). Here, large prey (≥180 kg) comprised 38.2% of the diet and small prey only 1.1% (Sogbohossou 2011). This pattern is significantly different to prey selection by lions in East and Southern Africa. Here lions preyed on medium-sized ungulates less so (~35%) than large ungulates (~65%; Bauer et al. 2008).

It should be noted, however, that the West African studies cited above were based on carcasses of prey that were located while lions were still feeding on them. When Sogbohossou (2011) looked at lion scats as opposed to carcasses located, a different prey selection pattern emerged. She found that buffalo, a large prey species, were the most strongly selected prey species (21.5%, n = 156 scat samples) and comprised 50% of the biomass lions consumed. Furthermore, small to very small prey made up the remains in about 16% of scats as opposed to just 1.1% of observed carcasses (Sogbohossou 2011).

These findings illustrate that prey assemblage studies based on located carcasses can be biased, and that large prey probably predominate in lions' diet throughout much of their range. Furthermore, it should be noted that even with an even number of medium and large-sized prey, the biomass of meat available from large prey would be more significant than from medium sized ungulates. A predominance of buffalo meat biomass in the diet of lions has been reported in many studies of lion diet throughout East and Southern Africa (Prins & Iason 1989; Mills et al. 1995). Thus, large prey species such as buffalo (*Syncerus caffer*) and eland (*Taurotragus derbianus*, *T. oryx*), are likely to play a similarly important role in the diet of lions in Central and West Africa, just as they do in East and Southern Africa.

In terms of prey preference in Pendjari National Park, waterbuck (*Kobus defassa*) and hartebeest (*Alcelaphus buselaphus major*) were selected for more often than would have been expected. While buffalo, Buffon's kob (*Kobus kob kob*) and warthog were selected in proportion to their occurrence (Sogbohossou 2011). The importance of Buffon's kob in the diet of lions in West and Central Africa was also observed in Faro National Park in Cameroon (Breuer 2005) and in Comoé National Park in Côte d'Ivoire (Bodendorfer et al. 2006). The position of hartebeest and roan antelope (*Hippotragus equines*) among the top five numerically abundant species in lion diet was confirmed by several studies in Central, East and Southern Africa (Hayward & Kerley 2005).

Livestock (predominantly cattle) comprised part of the diet in a few studies. Cattle comprised as much as 21.6% of the diet of lions in Waza National Park. This is known to result in retaliatory persecution by herdsmen (Tumenta et al. 2013a). However, as with most protected areas in Central and West Africa, livestock attacks were strongly influenced by herders driving their cattle into the park for forage and water. Lions did, however, prefer wild prey over livestock when relative abundances were con-

sidered (Tumenta et al. 2013a). Livestock was not always common in the diet of lions in the region, with an absence of livestock in scat samples from Pendjari National Park (Sogbohossou et al. 2011).

In our report, aerial survey estimates of ungulates were used to estimate potential ecological thresholds (carrying capacity) for lions using the preferred prey species approach described by Hayward et al. (2007). Simply put, the method regresses predator density against the biomass of significantly preferred prey and the biomass of prey within each predator's preferred weight range. The result was a prediction of the carrying capacity or ecological threshold for lions based on available resources at that time. Reaching such ecological thresholds, however, is unlikely in most northern lion populations due to significant human influences. Thus, ecological thresholds given in the Appendix A-I are only a guide for the potential for lion populations if all human influences could be adequately addressed.

2.2 HABITAT USE

Studies on lion's home range and habitat use are quite rare in Central and West Africa. Most home range estimates are for Bénoué and Waza National Parks in Cameroon (Bauer & de Iongh 2005; Schoe 2007; Tumenta et al. 2013b) and Pendjari National Park in Benin (Sogbohossou 2011).

In Pendjari, lionesses spent most of their time in swamp savannahs, grasslands, and woodlands, but shifted to riparian forest and dense woodlands in the late dry season (Sogbohossou 2011). They tended to avoid rocky and hilly areas throughout the study. The mean home range size estimated by the 100% minimum convex polygon (100% MCP) was 256 ± 154 km² (range from 96 to 403 km²). The mean core home range expressed as the 50% Kernel was 33.6 ± 18.4 km² (Sogbohossou 2011). In the ecologically similar Bénoué National Park, lions had similar sized home ranges on average to those in Pendjari of about 308 km² (100% MCP; Schoe 2007).

When compared with lion home range estimates for Pendjari and Bénoué, those in Waza National Park were about three times larger (100% MCP 1,018 km², 1999–2001 in Bauer & de Iongh 2005, 100% MCP 1,015 km², 2007–2009 in Tumenta et al. 2013b). Lion home ranges in Waza are most likely so much larger because of different habitat types and lower prey densities. Waza National Park is a floodplain ecosystem, in which the eastern half is flooded from September to December. The western half is open woodland on sandy soils that does not support high prey biomass.

During both Waza studies, lion home ranges exceeded the park boundaries by about 20%, especially during the wet season, due to flooding and resultant prey dispersal and livestock migration into areas beyond the park (Bauer & de Iongh 2005; Tumenta et al. 2013b). In Waza, the time lions spent outside the park coincided with increased livestock predation, especially by male lions (Tumenta et al. 2013b). During 1999 to 2001, five radio-collared lions were inferred to kill over 100 heads of cattle annually, causing considerable damage and prompting retribution killing by pastoralists (Bauer & de Iongh 2005). A similar pattern was recorded in Zakouma National Park, with lions venturing well beyond the park's boundary in the wet season and killing proportionally more livestock (African Parks 2022a).

2.3 LIFE HISTORY AND SOCIO-ECOLOGY

Throughout Central and West Africa, lions live at low to very low densities relative to area size, typically <3 lions/100 km² (Bauer et al. 2003; Sogbohossou et al. 2014). One of the reasons for this is that throughout the region, there is generally low lion prey biomass due to poor quality soils. Lions are

often recorded as solitary individuals, and groups that could be described as prides are seldom encountered (Bauer et al. 2003; Phil Henschel pers. comm.).

Schaller (1972) defined a lion pride as 'resident female lions and attendant territorial males living in an area and interacting peacefully'. However, due to the fission–fusion nature of lion prides, long-term data based on the recognition of individuals is needed to accurately monitor pride dynamics and determine pride size (Packer et al. 2005). The average size of lion prides in East and Southern African populations in well protected areas (with high management effectiveness and financial investment; see Lindsey et al. 2017) is about 12–14 lions per pride (Schaller 1972; Stander 1991; Funston 2011; Loveridge et al. 2016). Thus, across a range of densities from as low as about 1 lion/100 km² through to very high densities of >20 lions/100 km², lions in well protected areas in East and Southern Africa, all live in large prides of roughly similar size. These prides typically comprise 4–6 adult lionesses, 1–2 adult males and 6–8 cubs (Schaller 1972; Smuts et al. 1978; Stander 1991).

Similarly, in the Gir Protected Area in India, northern lions occur at high densities (15 lions/100 km²; Jhala et al. 2019). Banerjee & Jhala (2012) concluded that demographic parameters of Asiatic lions do not differ from those of African lions. The average number of adult lionesses per pride being 5.4 typically with 1.9 males per coalition (Chakrabarti & Jhala 2017). However, in terms of typical group composition, group sizes tend to be small in Gir lions, with male and female groups averaging at 1.7 and 2.5 adults respectively (Gogoi 2015). This is similar to what Bauer et al. (2003) described in Central and West Africa. In fact, a typical group size of about 2.5 adult lioness per group is pretty much a universal average for lions irrespective of total pride size, other than in very high lion density areas with abundant large-bodied prey (Chakrabarti et al. 2021).

2.4 SYNOPSIS

Although one might assume that northern lions are somehow intrinsically socially and ecologically different from Eastern and Southern lions, their social composition and prey selection do not support this. The correlation between lion group size and the ratio of medium to large prey biomass in Central and West Africa, therefore, offers the best explanation of smaller group sizes. This is because prey size influences key determinants of lion group size, such as aggression during feeding, hunting efficiency, interspecific carcass protection and, indirectly, communal cub rearing (Van Orsdol et al. 1985; Packer et al. 1990).

At this stage we cannot be sure that the northern lions is markedly different ecologically or socially from their eastern or southern counterparts. The differences that have been noted may yet have a phylogenetic origin. Further studies will be needed at sites where prey biomass and species composition has recovered with improved management and when lions are once again at higher densities.

CHAPTER 3:

THREAT AND GAP ANALYSIS

3.1 INTRODUCTION

During the IUCN 2006 lion strategy workshops, Lion Conservation Units were categorised as viable (I), potentially viable (II) or significant but of doubtful viability (III; Fig. 1.2a, Table 1.1). This was based on expert knowledge on population size, prey base, level of threats, habitat quality and area size. The results were useful for the defining of the strategy as they provided insights into threats and opportunities for strategic intervention and population recovery (Table 3.1).

In Central and West Africa, national governments and statutory authorities often lack the required financial resources and technical capacity to successfully mitigate threats against lions and their prey. Seeking and facilitating collaborative management partnerships has become a vital short- to medium-term solution. However, the longer-term goal must also be to increase financial support and capacity development for park management services within the governments of the region (Scholte 2022).

3.2 DIRECT AND INDIRECT THREATS TO LIONS IN CENTRAL AND WEST AFRICA

The predominant reasons for the decline of northern lions include most of the threats that lions face elsewhere (Lindsey et al. 2017). The most prevalent of these in the region include depletion of their prey base, encroachment into protected areas, and various reasons for illegal killing (Henschel et al. 2016, Table 3.1). Encroachment mainly takes the form of livestock being driven into and residing in protected areas. In some cases, it also includes agricultural and deforestation activities. Illegal killing includes lions being caught in traps set for other species, actively hunting lions for body parts, and killing lions due to conflict with pastoralists over livestock depredation (especially including poisoning).

These threats are heightened in West Africa, and parts of Central Africa, by very high human densities outside protected areas. Failure to adequately mitigate these threats is generally the result of critical underfunding of protected area management needs and severe lack of capacity in government departments (Lindsey et al. 2018). Throughout the region, an inability to limit damage to protected areas by pastoralist or fundamentalist groups, as well as over-hunting wildlife, has resulted in a virtual collapse of wildlife populations, resulting in particularly severe declines of lions, cheetahs, and African wild dogs.

Even though northern lion populations are at very, or in some cases critically low levels, they are still often targeted for body parts. This included primarily skins, but also bones, teeth, urine, and other products (Williams et al. 2017; Fig. 3.1). There is reportedly significant trade between countries that still have lion populations and those that don’t or have very few (Williams et al. 2017). In West Africa in particular, Benin is reported to be the source for lion body parts received by Côte d'Ivoire, Ghana, Gabon, Guinea, Niger, Nigeria, and Senegal, whereas Burkina Faso was the origin of parts received by Benin, Côte d'Ivoire, Guinea, Senegal, and Togo (Williams et al. 2017). Except for Benin, lions are very rare or extinct in these West African countries.

Table 3.1. Characteristics of Lion Conservation Units (LCUs) in West, Central and North-East Africa giving an approximation of viability (LCU Type), IUCN protected area category, lion population size and predominant threats (sourced from IUCN 2006a, b). Potential threats included [1] livestock encroachment, [2] habitat encroachment and [3] illegal killing. Smaller protected areas are likely to offer doubtful opportunity for viable lion populations. *Caractéristiques des Unités de Conservation du Lion (UCL) en Afrique de l'Ouest, centrale et du Nord-Est donnant une approximation de la viabilité (Type d'UCL), la catégorie d'aire protégée de l'UICN, la taille des populations de lions et les principales menaces (tiré de UICN 2006a, b). Les menaces potentielles comprennent [1]l'empiètement du bétail, [2]l'empiètement de l'habitat et [3]les destructions illégales. Les plus petites aires protégées offrent des opportunités incertaines pour des populations de lions viables.*

LCU	LCU Type	% PA under IUCN category			Estimated lion pop. size	Primary threats		Pop. trend
		II	IV	VI		PA size	Anthropogenic threats	
West Africa								
Niokiolo-Guinee	I				500–1000	Large	Prey depletion, encroachment[1,2]	↑
Boucle du Baoulé	III	40	20		30–50	*Small	Prey depletion, encroachment[1]	↓
Comoé-Léraba	II	70		23	< 50	*Small	Illegal killing, prey depletion	↓
Bui-White Volta	II	40		40	10-20	Small	Prey depletion	↓
Mole	II	90		8	<50	*Small	Prey depletion	↓
Gbele Ecosystem	II		90		<50	*Small	Prey depletion	↓
Digya	II	100			<50	*Small	Prey depletion	↓
Nazinga-Sissili	II		60	15	<50	*Small	Prey depletion	↑
Oti-Mandouri	III	100			<50	*Small	Prey depletion[3], encroachment[1,2]	↓
W-Arly-Pendjari	I	40	55	5	250–500 or 100–250	Large	Prey depletion[3], encroachment[1]	→
Mt Kouffe/Wari Maro	II			100	<50	*Small	Prey depletion, encroachment[1,2]	↑
Old Oyo	III	100			<5	*Small	Prey depletion, encroachment[1]	↓
Kainji Lake	II	100			50	Medium	Prey depletion, encroachment[1]	→
Kamuku/Kwiambana	II	30	70		25–35	*Small	Prey depletion	↓
Central Africa								
Lame-Burra/Falgore	II		100		25–35	*Small	Prey depletion	↓
Yankari	II	100			50	Medium	Prey depletion[3], encroachment[1]	→
Bénoué complex - Gashaka-Gumti	I	30	65		200–300	Large	Illegal killing, prey depletion	↓
Waza	II	100			60	Medium	Prey depletion[3], encroachment[1]	→
Chad RCA	I	10	15	55	1500	Large	Prey depletion[3], encroachment[2]	→
Southwestern Sudan	I	10		90	250–500	Large	Prey depletion, encroachment[12]	?
North-East Africa		**% Gazetted**						
Garamba-Bili Uéré Complex	I	>50			100–250	Large	Prey depletion	→
Boma-Gambella	II	n/a			250–500	Large	Prey depletion, encroachment[2]	?
Kidepo Valley Sudan	III	>50			<50	Medium	Prey depletion, resource extraction	↓
South Omo	I	<25			100–250	Medium	Prey depletion, encroachment[2]	↓
Bale	II	<50			<50	*Small	Prey depletion, encroachment[2]	→
Welmel-Genale	II	<25			50–100	Small	Prey depletion, encroachment[12]	→
Awash	II	25-50			<50	Medium	Prey depletion[3]	↓
Ogaden	II	<25			50–100	Medium	Prey depletion, encroachment[1]	↓

Fig. 3.1 Full lion and leopard skins in a tourist market in Accra, Ghana in March 2022 and lion head and leopard skins in a local market in Tamale in northern Ghana in February 2022 (photos courtesy of Marine Drouilly, Panthera). *Peaux entières de lion et de léopard dans un marché touristique à Accra, au Ghana, en mars 2022, et peaux de têtes de lion et de léopard dans un marché local à Tamale, dans le nord du Ghana, en février 2022 (photos reproduites avec l'aimable autorisation de Marine Drouilly, Panthera).*

In Central Africa, Cameroon is reported to be the origin of lion body parts received by Benin, Gabon, and Nigeria (Williams et al. 2017). While leopard skins and other body parts seem to be traded in substantially higher amounts than lion skins (Table 3.2), given the scarcity of lions in the region, seizures indicate that trade in lion body parts is still a significant threat (EAGLE Network pers. comm.).

Table 3.2 Big cat traffickers arrested due to the efforts of the conservation NGO EAGLE Network (Eco Activists for Governance and Law Enforcement) in West and Central Africa from 2019 to June 2022 and lion and leopard parts that were recovered. *Trafiquants de grands félins arrêtés grâce aux efforts de l'ONG de conservation EAGLE Network (Eco Activists for Governance and Law Enforcement) en Afrique de l'Ouest et centrale de 2019 à juin 2022 et les parties de lions et de léopards qui ont été récupérées.*

Year	Big cat traffickers arrested	Number of lion related arrests	Countries in which lion related arrests were made	Number of lion skins	Number of leopard skins	Lion and leopard claws	Lion and leopard body parts
2019	29	4	Cameroon, Côte d'Ivoire, Senegal	2 full and 4 head skins	19		5 lion skulls, lion bones
2020	23	3	Senegal, Nigeria, Cameroon	1	20	48 lion and leopard claws	
2021	33	2	Côte d'Ivoire, Nigeria	1	30	Unspecified amount	
2022	14	2	Togo	2	17	30 lion claws	

In West Africa, lion skins are typically sold cut into small squares, that are often used to encapsulate religious phrases or to be worn as amulets to keep the wearer safe (Drouilly pers. comm.). The images

above (Fig. 3.1) are from several lion and leopard skins provided for viewing after request in tourist curio markets in Ghana.

Pastoralism in Central and West Africa has undergone a period of rapid transformation in recent years, with herders moving their livestock over increasingly greater distances. This is driven by multiple factors, including insurgencies by fundamentalist groups, climate change, and better veterinary care being available (RICC 2021). This expansion drives intensifying conflicts with indigenous communities and protected area managers (Sogbohossou et al. 2011, Tumenta 2012). Pastoralism is quickly developing as an intrinsic threat to biodiversity conservation throughout the region (Aebischer et al. 2020, Tumenta et al. 2021).

Along with increasingly unstable environmental factors, there is growing security uncertainty throughout the region. This is creating new challenges for governments, communities, and conservationists alike. Incursions by herders into protected areas in now the leading cause of environmental degradation and declining wildlife populations (Aebischer pers. comm.). Not only do livestock carry transmissible diseases, but pastoralists actively exterminate large predators and create new pathways for poachers to enter previously inaccessible environments.

3.3 GAPS IN KNOWLEDGE AND UNDERSTANDING

3.3.1 Lion distribution and population estimates

Throughout its range, the northern lion is generally poorly monitored in terms of population size, and the response to improved conservation interventions. Mostly, the methods used to survey northern lions are not suitable to reliably detect population change. Furthermore, there is not one site across the range of the northern lion in Africa where lion populations have been tracked on a consistent basis over an extensive area using techniques that can reliably detect change. Some longer-term data is available in parts of the WAP Complex and Zakouma, but improvements in precision of estimates could be achieved.

Methods that could most reliably detect population change would include (1) long-term continuous individual monitoring, (2) a mark-recapture framework using (2a) either camera trapping with high-quality photos allowing identifying lions in a grids sufficiently large to facilitate accurate estimates, or (2b) genetic tools to identify individuals applied to regularly collected scat over large areas, and (3) focal studies of lions in core areas using radiotelemetry and known individual monitoring. These were monitoring approaches deliberated at a lion survey methods workshop help in South Africa in April 2022 and will be discussed further below.

In 2021 and 2022, Panthera conducted camera-trap surveys in Niokolo Koba National Park that were able to estimate lion abundance rigorously (Henschel pers. comm.). There was another detailed study using faecal genetics in Yankari that produced a very solid lion population estimate (Tende et al. 2008). Recently in Zakouma National Park a mark-recapture lion monitoring program has been implemented (Gaylard pers. comm.).

The lion population surveys generally done are typically index-based spoor or call-up surveys, many of which are however not done according to the recommended study designs (Funston et al. 2010, Ferreira & Funston 2010). Detecting population trends has also been confounded in some areas by varying survey techniques being implemented at a site.

Thus, even well-funded conservation efforts generally cannot report with adequate certainty on how lion populations are responding to conservation initiatives. Although available conservation funding should be predominantly used for direct conservation interventions, it is important to invest the necessary resources to monitor lion populations to track where and which recovery efforts are successful. For example, improved park support efforts have had a doubtful impact on lion populations in Yankari National Park, where targeted poaching of lions may be hindering lion recovery.

A lot of the information collated in the IUCN (2006a, b) conservation strategies were 'guestimates', particularly with respect to distribution range and population estimates, especially in the Niokolo-Guinea LCU, the Chad-ECAR LCU, South Sudan and Ethiopia. Although experts have since concluded that lions no longer occur in several protected areas across Central and West Africa, very few additional survey data for these sites are available. Several LCUs designated in 2006 no longer seem to accurately represent the distribution of lions, and new surveys to identifying additional sites for lion recovery are scarce.

3.3.2 Ungulate surveys

As is often the case in wildlife conservation in Africa, there has been a much greater investment in aerial surveys done to determine status and trend of herbivores in West and Central Africa. There are, however, still several gaps and surveys have not always been repeated systematically over time. Nevertheless, some very useful surveys are available.

Some important Key Lion Areas would benefit from aerial surveys to assess the status of lion prey. A few keys sites include Niokolo Koba National Park in Senegal, Kainji Lake and Yankari National Parks in Nigeria, Waza National Park in Cameroon, and if feasible parts of the Greater Chinko Ecosystem in the Central African Republic (CAR). There are also relatively few aerial surveys of the North-East Overlap Zone although the Boma-Gambella LCU and surrounds, which is the most important part of the range for lions there, has had a few surveys done in the last decade and a half (e.g. Fay et al. 2007, Grossman et al. 2010).

3.4 SHORTCOMINGS IN INSTITUTIONAL/ORGANISATIONAL CAPACITIES

Across most of the protected areas in West and Central Africa, there are significant institutional and organisation capacity shortfalls for protected area management. Thus, many protected areas in the northern lion's range are either 'paper parks' or, if a management presence is apparent, the resources and capacity available is often marginal.

This lack of resources and capacity to secure protected areas leads to the expression of the threats that have been described above. These include widescale bushmeat poaching, significant levels of trade in wildlife products, invasion of protected areas by local and transhumant pastoralists, and significant retribution killing of lions by pastoralists. The result is that most parks have decayed to the point where wildlife populations have collapsed, and few tourists visit the parks each year. Such non-functional PAs are sometimes referred to as 'paper parks.'

These shortcomings, and the need to address them, were highlighted in the IUCN (2006a, b) Lion Conservation Strategies with lion conservation units (LCU's) being identified to prioritise action and recover lion and prey populations. Whether or not the IUCN (2006a, b) Strategies, and specifically the delineation of LCUs, made any significant difference since is an open question. Although they have shaped conservation thinking and approaches across the region. This includes the development of 18

action plans/guidelines/conservation strategy documents on, or including, the northern lion. Out of these, three had a specific focus on lions (or large carnivores) in West Africa, and one in Central Africa (Cameroon) and were published between 2007 and 2014 (see Part B). Visser et al. (in prep) found no updates, follow-up monitoring and/or evaluation of conservation measures to have been published, and not all relevant countries have produced such plans.

The regional listing of the lion in West Africa as Critically Endangered on the IUCN Red List in 2014 (Henschel et al. 2015) did not seem to significantly affect research efforts in the region. There has been no significant difference in the number of publications during the six years before and after the lion in West Africa was declared Critically Endangered in 2014, and lion numbers have remained low (Visser et al. in prep). By comparison, the same analysis was performed on publications about East African and southern African lion populations. Here the number of publications was found to be significantly higher since the last red list assessment was done in 2014 (Visser et al. in prep).

3.5 SYNOPSIS

The result of all these threats and short comings is that some time ago already, northern lions became largely restricted to core areas inside protected areas within which weak management effectiveness continues generally to result in depleted prey bases and persecution of lions by pastoralists. In the region, it is not unusual for pastoralists to graze livestock deep within protected areas, or parts of them, on a year-round basis (Henschel *pers. comm*.) or in a strongly seasonal way (Aebischer *pers. comm*.).

Thus, many protected areas in the region have lost their lions over large parts of each protected area, or even completely. For example, in Niokolo-Koba National Park in Senegal and Yankari National Park in Nigeria, lions are largely restricted to small, better-protected core areas in the centre of the respective parks. In the W-Arly-Pendjari complex, lion population density is extremely low in peripheral hunting zones of the park and lions that leave the park often get killed (African Parks 2019, 2021). Here, more than 50,000 cattle were recorded inside the W National Park during an aerial survey in 2012 (Henschel et al. 2014), which has persisted to the present (African Parks 2021). Recently armed incursions into these parks have increased and have destabilised conservation efforts (Lhoest et al. 2022).

Protected areas in West and Central Africa that have retained lions are typically larger than protected areas without lions, and often support lion populations in better protected core parts. Successful protected areas tend to have significantly higher management budgets than those where lions have been extirpated (Henschel et al. 2014). It is likely that the presence of pastoralists, and the associated density of cattle around many protected areas, are a greater source of illegal killing of lions than is poaching of lions and their prey.

In the Sahelo-Saharian bioclimatic region of Africa, cattle husbandry is mainly practiced through seasonally mobile pastoralism. To cope with declining rainfall in the Sahelo-Saharian zone, over the last few decades pastoralists have moved ever further southward in search of dry-season pasture (Basset & Turner 2007), leading to increasing grazing pressure on Sudanian protected areas. Both pastoralists and sedentary farmers have increasingly used poison to kill potential livestock predators (Brugière et al. 2015).

CHAPTER 4:

ENABLING FACTORS

4.1 PROTECTED AREA NETWORK

Protected areas in West and Central Africa tend to be smaller than in other parts of Africa, with most being no more than several thousand square kilometres (Appendix A-I). The largest single protected area that constitutes a national park is Comoé National Park in Côte d'Ivoire. There are, however, larger protected area complexes, namely W-Arly-Pendjari and Bénoué, and increasingly large areas under protection in Zakouma in Chad, the Greater Chinko Area in CAR and in the transboundary Boma-Gambella area in South Sudan/Ethiopia. In many instances formal protected areas such as national parks or game reserves are surrounded by a range of lower designation protected areas such as hunting areas, faunal reserves, etc. Together, these often form a 'complex' (e.g. W-Arly-Pendjari, Bénoué). In complexes, conservation efforts are typically prioritised in the protected areas of high designation, often with little attention to surrounding areas of lower conservation designation. The largest area under management where lions are a key focus is the Chinko Conservation Area in CAR. This area is, however, connected to in the form of a huge, protected area complex both east in South Sudan and to the Zakouma area in Chad via protected areas in northern CAR (Fig. 4.1).

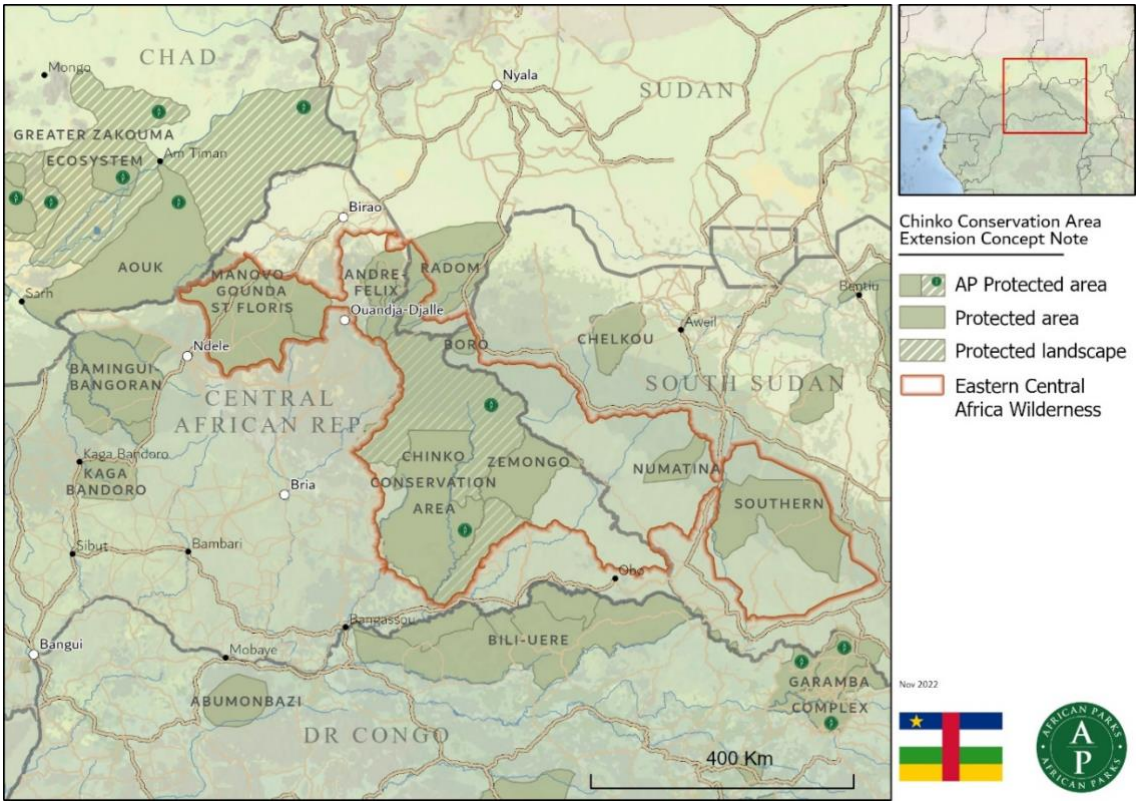

Fig. 4.1 Key protected areas in the Chad-CAR LCU, depicting the Greater Zakouma Landscape (Zakouma Key Lion Area) in Chad, the Northern CAR and greater Chinko areas in CAR, and neighbouring areas in Sudan, South Sudan, and the Democratic Republic of Congo (reproduced from African Parks 2022b). *Aires protégées clés dans l'UCL Tchad-RCA, représentant le paysage du Grand Zakouma (Zone clé pour le Lion de Zakouma) au Tchad, les zones du nord de la RCA et du Grand Chinko en RCA et les zones voisines au Soudan, au Soudan du Sud et en République démocratique du Congo (reproduit à partir d'African Parks 2022b).*

Transboundary conservation is not a strong focus yet in Central and West Africa, with the only significant transboundary conservation areas being W-Arly-Pendjari and the recently named Bouba Njida-Sena Oura transboundary complex. In the eastern Overlap Zone, two important transfrontier areas include the Badingilo-Boma-Gambella and Alitash-Dinder complexes between South Sudan and Ethiopia and Sudan and Ethiopia, respectively, and well as the Kidepo Valley complex between Ethiopia and Uganda.

4.2 THE EX-SITU POPULATION OF *P. L. LEO*

Recent there has been consideration into the broader role of zoos for the long-term conservation of the northern lion. The first step is to assess the studbooks and genetic lineage of lions within the zoo environment. Zoos could potentially assist ex-situ conservation and breeding efforts and translate these into in-situ initiatives, provided an accurate inventory of genetic diversity and information is reflected in studbooks and management decisions. Where possible, captive populations should mirror and conserve the genetic diversity found in wild populations. However, in most captive populations, information on phylogenetic structure and kinship is based on often anecdotal information from the studbooks and not on molecular-genetic analyses. This is problematic for the lion, which was kept in zoos in generic form or as regional variety, but where the Critically Endangered subspecies from West and Central Africa is severely underrepresented in captivity (Bertola et al. in prep).

Bertola et al. (in prep.) investigated 62 samples from zoos within the European Association of Zoos and Aquaria (EAZA) in response to a request from Givskud Zoo, Denmark. Further samples and finalisation of a publication are underway (Bertola pers. comm.). They found that of the 57 tested African lions from zoos, only five individuals could be assigned with confidence (>90%) to the West and Central Africa cluster, and ten individuals could be assigned with similar confidence to Southern Africa. Thus, only 26% of all zoo lions from Africa could be assigned with confidence to one of the four continental clusters (Fig. 1.1). This suggests that hybridisation between lineages is common in EAZA zoo lion collections. Similarly, Visser et al. (in prep) received responses from 57 individuals offering information on the origins of lions held in zoos and found that out of 350 lions present in 84 zoos, only 14 individuals held in 8 zoos were reported as being of northern lions' origin.

Thus, the Critically Endangered lions in West and Central Africa are at least in part represented genetically in the captive population in EAZA zoos. Efforts for more targeted breeding of the present captive individuals representing northern lions from Africa are presently undertaken by the EAZA and its lion holders (Skalborg Simonsen pers. comm.) and could ultimately lead to a West and Central African population in captivity.

Currently, information provided to visitors at zoos is very limited, with 72% of respondents (n = 89 zoos) stating that their conservation education material did not include the separate IUCN regional assessment for West African lions (Visser et al. in prep). When asked whether zoos provided specific information about the lion populations in West and Central Africa (i.e., their updated scientific name, phylogeny, regional population numbers, specific regional range, threats, or conservation status), 72% indicated that none of these elements were mentioned. Among these characteristics, phylogeny (i.e., explaining that these lions were more closely related to Asiatic lions than other African lions) was the least mentioned in conservation education material (Visser et al. in prep). However, most zoos were interested (58%), or potentially interested (20%), in addressing this gap (Visser et al. in prep).

This work is currently being expanded upon (Bertola pers. comm.), and once finalised could act as a clear directive to EAZA zoos. In so doing, it could become part of their management and public outreach campaigns that could incorporate information on the ecology of northern lions and highlight their status in West Africa as Critically Endangered. The efforts could be further broadened to include zoos in the AZA (American) association and give rise to a global programme to breed and secure northern lions in ex-situ populations that could potentially be used for reintroduction or reinforcement projects. By incorporating genetic data into management plans for the captive population, it is not only possible to assure a healthy level of genetic diversity, but also to efficiently conserve the evolutionary potential found in the wild. This could function as an additional level of security against loss of genetic lineages in the wild.

Given the low population size of northern lions it is increasingly apparent that an ex-situ population of northern lions should be protected in captivity (Nobuyuki pers. comm.). Especially in West Africa, climate, human population growth and extremist violence could conspire to reduce the number of wild lions to unsustainable levels that may require augmentation in the future.

4.3 INTERNATIONAL, REGIONAL, AND NATIONAL NGOS

Given the large number of international NGOs, only a few are well represented in West and Central African northern lion range. The key NGOs in the region focused on lion conservation include (ranked roughly in terms of size in the region) African Parks (AP), Wildlife Conservation Society (WCS), Panthera, Fauna and Flora International (FFI), African Wildlife Foundation (AWF), Noé and Conserve Global (CG). The NGOs tend to engage in park support or delegated management partnerships with statutory authorities. Table 4.1 summarises most of the Key Lion Areas in which international NGOs are engaged in lion conservation.

Since its inception in 2005, delegated management has improved the day-to-day management of the respective protected areas. There remain, however, challenges with funding and with the capacity of national managerial staff, and concerns regarding human rights (Scholte 2022). Collectively NGOs offer park support across about 168,739 km² of protected areas housing northern lions in West and Central (about 250,000 km² for all protected areas; Scholte 2022). The predominant focus is national parks, and to some extent surrounding hunting areas and faunal reserves.

As far as we can determine, about 650 (74%) of the approximately 855 northern lions estimated to occur in the region (Table 1.1) currently occur in protected areas with cooperative or delegated management partnerships (Table 4.1). Thus, the NGO community has a huge role to play in the management of PAs important for the conservation of the northern lion. The Spatially Explicit Conservation Action Plan (SECAP, Part B) will assist in galvanizing this effort, and realising a coordinated and integrated approach, with role players working together to save the northern lion, their prey, and their vital habitats.

Therefore, the opportunity for lion population recovery in protected areas is high, given proper management either by NGO partners or state institutions. Lion numbers could readily increase by about three-fold if the predominate threats they face could be mitigated in these PAs. This is, however, not an easy prospect to achieve. However, based on lower to moderate densities northern lion populations could increase by about three-fold in most West and Central African countries (Table 4.1). This would make them more resilient to change and future challenges.

The three main collaborative management partnerships, namely financial and technical support (referred to here as park support), co-management, and delegated management, yield median funding that is 1.5, 2.6 and 14.6 times greater than baseline state budgets for protected area management (Lindsey et al. 2021). This additional funding and support are critical for the short to medium term conservation of wildlife throughout the region. Ideally, however, in the long-term, governments should have the financial resources and capacity to manage and conserve their protected areas.

Table 4.1 Some of the Key Lion Areas where international NGOs are engaged in lion conservation via cooperative partnerships. Data presented includes estimates of the numbers of northern lions existing in each, % of extant population = share of the respective PA in the total estimate of northern lions; Potential = Estimated number of lions the respective PA could support at a density of 2–3 lions/100 km² (1-2 lions/100 km² in Chinko and Southern because of less productive ecosystems). *Quelques-unes des Zones clés pour le Lion où des ONG internationales sont engagées dans la conservation du lion via des partenariats de coopération. Les données présentées comprennent des estimations du nombre de lions du nord existant dans chacune d'elles, le % de la population persistante = part de chaque aire protégée dans l'estimation totale du nombre de lions du nord; Potentiel = estimation du nombre de lions que chaque aire protégée pourrait accueillir à une densité de 2–3 lions/100 km² (1–2 lions/100 km² à Chinko et dans le Parc National du Sud en raison d'écosystèmes moins productifs).*

Protected Area (NGO partner) per region	Size (km²)	Estimated # lions	% of extant population	Potential
West Africa				
Niokolo Koba National Park (Panthera)	9,130	29	3.4%	182–273
Pendjari component of WAP Complex (AP)	14,793[1]	170	20.5%	294–441
Yankari National Park (WCS)	4,390	~10	1.2%	88–132
Central Africa				
Faro National Park and hunting blocks (AWF, Noe', CG)	5,000	40	4.7%	100–150
Bouba Njida-Sena Oura transboundary complex (WCS)	6,500	65	7.6%	130–195
Zakouma Complex (AP)	7,693[2]	130	15.2%	154–231
Northern CAR Complex (WCS)	28,100[3]	20	2.3%	562–843
Chinko Complex (AP)	65,000	108	12.6%	650–1300
Garamba Complex (AP)	5,133[4]	43	5.0%	102–153
Southern National Park (FFI)	23,000	~10	1.2%	230–460
Total	**168,739**	**~630**	73.7%	**2472–4178**

[1] Benin side (14,793 km²) of the W-Arly-Pendjari Complex (27,166 km²)
[2] Zakouma National Park (3,050 km²) and Siniaka Minia (4,643 km²) parts of ~50,000 km² system
[3] Bamingui-Bangoran (10,700 km²) and Manovo-Gounda Saint Floris (17,400 km²), part of an ~110,000 km² system
[4] Includes Garamba National Park (5,133 km²) and adjacent hunting areas (9,662 km²)

Although constraints to increasing the implementation of collaborative management partnerships do exist, they do seem to be increasingly accepted by African governments. Constraints include a concern that such partnership represent lack of success on the parts of governments, potential reduction in finances to government (especially from the donor community) and undermining of sovereignty.

Based on an analysis of these challenges with delegated management partnerships Scholte (2022) developed four recommendations to guide more mature delegated management:

1. Governments should ensure an enabling legal–procedural environment and prepare delegated management contracts systematically.

2. Private partners (NGOs) should facilitate capacity building of national managerial staff and help initiate sustainable financing mechanisms.
3. Governments and private partners alike should respect human rights and build coalitions with communities.
4. Governments, private partners, and funders should strive to delegate non-core management tasks, such as tourist guiding and reception, community development and research, to specialised locally based individuals and organisations.

Furthermore, Lindsey et al. (2021) suggest that governments might view collaborative management partnerships as strategic, forward-thinking mechanisms to unlock funding, investment and expertise for conservation and community development. They also suggest that expanding collaborative management partnerships improves protected area management and security (especially when supported by the national conservation authority, police and even the army). Collaborative management partnerships have the potential to shares the costs of protecting Africa's protected areas with the global community. Furthermore, they should build local capacity and helps ensure that opportunities are unlocked to stimulate rural development and benefit local communities in a sustainable way.

Resolving all these challenges is indeed important. Equally, given the collapse of wildlife populations in West and Central Africa, implementing such partnerships in a developing and improving framework is vital to halt potentially catastrophic loss of habitat and wildlife populations.

4.4 CONSERVATION INITIATIVES AND PROJECTS SUPPORTIVE TO LION CONSERVATION

Additional to the involvement of NGOs in collaborative management partnerships, there are several research projects that do offer conservation benefits for lions. In the last three decades several masters and PhD level studies were undertaken largely to look at ecological aspects but also the threats associated with conflict with livestock herders and more recently transhumance. Such research projects have also led to build wildlife research and conservation capacity at regional universities.

These local lion conservationists joined with other lion conservationists, particularly from West Africa, to establish the Regional Lion Conservation Network for West and Central Africa (*Réseau Ouest et Centre Africain pour la Conservation du Lion*, or ROCAL). The group actively pursued research and some conservation agendas in the region.

The group became known as the Large Carnivore Initiative at a workshop in Maroua, North Cameroon in November 2010. The group aims to foster the exchange of information between partners through the website and e-mail communication on fundraising opportunities. The protection of large carnivores is promoted on the website: https://leofoundation.org/en/projects/the-large-carnivore-initiative/organisation/.

4.5 CONSERVATION APPROACHES

As with lion conservation initiatives elsewhere in most parts of Africa, the three key lion conservation strategies required in the region include:

1. Securing and recovering prey and lion populations in Key Lion Areas, also known as core areas.

2. Securing and maintaining corridors between various Key Lion Areas or simulating connectivity through translocation ('assisted dispersal').
3. Effectively mitigating intense human killing and persecution of lions by communities living adjacent to or alongside lions.

The SECAP (see Part B) recognises that several Key Lion Areas in the region either have currently extirpated lion populations (e.g. Comoé and Mole National Parks) or have lion populations at such low numbers that recovery without population and genetic augmentation may not be possible in the short term (e.g. Kainji Lake, Yankari, Waza). In these cases, some amount of lion translocation and fast tracking of lion recovery would be required to ensure lions are on a path to recovery within the next ten to fifteen years.

Recognising the difficulties involved, the most suitable approach to implement the SECAP requires a combination of securing core and corridor areas, and mitigating lion killing, while simultaneously translocating lions to restock areas where they are extinct or where augmentation is needed. In essence this approach can be described as a 'managed metapopulation', which is a conservation concept developed to address similar conservation challenges for large carnivores in southern Africa (e.g. Davies-Mostert et al. 2015). The SECAP, including metapopulation theory along with applied conservation interventions, embraces both key ecological considerations with conservation practice and is likely to be the most practical approach to recover a wild, functioning regional northern lion population. Maintenance and transfer of as much genetic diversity as possible, together with increased populations of lions to be conserved within well-protected areas, is a cornerstone of the recovery plan using a managed metapopulation approach.

A challenge with small lion populations seems to be that the rate at which they increase is not directly related to the amount of prey that is available. This was described by Kiffner et al. (2009), where lions were well below ecological carrying capacity due to anthropogenic mortality. The slow recovery of diminished lion populations could be driven by several factors including:

1. Continued high levels of human persecution pressure even when lions have declined to very low numbers.
2. Resistance of lionesses to disperse into vacant areas – lionesses are significantly less likely to move into empty areas or through areas with human presence than are male lions (Elliot et al. 2014).
3. Lack of social cohesion when at low densities – the drivers of pride forming/sociality are not at play which may increase the risks to individual survival (Packer & Pusey 2007).
4. In the 'establishment phase' of the growth curve, chance events for specific individuals can affect the rate of growth very strongly.

These sort of population effects collectively can result in what is known as the 'small population paradigm' (Caughley 1994).

CHAPTER 5:

INVOLVEMENT OF LOCAL PEOPLE, NATIONAL INSTITUTIONS, AND TRANSBOUNDARY COOPERATION

5.1 ECONOMIC SITUATION AND LIVELIHOOD OF LOCAL PEOPLE

Throughout West and Central Africa, a review of community-based programmes outside protected areas needs to be done. In areas surrounding Key Lion Areas, there are often community programmes in place. However, they generally have different funding streams and are not aligned with park support projects (Drouilly pers. comm.). Direct benefit streams directly to communities in the form of jobs, tourism, related services businesses, and produce for sale would enhance the support for lion conservation projects by the local population. Without such support, it is going to be even more challenging to recover lion and prey populations in the protected areas. The review here suggests that park support and management NGOs are generally not closely involved with community development or upliftment projects in area surrounding protected areas (see Appendix A-I).

A further challenge in the region is that people living around protected areas are often still dependent on bushmeat. Access to this resource needs to be controlled and, again on a site-by-site basis, this will need to be openly discussed between park management authorities and communities. A further challenge is that in some village communities, individual hunters often aspire to be recognised as "master hunters". This can require that the hunter has killed several high value species, often including a lion (Drouilly pers. comm.). Given the status associated with hunting a lion, and the active markets and trade in lion skins and body parts, it will be challenging to secure alternative income streams that outcompete choosing to hunt a lion. However, through dialogue and creative approaches this could be achieved.

5.2 PARTICIPATORY APPROACH AND INVOLVEMENT OF STAKEHOLDERS

On a site-by-site basis, protected area managers, community leaders, supportive NGOs, safari and meat hunters and government officials, ideally need to meet regularly and discuss and improve the participation in the overall management of protected areas and corridors between them. It is vital to develop and maintain communication forums around all the Key Lion Areas in West and Central Africa. Without the engagement, support and buy-in from all stakeholders, it will be very difficult for governments and park support NGOs to secure protected areas from excessive resource use, even if such is illegal. Each step in the park management and development process should be engaged upon with as broad a base of stakeholders as is possible.

This will be particularly important if lions are to be reintroduced into protected areas where they have been extirpated. The challenge then is often that communities having not lived alongside lions for extended periods often know very little about the behaviour of lions, and experience high levels of fear and anxiety associated with animals like the lion. Working with communities to improve their knowledge and understanding of lions, and to plan for how threats from lions will be mitigated, is a critical step in sensitising communities to lions being reintroduced into an area.

Such challenges are not only likely to be experienced with reintroduction initiatives but will also come to the fore as lion populations recover in protected areas where their numbers are highly depleted.

Increasing numbers of lions will lead to higher rates of contact between people and lions, and between lions and livestock. People often need to be re-taught how to respond in these situations (Drouilly pers. comm.). The same is true for corridor areas that need to be identified and gazetted in order to inform people living there and where conflicts also need to be mitigated. Minimising contact rates is vital and can be achieved in part through respecting zonation of land use, but also through continuous informing people.

5.3 INVOLVEMENT AND ROLE OF NATIONAL EDUCATIONAL INSTITUATIONS

National institutions, especially university and other education institutions, should play an important guiding, mentoring, and training leadership role, and be brought into the stakeholder engagement group of each protected area. These institutions and their staff could identify young people with a passion for lion and wildlife conservation and can source and train nationals to join lion monitoring and survey teams, and to work with rural communities.

National scientific institutions are also well positioned to communicate with colleagues across various West and Central African countries, and with universities in other parts of the world. Identifying young talented people, creating opportunities, and nurturing development is an excellent way to improve capacity, and provide skilled technicians and managers to find employment with statutory authorities, conservation organisations and NGOs.

5.4 CAPACITY BUILDING

Generally, protected area management staff in West and Central Africa are challenged by inadequate resources, which is predominantly a financial issue. However, lack of financial resources also affects the abilities and aspirations of staff in terms of desire to develop further.

If protected area management and support is to advance and prosper, well trained people with a range of specialised skill sets are required in a park management team. Many parks in the region employ very few, poorly trained game guards/scouts and park managers. Lacking means are also responsible for ill-equipped management teams typically with poor infrastructure. Fixing this is a big challenge and requires substantial basic investment. The conservation NGOs can assist with this in some cases, but development organisations, banks, and international funders are going to be needed in many instances to revamp and reequip the national parks services of protected area complexes in the range of the northern lion.

5.5 NEED FOR INTERNATIONAL COOPERATION AND TRANSBOUNDARY APPROACHES

There is a clear need for greater international cooperation and investment in addressing the challenges of park management and community upliftment for most Key Lion Areas. In some cases, these efforts also need to be transboundary to be successful. A critical need across most protected areas is to define tools such as ‘protected areas landscape wildlife protection and law enforcement strategies’, effective park management plans, and to integrate these with rural development initiatives.

Having the right set of actors and enablers together to develop plans at the appropriate scale, and being as inclusive enough as possible, is vital. Within the range of the northern lion, each Key Lion Area needs its own action plan harmonised across all needs, and with specified targets and processes identified to achieve them.

5.6 DEALING EFFECTIVELY WITH TRANSHUMANCE

One of the biggest challenges protected areas face in Central and West Africa is that of seasonal invasion by pastoralists (Aebischer pers. comm.). This issue is now very prevalent and is described as transhumance. Sharing information on each area's protection status with local communities and pastoralists, and followed up by law enforcement efforts, is a key tactical strategy that park managers can employ. Developed for the Chinko Conservation Area, park managers there employ the TANGO system with Transhumance Sensitisation Officers (Tango's), which could be replicated in other parts of the northern lion's range (Fig. 5.1).

Fig. 5.1 The TANGO approach implemented to mitigate risks associated with pastoralism and poaching in the Chinko Conservation Area since 2017 (reproduced from African Parks 2022b*). L'approche TANGO mise en œuvre pour atténuer les risques liés au pastoralisme et au braconnage dans la Zone de conservation de Chinko depuis 2017 (reproduit à partir d'African Parks 2022b).*

In this tiered approach, the first step is to engage with community leaders from the pastoralist community, to present the mission of the protected area concerned. It is important that all communities know what the mandate of the park is, where the park boundaries lie, and what the rules are with respect to access and resource use.

Then, through various forms of patrolling, including daily reconnaissance flights where possible, park managers should plot and monitor the movements of pastoralists into the protected area. Specific paths and routes are important to determine as these are often used by poachers. When pastoralists are encountered within the protected area, teams of sensitisation officers need to be deployed to intercept them. These teams explain to the pastoralists that they are inside the protected area and encourage them to leave.

In the Chinko Conservation Area in CAR, these are called Tango teams (Fig. 5.1). Tango teams then attempt to guide pastoralists out of the protected area and reinforce community knowledge and acceptance of the protected area boundary and rules. At times, a Tango team might be deployed more than once to interact with a particular group of pastoralists.

When this fails, the Tango sensitisation teams are replaced by law enforcement and management staff to increase the level of recognition of the rules by the pastoralists. Should the pastoralists still proceed further into the protected area or should signs of illegal resource use and poaching be identified, then park rangers are deployed to make arrests and/or confiscate illegal materials.

This approach has worked very well in the Chinko Conservation Area, increasing the size of the area that is safe for lions rapidly on a year-by-year basis from ~6,000 km² in 2017 to ~17,000km² in 2022 (African Parks 2022b). It is an example of core area protection and mitigation of illegal killing that could be replicated by organisations and NGOs in other parts of West and Central and West Africa. Effective site security and effectively dealing with intrusion of parks by pastoralists in a sensitive and responsible manner is a vital component of core protected area support.

This approach can also be implemented in well-defined areas of connectivity, where the maintenance of habitat integrity is similarly vital to protected area security and management. Keeping corridors as functional ecological units without the intrusion of agriculture, or deforestation of woodlands, is vital to keep corridors as attractive areas for wildlife to use, and for lions to move through. Key corridors need to be gazetted and have adequate legal status.

CHAPTER 6:

MONITORING THE RECOVERY OF THE NORTHERN LION

Tracking population abundance or density is critical for understanding ecological processes, population dynamics, and for effective target-driven conservation planning. However, obtaining robust and repeatable density estimates of animals in natural settings is often practically and technically difficult (Elliot et al. 2020). This is particularly the case for large carnivores because they naturally occur at low densities and are wide-ranging and often cryptic. To date, therefore, most lion surveys and studies, regional and continental populations assessments (e.g. Chardonnet 2002, Bauer & van der Merwe 2004, Riggio et al. 2013) and numerous meta-analyses (e.g. Hayward et al. 2007, Bauer et al. 2016) have drawn on expert opinion or surveys of debatable reliability (Elliot & Gopalaswamy 2017).

For lions, density estimates from surveys and monitoring frameworks, however, must be accurate and precise (Elliot & Gopalaswamy 2017) as they inform regional conservation strategies (e.g. IUCN 2006a, b) and status classifications (e.g. Bauer et al. 2015, Henschel et al. 2015), the definition of areas for lion conservation focus (e.g. Riggio et al. 2013), trophy hunting quotas (e.g. Croes et al. 2011, Packer et al. 2013), lion management options (e.g. Miller et al. 2013), and measures of lion conservation success (e.g. Hayward et al. 2007).

Perhaps more so than for any other large carnivore, a wide array of methods has been used to estimate lion density, including direct counts and long-term individual monitoring (e.g. Smuts et al. 1977, Packer et al. 2011), camera trapping (e.g. Strampelli et al. 2022), distance sampling (e.g. Durant et al. 2011), and genetic surveys (e.g. Creel & Rosenblatt 2013). However, because these techniques are costly and time-consuming index-based approaches, typically track surveys (e.g. Funston et al. 2010) or call-up surveys (e.g. Ogutu & Dublin 1998, Ferreira & Funston 2010) are the most frequently used methods to estimate lion density and are still recommended in lion management guidelines (e.g. IUCN SSC Cat Specialist Group 2018).

However, the general assumptions of track- or call-up-based index approaches – (i) that abundance is known at small scale to ensure calibration, (ii) that there is a consistent relationship between track density and abundance, and (iii) that all animals are equally detectable at all sites and across all habitats and substrates – cannot always be readily shown (Elliot & Gopalaswamy 2017). Furthermore, in the vast number of cases, researchers do not implement site calibrations and apply a calibration equation from other sites as if it was universal (e.g. Henschel et al. 2014, Bauer et al. 2016).

Thus, index-based abundance indices have been widely critiqued (see Anderson 2001 and references therein). One statistical examination of the approach concluded that index-calibration experiments produce faulty inferences (Gopalaswamy et al. 2015). This study most notably found that because of variable detection probability, especially when the target species occurred at low and variable density, then the observed variation is higher than would be expected (overdispersion). Therefore, to obtain precise estimates of these overdispersion parameters, sample size must be very high.

However, conservation practitioners in the region seem to prefer using index-based approaches, sometimes recognising these constraints. In Central and West Africa, it is likely that given the size of the areas for which estimates are needed, that researchers and managers will use index-based approaches for some time to come. These surveys are also more easily accommodated by

management budgets focussed more on conservation activities. In time other survey methods may be phased in, but for now it is important to support practitioners on the best possible approaches to index-based surveys, and to clearly recognise their constraints.

Track and call-up surveys have produced many useful first general estimates for areas that have received little to no monitoring (e.g. Henschel et al. 2014, Bauer et al. 2015, Aebischer et al. 2020), and can be set up to produce predicted-occupancy maps (e.g. Petracca et al. 2019). However, their wide confidence intervals and lack of precision do not make them suited to detect population change over time. In the last two decades, significant progress has been made in estimating the density of carnivores that can be readily identified from their coat patterns. These species are often surveyed using camera traps with identified individuals being used in well-established mark-recapture statistical analysis (e.g. Karanth & Nichols 1998).

Previously, lions were thought to be ill-suited for camera traps analysis as it was deemed too difficult to 'capture' individually identifiable lions on cameras available at the time. However, recently, there have been several efforts to produce estimates using a mark-recapture framework (e.g. Blackburn et al. 2016, Loveridge et al. 2016). Furthermore, with advances in camera trap design it is now feasible to use camera trap surveys to estimate lion density albeit in small sample areas if suitable cameras are used (e.g. <1000 km² per survey: Strampelli et al. 2022).

These approaches can be augmented or replaced by an array of additional methods including genetic sampling and photography by observers, which can be as effective at identifying individual lions. Importantly, this method can incorporate different data types (e.g. Gopalaswamy et al. 2015) within an SECR framework that is applicable to a variety of study sites and could simultaneously monitor other large carnivore species if designed accordingly (Elliot & Gopalaswamy 2017).

It should be noted that currently both, index-based and spatially explicit mark-capture survey techniques seem set to persist in the region. Practitioners of either approach need support and guidance in how to do these as precisely as possible. Combining all approaches, and looking at each site in turn, it is possible to implement a long-term, spatially explicit, or index-based, monitoring framework for lions across Central and West Africa. During a transition period, it would be advisable to apply index-based surveys and more robust approaches in the same study areas, in order to have a direct comparison, and to demonstrate the pros and cons of both approaches directly. In the long, cheap methods may be needed to survey large areas and more robust, but also more expensive methods may be used in core areas to calibrate the 'cheap' data. A framework to adapt and utilise for surveys and monitoring of lions across West and Central Africa is present in Appendix A-2.

The results of such surveys need to be conveyed to park managers to guide and refine the actions to secure these populations, including the herbivore prey species. Importantly, distribution maps and density estimates should become an integral part of the IUCN Red List assessments and widely used to formulate conservation policies and strategies. The outputs of multiple replicated lion monitoring initiatives across Central and West Africa (including the overlap zone) would be invaluable in planning, revising and fine-tuning conservation initiatives.

CHAPTER 7

SUMMATION AND CONCLUSIONS

As lions, other large carnivores, and herbivore prey populations continue to decline in West and Central Africa, we encourage that all interest and affected parties involve themselves in its conservation and recovery. Importantly, governments, non-government organisations, and scientific and conservation institutions need to work together in a coordinated manner towards halting bio-diversity loss and ensuring that conservation goals are met. Lions, and large carnivores more broadly, are good surrogate species against which to monitor and evaluate conservation efforts (see Brennan et al. 2020).

The distribution range of the northern lion in Africa is severely fragmented and populations are small, especially in West Africa. Some of these populations are now so isolated and small that – even if further anthropogenic losses could be suppressed immediately – these isolated populations may genetically or demographically no longer be viable. It is therefore important to maintain these small populations as a part of an over-all metapopulation of northern lions in Africa. As the exchange of lions with neighbouring populations through natural dispersal is unrealistic for many of these isolated populations, assisted dispersal will be needed for a shorter or longer period, until natural migration corridors can be established again. Hence, the most promising approach for the time being is to maintain the northern lion population in Africa as a managed metapopulation. Many of the extant populations are situated in areas of severe insecurity and implementing conservation programmes there might be difficult. On the other hand, several protected areas in the region where lions have been extirpated during the past decades today offer ecological and anthropogenic conditions allowing to bring lions back. The approach therefore should be to create and maintain a mosaic of small to medium sized lion populations through strict protection of the remaining source populations, reinforcement of the sink populations, and reintroducing lions to areas that could host (small) populations and so enlarge the over-all metapopulation of northern lions.

The approaches defined above should integrate lion monitoring and community sensitisation teams employed from local communities with park managers, supported by academics from in country universities and guided by global scientific expertise. This needs to be replicated across as many Key Lion Areas as possible. This is a model that could work and if implemented could eliminate many of the current inadequacies.

To achieve the goal to conserve northern lions in Africa as a managed metapopulation, very close transboundary and international, but also cross-sectoral cooperation will be needed. This requires not only an agreement on a common strategy, but also the implementation of coordinated and concerted action and the regular exchange of experiences and sharing data. A platform for all institutions to meet could be the Joint CITES CMS African Carnivores Initiative, under which for instance the hereafter proposed Spatially Explicit Conservation Action Plan (SECAP; Part B) for the northern lion in Africa could be advanced. A common approach with close cooperation between all Range Countries and partners is an important requirement for the recovery of the northern lion in Africa. Working together and synergistically will also allow time to be saved avoiding replication of effort. Finally, the recovery of the northern lion will require substantial funding. Working together under one strategy will facilitate the generation of the means needed for implementing all these conservation projects.

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APPENDIX A-1

NORTHERN LION POPULATION HISTORY AND ESTIMATES, PREY POPULATION TRENDS, AND MANAGEMENT EFFECTIVENESS IN WEST, CENTRAL AND NORTH-EAST AFRICA

Please note: Figures and Tables in the Appendix are indicated with an "A" preceding the number. References to Figures and Tables without "A" refer to the main body of text above.

A-I. 1 WEST AFRICA

Northern lions of the haplotype found in West Africa are currently only resident in three protected areas within West Africa (Fig. A1 numbers 2, 14, 17). Lions of the 'fourth' West African lion population in Yankari National Park, Nigeria (Fig. A7, number 20), cluster with the Central African haplotype and are discussed there (see Bertola et al. 2022). Below, a technical review of all LCUs defined in 2006 (IUCN 2006a, Fig. 1.2a) is presented along with the recent history of lions and their prey and a description of management effectiveness in each of the core of Key Lion Areas. The numbers given in square brackets refer to the identification labels for the PAs and Key Lion Areas presented in the maps hereafter according to Table 1.1.

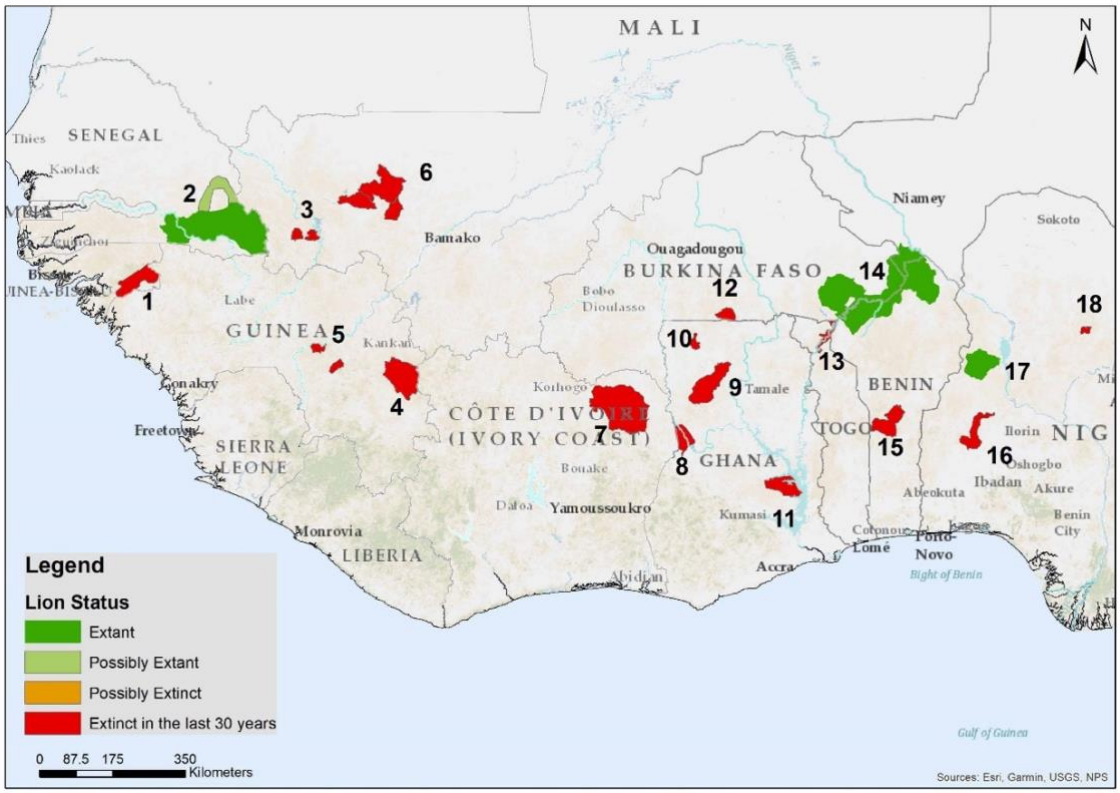

Fig. A1. West Africa indicating the status of lions in Key Lion Areas. Identification labels (numbers) correspond to those in Table 1.1. These labels are referred to in square brackets hereafter. *Carte de l'Afrique de l'Ouest indiquant le statut des lions dans les Zones clés pour le Lion. Les étiquettes d'identification (numéros) correspondent à celles du Tableau 1.1. Ces étiquettes sont désormais mentionnées entre crochets dans la suite du texte.*

1.1 Niokolo-Guinea LCU

This LCU was defined as spanning the borders between Guinea-Bissau, Guinea, Senegal, and Mali covering a total area of 173,769 km^2 (IUCN 2006a, Fig. A2). The Niokolo-Guinea LCU extent was, however, based on unconfirmed personal information and was unlikely to accurately represent lion range or conservation potential within it (Henschel pers. comm.). Chardonnet (2002) had suggested a total of about 205 lions in this region, while Bauer & van der Merwe (2004) gave a higher estimate of about 340 individuals. The estimates were largely based on 'expert-based' guesses. However, Bauer et al. (2005) suggested that Bauer & van der Merwe (2004) overestimated lion numbers by three times in Guinea, resulting in a revised estimate of about 206 lions across the LCU. The IUCN (2006a) report estimated about 500 to 1,000 lions in this region. There was, however, actually very little survey-based information at the time and the estimates, especially the IUCN (2006a) estimate, were highly speculative (Henschel pers. comm.).

Riggio et al. (2013) indicated that the LCU had lost a considerable amount of area to land conversion and human settlement. They thus recommended splitting the LCU into three lion habitat patches: Guinea-Bissau/Guinea (15,489 km^2), Niokolo Koba/Guinea-Mali Border (73,793 km^2), and Haut Niger (613 km^2). However, surveys by Henschel et al. (2014) and Henschel (pers. comm.) suggest that due to land conversion and human settlement patterns, lions are today restricted to Niokolo Koba National Park (9,130 km^2) [2] with a few individuals possibly residing in the Faleme hunting area east of the park. In this plan, therefore, the only Key Lion Area in the region is Niokolo-Faleme [2].

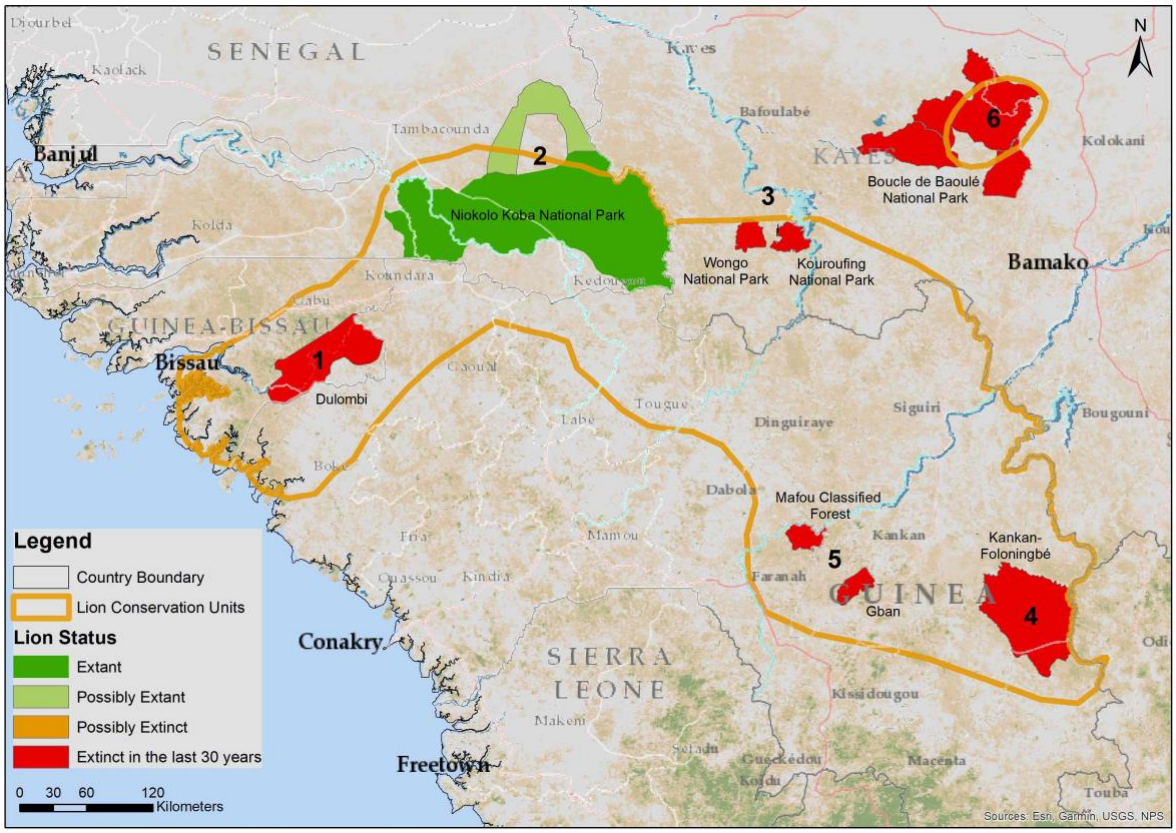

Fig. A2. The Niokolo-Guinea LCU (delineated by orange line) with lions now only extant in the Niokolo-Faleme Key Lion Area [2]. *L'UCL Niokolo-Guinée (délimitée par la ligne orange) avec des lions ne persistant plus que dans la Zone clé pour le Lion de Niokolo-Falémé [2].*

a) Niokolo-Koba and Falémé Key Lion Area [2]

Lions: The first park manager estimated that the Niokolo-Koba National Park was home to around one hundred lions in 1970 (Dupuy 1971). A 1993 report on wildlife in the park increased the figure to 100-200 lions likely occurring in the park (Benoit 1993). However, neither of these estimates were based on any actual lion surveys, or on numbers of known prides of individuals. Lions were systematically surveyed in the Niokolo-Koba and Falémé landscape for the first time in 2011.

In the 2011 survey, an estimate of 16 lions was derived using spoor counts, while a simultaneous call-up survey produced an estimate of 12 lions (Ndao & Henschel 2011). Using genetic fingerprinting on lion scats collected during these above-mentioned survey efforts, a minimum number of seven individual lions was identified (Panthera, unpublished data).

Since 2017, the park has received increased management support from the NGO Panthera, and lion and prey population trends appear to indicate steady growth. A 2021 camera traps survey covering most of the known and suspected lion range in the park produced over 150 camera trap records of lions. Applying individual identification via whisker spots and other markers to this dataset followed by SECR analysis produced an estimate of 29 (16-50) lions in the park. Similarly, photographic capture rates of ungulates and standardized large ungulate encounter rates retrieved from SMART ranger patrol data have increased gradually over the past four years (Henschel pers. comm.).

Management effectiveness: Park support has been implemented in Niokolo Koba National Park largely in the south-eastern third of the park by Panthera since 2017. This support to the park authority Directorate of National Parks (DPN) for anti-poaching operations has been expanded to cover the entire park in mid-2021. Consequently, patrol coverage across the park has shown significant increase in recent years. Lion range in the park has expanded and lions now likely occupy about 30% of the park, compared to 5-10% in 2011. Further lion population increases within the park can be expected if patrol intensity and coverage can be increased even further.

1.2 Boucle du Baoulé LCU [6]

The Boucle du Baoulé National Park (25,330 km²) lies in western Mali and was declared in 1982 (see Fig. A2). The park has little large wildlife and is known for prehistoric rock art and tombs. It is part of the UNESCO Boucle du Baoulé Biosphere Reserve, along with Badinko Faunal Reserve to the south-west, Fina Faunal Reserve to the south, and Kongossambougou Faunal Reserve to the northeast.

Lions: Chardonnet (2002) suggested that a small relict population of lions may still have occurred in Boucle du Baoulé National Park and surrounding reserves in the Mali LCU. Without any supportive data, the IUCN (2006a) estimated a population of 30-50 individuals for the LCU. Based on no recent records of lions from faunal inventories using foot patrol surveys, Henschel et al. (2010) considered the lion at least functionally extinct in the region.

Prey populations: Prey populations have been decimated throughout the park and surrounding areas and could no longer support a lion population (Henschel pers. comm.).

Management effectiveness: Mali is one of the sub-Saharan countries most affected by drought and over-grazing by livestock, putting its ecology and biodiversity under pressure. The Boucle du Baoulé National Park was created to try to address this issue. Management of the park comes under the National Parks Department of the Ministry of Natural Resources and Animal Husbandry. However, Stuart et al. (1990) considers that the control of protected areas within the country has been

ineffective, with continuing illegal hunting and encroachment on the reserves by villagers for pastoralism and agriculture. Henschel (pers. comm.) suggests that conditions for lions in the area are not better today with too many livestock and people in the reserve.

1.3 Comoé-Léraba LCU (Comoé Key Lion Area) [7]

The Comoé-Léraba LCU (22,880 km^2) encompasses Comoé National Park in northeast Côte d'Ivoire and Comoé-Léraba Faunal Reserve (1,250 km^2) in south-west Burkina Faso. The area is a transition zone between savannah and rainforest, which is made up of permanent rivers and seasonal freshwater marshes, dense dry forests, shrubby savannah, and grassland. There is currently no chance to reintroduce lions into the Léraba Faunal Reserve, but prospects look better for Comoé National Park, which is thus a Key Lion Area (Fig. A1). Comoé is a Biosphere Reserve and UNESCO World Heritage Site with the highest biodiversity index of any savanna in the world including 135 mammal species. It is the largest protected area in West Africa, with an area of 11,500 km^2, and ranges from the humid Guinea savanna to the dry Sudanian zone. The park was initially added as a World Heritage Site in 1983 due to the diversity of plant life present around the Comoé River.

Lions: Chardonnet (2002) and Bauer and van der Merwe (2004) estimated 100 and 30 lions in the park, respectively. However, a survey by Henschel et al. (2010) found no lions occupying the park. Comoé National Park should however be defined as a Key lion Area due to its size, improvements in management effectiveness and because it seemingly has sufficient prey to support a reintroduced lion population.

Prey populations: In Comoé National Park, western kob were the target of heavy overhunting for many years (Fischer & Linsenmair 2001, 2007, Bouché 2016). However, the management of the park by the statutory authority has improved in recent years and most of the important potential prey species for lions have recovered to some extent. These improvements would no doubt gain momentum if the park would receive attention both locally and internationally, and if lions could potentially be re-introduced. Recent aerial surveys of the park were conducted in 2016, 2019 and 2022 (Bouché et al. 2016, Linchant et al. 2022; Fig. A3). Based on these aerial survey estimates of ungulates, the park could support about 450 lions at a density of about 3.9 lions/100 km^2 (Table A1).

Table A1. Aerial survey estimates and densities of suitable lion prey species/100 km^2 from aerial surveys in Comoé National Park, Côte d'Ivoire (Bouche et al. 2016, Linchant et al. 2022), and estimated ecological thresholds for lions based on current prey numbers (following Hayward et al. 2007). *Estimations de l'abondance et densités des espèces proies du Lion/100 km^2 obtenues à partir des suivis aériens dans le Parc National de la Comoé, Côte d'Ivoire (Bouché et al. 2016, Linchant et al. 2022), et seuils écologiques estimés pour les lions sur la base du nombre actuel de proies (selon Hayward et al. 2007).*

	2016		2019		2022	
Species	**Abundance**	**Density**	**Abundance**	**Density**	**Abundance**	**Density**
Buffalo	1,186	10.31	1,860	16.17	2,602	22.62
Hartebeest	8,872	77.14	11,638	101.20	17,926	155.87
Kob	950	8.26	1,914	16.64	2,542	22.10
Roan	3,654	31.77	887	7.71	4,763	41.41
Waterbuck	450	3.91	2,340	20.34	1,401	12.18
Potential lion abundance					**450**	**3.91**

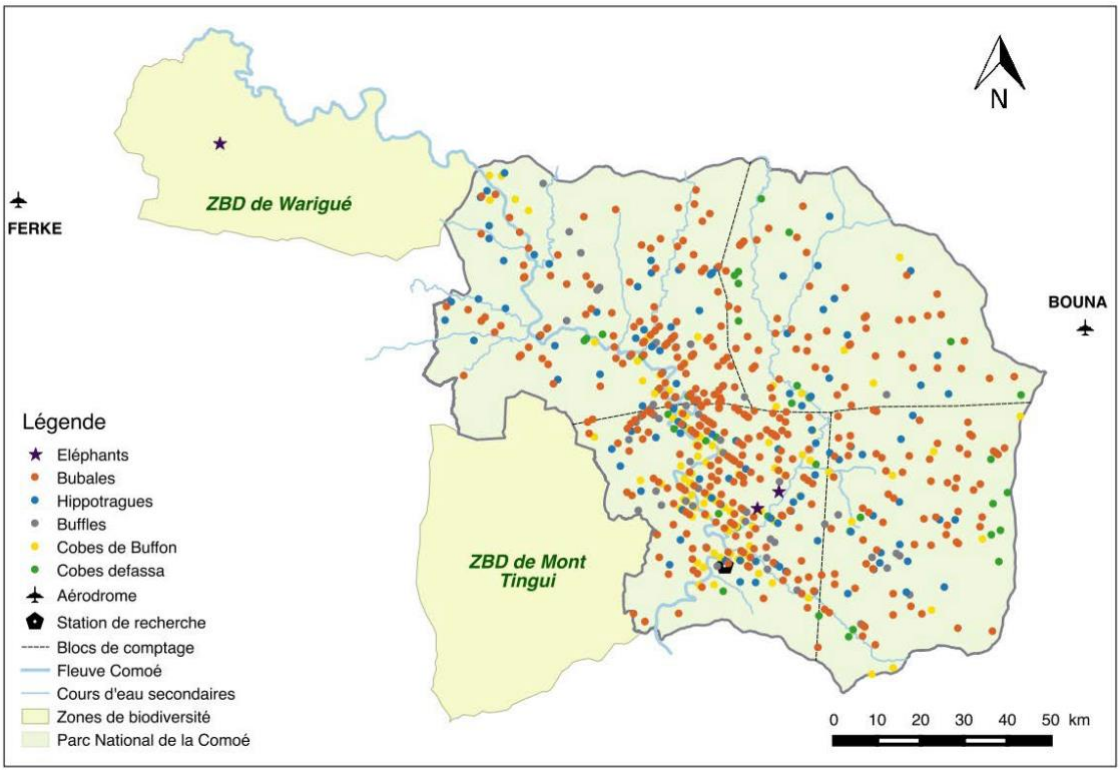

Fig. A3. Map of the Comoé National Park and surrounding hunting zones in Côte d'Ivoire, depicting the distribution of key ungulates during an aerial survey conducted in 2022 (reproduced from Linchant et al. 2022). *Carte du Parc National de la Comoé et des zones cynégétiques environnantes en Côte d'Ivoire, illustrant la distribution des principaux ongulés lors d'un suivi aérien mené en 2022 (reproduit à partir de Linchant et al. 2022).*

Management effectiveness: Comoé National Park was added to the list of World Heritage in Danger in 2003 because it was seriously imperilled due to poaching, absence of management, overgrazing of the park by cattle. These problems intensified after the outbreak of the First Ivorian Civil War (Geoffroy & Diedhiou 2012). However, following the Second Ivorian Civil War, and the stabilisation of the region, the wildlife authority agency OIPR resumed their work in the Comoé National Park. The World Heritage Committee decided to take Comoé National Park off the List of World Heritage in Danger in 2017 following improvements in the conservation of its fauna and habitat (IUCN 2017).

The major management improvements since 2013 included more effective combating of poaching, reducing agricultural pressures, and improvement of roads for better access. These were guided by the development of a new park management plan, developed in consultation with local communities who take part in wildlife monitoring and other conservation activities. However, threats remain, including farming and artisanal gold mining taking place within the park. Such activities still pose a threat to its species' key habitats, and continued action is needed to tackle them (Souleymane & Kampmann 2010).

Five years after the implementation of the new management plan, a UNESCO/IUCN monitoring mission noted with satisfaction that considerable efforts have been made by the OIPR by April 2017 (IUCN 2017). These included strengthened surveillance with the integration of tools such as SMART, the continuation of ecological monitoring activities, an inventory of large fauna (elephants, chimpanzees, buffaloes, etc.), strengthened of relations with universities and research centres,

development of income-generating micro-projects and socio-community projects, and the involvement of stakeholder's management of the park (IUCN 2017). Furthermore, several financial and technical partners had supported the park including KfW and GIZ.

Because of the improvements in management effectiveness, and the ensuing increases in suitable lion prey, Comoé National Park offers a rare opportunity for lion conservation in this region. We therefore recommend assisting the government/OPIR in their decision to plan and implement a lion reintroduction programme. One note of caution for this vision is the risk of Jihadist extremists and associated conflict and violence due to the relative proximity of the park to the Burkina Faso border.

1.4 Bui-White Volta LCU [8]

The Bui-White Volta Ecosystem LCU is located completely within Ghana, largely covering Bui National Park and two adjacent faunal reserves with a total area of 5,230 km^2 (see Fig. A1).

Lions: The IUCN (2006a) report places the estimated population size between 10 and 20 individuals, but Henschel et al. (2010) found no evidence of lions occupying the park. Therefore, this LCU was not included as a current habitat patch by Riggio et al. (2013).

1.5 Mole LCU (Mole Key Lion Area) [9]

The Mole LCU (6,790 km^2) is located completely within Ghana and is comprised of Mole National Park (4,577 km^2) and surrounding protected areas and is relatively close to Comoé National Park in Côte d'Ivoire (Fig. A4). Mole National Park protects Guinea savanna woodland, making it an important habitat for threatened West-African fauna and flora. Its main management focus is managing habitats through controlled burning, growing tourism, and reducing illegal activities such as poaching and logging (Hauptfleisch & Brown 2019).

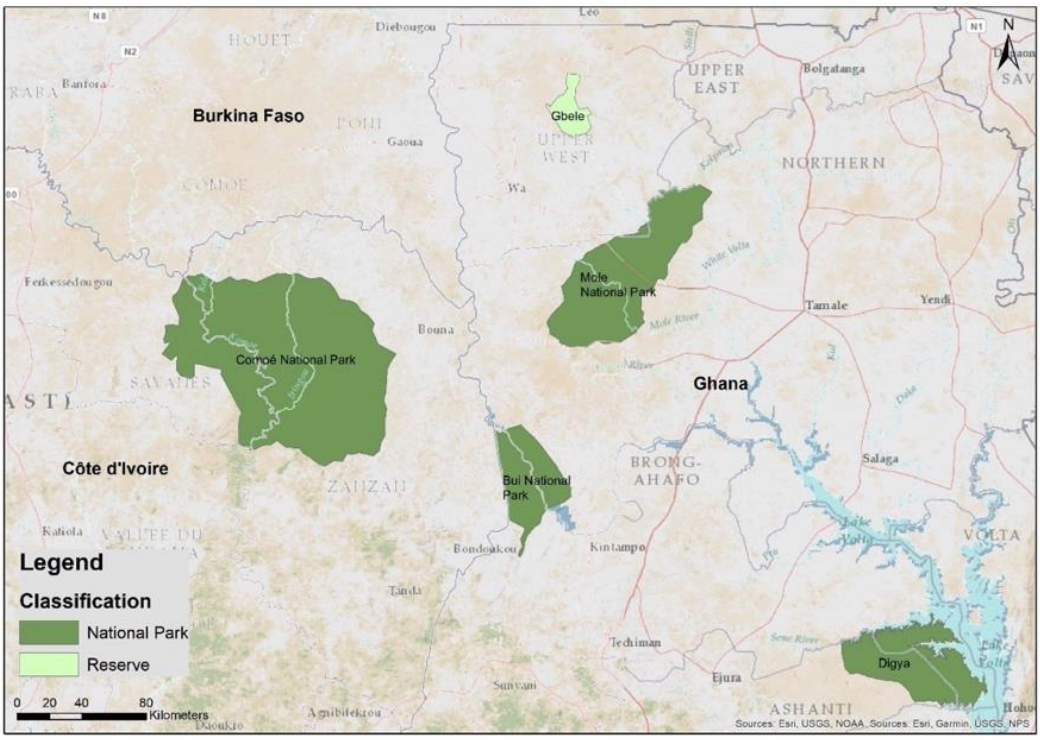

Fig. A4. Map depicting the relative proximity of Mole and Comoé national parks and other protected areas nearby. *Carte montrant la proximité relative des parcs nationaux de Mole, de la Comoé et d'autres aires protégées alentours.*

Lions: Chardonnet (2002) suggests a population of 15 lions in the park while Bauer and van der Merwe (2004) estimate 20 resident lions. The IUCN (2006a) report places the estimated population size at less than 50 individuals. Burton et al. (2010) notes a significant decline in the lion population of Mole National Park from 1968 to 2008 based on lion sightings by park rangers.

Using call-in station and spoor transect surveys Henschel et al. (2010) found no evidence of lions occupying the park but did note that the northern portion of the park should be surveyed. This is supported by a recent leopard focused camera trap and questionnaire survey that found no evidence of lions anywhere within the park or surrounding area (Drouilly et al. 2022). Lions being most likely extinct here, this LCU was not included as a current habitat patch by Riggio et al. (2013). However, as with Comoé National Park, recent improvements in park management suggest that Mole could be a lion recovery area due to its size, improvements in management effectiveness and because it seemingly now has sufficient prey to support a reintroduced lion population.

Prey populations: Prey populations declined by about 63% in Mole National Park between 1993 and surveys in 2004 and 2006 (Table A2), especially larger bodied ungulates such as buffalo. However, with improved park management, the ungulate populations have recently increased to 1993 levels with the park being estimated to support about 1,392 (702-2,462) buffalo and about 4,500 individuals of other suitable lion prey species (Table A2; Hauptfleisch & Brown 2019). Based on these ungulate estimates, Mole National Parks could support about 200 lions at a density of 4.4 lions/100 km^2.

Table A2. Recent larger herbivore aerial survey estimates and densities (per 100 km^2) for Mole National Park and estimated ecological thresholds for lions based on current prey numbers (following Hayward et al. 2007). *Estimations récentes de l'abondance des grands herbivores et densités (par 100 km^2) obtenues à partir de suivis aériens effectués dans le Parc National de Mole et seuils écologiques estimés pour les lions sur la base du nombre actuel de proies (d'après Hayward et al. 2007).*

	1993	2006	2019	
Species	**Abundance**	**Abundance**	**Abundance**	**Density**
Buffalo	1,665	692	1,392	28.76
Bushbuck	55	32	82	1.69
Duikers and oribi	241	55	62	1.28
Hartebeest	1,632	583	2,813	58.12
Kob	781	100	337	6.96
Roan	1012	259	667	13.78
Warthog	105	65	126	2.60
Waterbuck	298	146	253	5.23
Potential lion abundance			**200**	**4.40**

Management effectiveness: Mole National Park was the first protected area to be established in Ghana and is the largest and most prestigious protected area in the country. It is managed by the Wildlife Division of the Forestry Commission of Ghana. Park managers conduct regular patrols, surveillance, and monitoring operations against any illegal activities within the park to safeguard its ecological integrity. However, funds allocated by the government for protected management in Ghana have been consistently low, limiting the enforcement of wildlife laws and the efficiency of anti-poaching activities (Ashiagbor & Danquah 2017). Nevertheless, the park is generally well managed by the statutory authority leading to recent increases in general wildlife numbers (Hauptfleisch & Brown 2019).

Ghana has undergone several changes in its political structures since independence in 1957. The country entered its most recent designation as a republic in 1993 and has been relatively stable since then, getting a political stability and absence of violence/terrorism percentile rank of 49% in 2021, according to the World Banks development indicators. With support from NGOs and the international investment community, Mole National Park is currently suitable for the reintroduction of lions. However, proximity with Burkina Faso does leave the park and northern Ghana vulnerable to conflict associated with extremist groups.

1.6 Gbele LCU [10]

The Gbele Resource Centre or Gbele Game Production Reserve (1,510 km^2) is one of the lesser-known game reserves in Ghana. It is in the north-west of the country and is the fourth largest protected area in Ghana (see Fig. A1).

Lions: Bauer and Van Der Merwe (2004) estimated that there are 10 lions within the reserve, while The IUCN (2006a) report put the estimated population size at less than 50 individuals. A survey by Henschel et al. (2010), however, found no lions occupying the park, and therefore this LCU was not included as a current habitat patch by Riggio et al. (2013).

1.7 Digya LCU [11]

This LCU covers Digya National Park (3,180 km^2) in Ghana (see Fig. A1).

Lions: While the IUCN (2006a) report places the estimated population size at less than 50 individuals, Henschel et al. (2010) found no lions occupying the park. Therefore, this LCU was not included as a current habitat patch by Riggio et al. (2013).

1.8 Nazinga-Sissili LCU [12]

The Nazinga Game Ranch (940 km^2), the Sissili Hunting Concession (327 km^2) and the village hunting zones form a complex of reserves called the Nazinga-Sissili Complex (2,510 km^2) along the border region between Burkina Faso and Ghana (see Fig. A1). The area serves as an ecological corridor enabling large mammals such as elephants to migrate from similar ecosystems in northern Ghana, namely the Morago River area and Mole National Park. As with Comoé, the relative proximity to the Burkina Faso border does increase the risks associated with extremist groups.

Lions: The IUCN (2006a) report places the estimated lion population size at less than 50 individuals, however, Henschel et al. (2010) found no lions occupying the park, and therefore this LCU is not included as a current habitat patch by Riggio et al. (2013).

Management effectiveness: Despite the absence of a management plan, the complex has some tourism facilities such as watchtowers and observatories to improve the conditions for visitors. The complex is threatened by fragmentation due to livestock and arable farming activities, logging, charcoal burning, poaching, and conflicts between people and elephants. These conflicts have a negative impact on the food security and livelihoods of the affected populations, leading them to have a hostile attitude towards wild animals around their communities.

1.9 Oti-Mandouri LCU [13]

The Oti-Mandouri LCU is located on the northern border of Togo and Benin and covers only 990 km^2 (see Fig. A1).

Lions: Chardonnet (2002) notes that lions may occasionally occur in this region as transients while Bauer and Van Der Merwe (2004) state that no resident lions remain in the region. Bouche et al. (2004) confirmed the absence of lions in the LCU, which was not included as a habitat patch by Riggio et al. (2013).

1.10 W-Arly-Pendjari LCU (Pendjari-W Key Lion Area) [14]

The W-Arly-Pendjari (WAP) LCU covers a large complex of protected areas spanning the border region between Burkina Faso, Niger, and Benin (31,047 km^2) (Fig. A5).

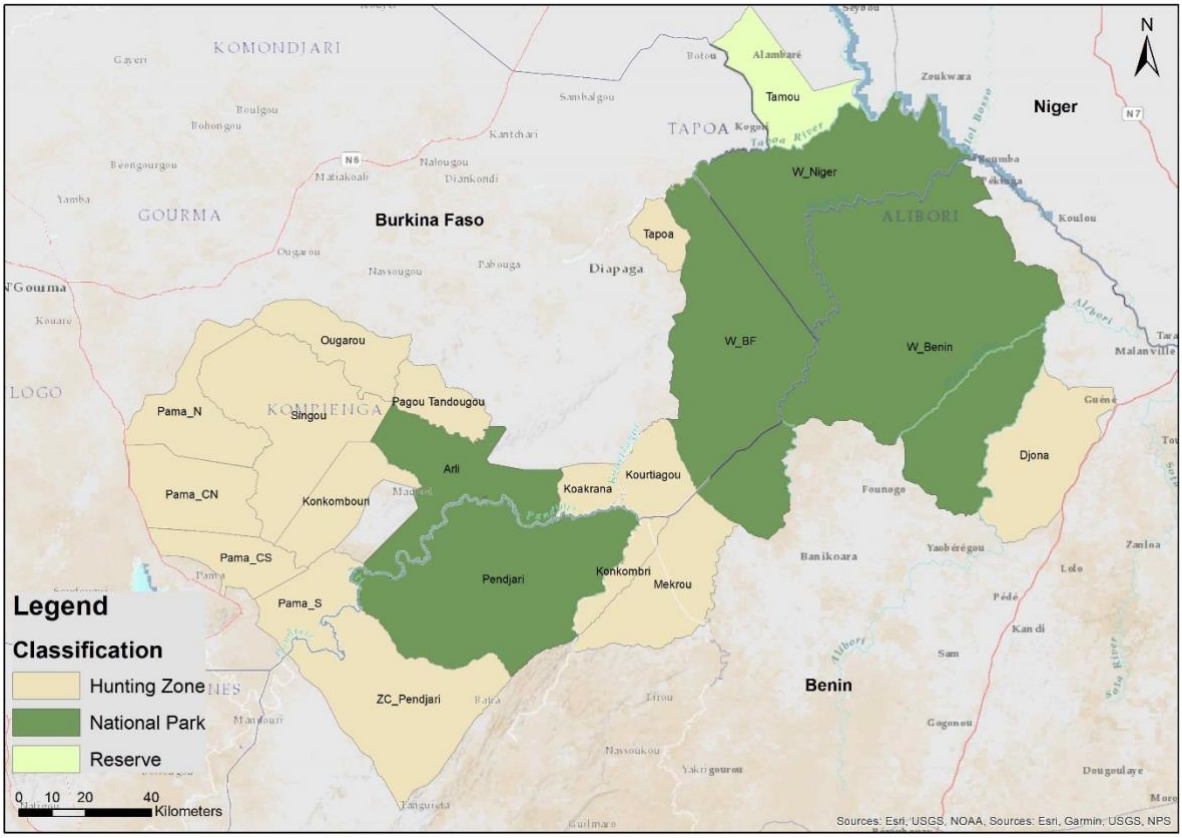

Fig. A5. Map indicating the location of the W-Arly-Pendjari Complex [14] including national parks and hunting zones in Benin, Burkina Faso and Niger. *Carte indiquant l'emplacement du Complexe W-Arly-Pendjari [14], y compris les parcs nationaux et les zones cynégétiques au Bénin, au Burkina Faso et au Niger.*

Lions: Chardonnet (2002) reported an estimate of 768 lions occupying this area, however, Bauer and van der Merwe (2004) gave a more conservative estimate of 215 individuals. The IUCN (2006a) report reflects this discrepancy noting a population size of either 250 to 500 or 100 to 250 lions (see Table 3.1). Given that there was relatively little land conversion in the area and including new data on resident lion populations in Benin, Riggio (2011) proposed that the lion habitat patch covers 29,403 km^2 and contained about 500 lions.

The first complex-wide survey estimated that 311 lions (123-489) occurred across 27,166 km^2 of the complex in 2012 (Henschel et al. 2012). In 2014, however, the same survey approach resulted in an estimate of 418 (230-648) lions across the complex (UEMOA/PNUD 2014). The increase was, however, ascribed rather to methodological improvements rather than an actual increase in lion numbers (Henschel pers. comm.).

In 2019 and 2021, repeat surveys were conducted only on the Benin side of the complex across the Pendjari and W national parks and surrounds (14,793 km^2, African Parks 2019, 2021). These resulted in estimates of 155 (57-242) lions in 2019 and a slightly higher estimate of 187 (24-329) in 2021. Both are cited by African Parks as an increase relative to 2012, with the assumption being that the 2014 count was an overestimate.

Since 2015, Burkina Faso has witnessed an exponential increase in terrorist attacks. The country has been confronted with the presence of various organisations affiliated with al-Qaeda, the Islamic State, as well the Burkinabe group Ansarul Islam. By 2019, Burkina Faso had experienced the largest annual increase (+590%) worldwide in terrorism-related fatalities. And while until 2019 extremist violence in the country was largely contained to the Liptako-Gourma region along the Mali-Niger-Burkina Faso border, in recent years attacks have spread to previously unaffected regions of the country and could spill over into Côte d'Ivoire and Ghana, already affecting Niger and Benin in the vicinity of the W-Arly-Pendjari Complex (Demuynck & Coleman 2022).

Burkina Faso and Niger account for 52% of the surface area of the WAP complex but have been abandoned by park management staff due security risks associated with incursions of Islamist militant Jihadist groups (Lhoest et al. 2022). The ensuing violence has not only resulted in the parks being abandoned, but wildlife including lions has most likely been decimated, with few to no lions likely to still exist in more than half of the complex (Henschel *pers. comm*.). Furthermore, as of 2022, African Parks no longer has a management presence in W National Park in Benin also due to security risks and is now largely restricted in terms of operations to a secure zone inside Pendjari National Park (see Fig. A6).

It is possible, therefore, that the 300 odd lions that might have occurred in the W-Arly-Pendjari Complex in 2012/14 may have been decimated to 150-180 very recently and may yet decline further if the jihadist groups overrun the entire complex (Henschel pers. comm.).

Prey populations: Aerial surveys were carried out within the complex in 2003, 2004, 2006, 2008, 2015, 2019 and 2021, although different methodologies were used, and they covered slightly different areas. The entire complex was surveyed in 2003, 2015 and 2021. Generally, wildlife was more abundant in 2003 than in 2021, with declines occurring mostly in the Burkina Faso part of the WAP complex (see Table A3; Bouche et al. 2004, Ouindeyama et al. 2022). This was due to insurgencies, and the escalation of violence in the Burkina Faso and Niger parts of the WAP complex.

Only the Pendjari component of the WAP complex was surveyed in 2022 (Table A3). Based on this survey, lions could potentially reach an ecological threshold of about 6 lions/100 km^2 (about 393 lions) in the Pendjari component if all threats could be mitigated (see Table A3), about two to three times higher than current densities.

Management effectiveness: African Parks has had the management mandate for the Pendjari complex since 2017 and have focused much of their conservation efforts within the Pendjari National Park (4,800 km^2). African Parks then secured the management contract for W National Park in Benin in 2019. Although lions seem to have declined quite markedly across the W-Arly-Pendjari complex since surveys in 2014, this seems not to have been the case on the Benin side with the African Parks interventions since 2017.

Table A3. Larger herbivore aerial survey estimates and densities (per 100 km^2) for the W-Arly-Pendjari complex in 2003 and 2021, the Pendjari component in 2022 (Bouche et al. 2004, Ouindeyama et al. 2022), and the estimated ecological threshold for lions in the Pendjari based on prey numbers (following Hayward et al. 2007). *Estimations de l'abondance des grands herbivores et densités (par 100 km^2) obtenues à partir de suivis aériens effectués dans le Complexe W-Arly-Pendjari en 2003 et 2021, la composante Pendjari en 2022 (Bouché et al. 2004, Ouindeyama et al. 2022), et le seuil écologique estimé pour les lions dans la Pendjari sur la base du nombre de proies (d'après Hayward et al. 2007)*.

	W-Arly-Pendjari Complex 2003		W-Arly-Pendjari Complex 2021		Pendjari component 2022	
Species	**Abundance**	**Density**	**Abundance**	**Density**	**Abundance**	**Density**
Buffalo	10,560	39.11	6,619	24.51	5,323	80.17
Bushbuck	254	0.94	311	1.15	28	0.42
Duiker	812	3.01	323	1.20	108	1.63
Hartebeest	2,033	7.53	1,117	4.14	368	5.54
Kob	1,040	3.85	4,082	15.12	827	12.45
Oribi	669	2.48	1,376	5.10	10	0.07
Reedbuck	125	0.46	177	0.66	13	0.20
Roan	7,582	28.08	2,975	11.02	718	10.81
Topi	132	0.49	209	0.77	47	0.73
Warthog	1,133	4.20	488	1.81	81	1.22
Waterbuck	346	1.28	164	0.61	69	1.04
Potential lion abundance					**373**	**6.50**

However, there are still several significant threats to the lions of the Pendjari component in Benin that need to be addressed. African Parks has the law enforcement capacity to secure the integrity of the Pendjari National Park core area, but it seeks information to guide its conservation strategies related to addressing human-lion conflict, lion poaching towards and in the peripheral areas, and the trafficking of lion products (African Parks 2020). The trafficking of lion products in the region remains prevalent, with several sources having confirmed the trafficking of lion skins present in markets nearby the park (African Parks 2020). This has prompted the development of an intelligence gathering team working in areas outside the area of primary operations in the park.

In 2021 and 2022, however, a much more severe threat developed rapidly that threatened the entire WAP complex due to a marked increase in militant activity. In February 2022, this culminated in an attack that tragically led to the death of 8 people – four African Parks rangers, two civilians, one Beninese soldier and one African Parks instructor (African Parks 2022). The security issues continue, ranging from observed militant activity in or around the park, sabotaging of park infrastructure, and tragic incidents leading to loss of life or serious injuries (see Fig. A6, Lhoest et al. 2022). There is no longer any park management staff in the protected areas in Burkina Faso and Niger. In Benin, African Parks are now restricted to operating in the Pendjari component on the Benin side.

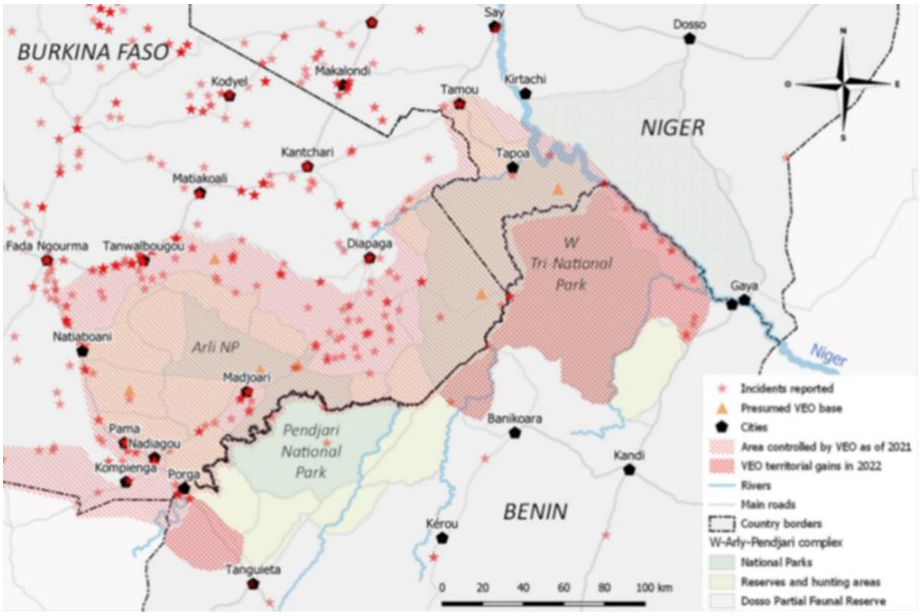

Fig. A6. Area under the influence of violent extremist organizations in the W-Arly-Pendjari Complex of protected areas in early July 2022. Red stars represent locations of reported security incidents from January 2021 to June 2022, with the intensity of the red colour being proportional to the number of reported incidents. Security incidents include direct attacks, clashes, irruptions, raids, kidnappings, targeted assassinations, rackets, and intimidations (reproduced from Lhoest et al 2022). *Zone sous l'influence d'organisations extrémistes violentes dans le Complexe d'aires protégées de W-Arly-Pendjari au début du mois de juillet 2022. Les étoiles rouges représentent les emplacements des incidents de sécurité signalés entre janvier 2021 et juin 2022, l'intensité de la couleur rouge étant proportionnelle au nombre d'incidents signalés. Les incidents de sécurité comprennent les attaques directes, les affrontements, les irruptions, les raids, les enlèvements, les assassinats ciblés, les rackets et les intimidations (reproduit à partir de Lhoest et al 2022).*

1.11 Alibori Superieur/Trois Rivières

Lions: These faunal reserves in Benin were not included in a LCU by the IUCN (2006a), but nevertheless were thought to contain resident populations of lions by Chardonnet (2002) who estimated 35 lions in these two reserves. Pellerin et al. (2009) suggest a population of 18 lions in Alibori Superieur and 19 individuals in Trois Rivières. Land use conversion outside of these faunal reserves and encroachment in the reserves themselves has likely fragmented these two populations. This prompted Riggio (2011) to create two new lion habitat patches, the habitat patch surrounding Alibori Superieur covers 1,742 km^2 while the patch in and around Trois Rivières covers 1,939 km^2. Henschel et al (2014) do not cite either of these in their papers suggesting that not enough evidence of survey efforts was available to include them in their assessment of lion status in West Africa.

1.12 Mt Kouffe/Warri Maro LCU [15]

This LCU is located completely within Benin and covers two faunal reserves totalling 3,510 km^2 (see Fig. A1).

Lions: Bauer and van der Merwe (2004) suggested that 20 lions inhabited these reserves, and the IUCN (2006a) report placed the total number of lions at less than 50. A report from Pellerin et al. (2009) suggested that there might only be three lions in the reserves. However, Henschel et al. (2014) listed the lion as confirmed absent from the LCU based on a report by CENAGREF (2013).

1.13 Old Oyo LCU [16]

This LCU covers Old Oyo National Park (1,700 km^2) in western Nigeria (see Fig. A1).

Lions: The only estimate of a lion population within the park is by the IUCN (2006a) who put the total population at less than five individuals. Henschel et al. (2010) recorded that lions were extirpated in the park.

1.14 Kainji Lake LCU (Kainji Lake Key Lion Area) [17]

The Kainji Lake LCU is located completely within Nigeria (Fig. A1) with the national park covering an area of 5,340 km² and consisting of two non-contiguous sectors, Borgu and Zugurma.

Lions: Chardonnet (2002) estimated 25 lions in the park, while the IUCN (2006a) suggests a higher number of about 50 individuals. Saidu (2010) conducted a call-up survey in 2009 and estimated that there were about 29 lions in the park. A survey the next year by Henschel et al. (2010) estimated that a similar total of about 31 lions remained within the park. No subsequent surveys have been conducted. The latest 'expert based guess' is less than 20 lions (Dunn pers. comm.).

Prey populations: There are no aerial survey estimates available for the park over the last decade and an assessment of suitable lion prey is urgently required.

Management effectiveness: The park is plagued with many of the threats that lions face throughout Central and West Africa. Saidu (2010) observed that activities such as poaching, illegal livestock grazing and human encroachment had appeared to have caused a decline of large ungulates at the periphery of the park, restricting lions to the central core area of the park around Oli Camp. Henschel et al. (2010) similarly found encroachment and expanded agricultural practices along the shoreline of Lake Kainji, together with increasingly heavy vehicle traffic along the Wawa-Luma highway that bisects.

An urgent assessment needs to be conducted of Kainji Lake National Park to assess management effectiveness and obtain estimates of lion and lion prey abundance. Presumably, the park still has the potential to function as a lion recovery area within West Africa, but this does need to be verified and a park support plan is likely to be needed.

1.15 Kamuku/Kwiambana LCU [18]

This LCU totals 3,220 km^2 and covers Kamuku National Park and Kwiambana Game Reserve in central Nigeria (see Fig. A1).

Lions: Chardonnet (2002) estimated a total of 10 lions in these protected areas, while the IUCN (2006a) report suggests a slightly higher number of 25 to 35 individuals. A survey by Henschel et al. (2010) found no lions occupying the park, and therefore this LCU was not included as a lion habitat patch by Riggio (2011).

A-I. 2 CENTRAL AFRICA

Northern lions of the haplotype found in Central Africa (see Bertola et al. 2022a) are currently found in resident lion populations in ten Key Lion Areas in Central Africa, stretching from Yankari National Park in Nigeria in the western part of the region to Garamba and Southern national parks in the east (Fig. A7). Here, a review of all LCUs defined in IUCN (2006a) is presented along with the recent history of lions and their prey and a description of management effectiveness in each.

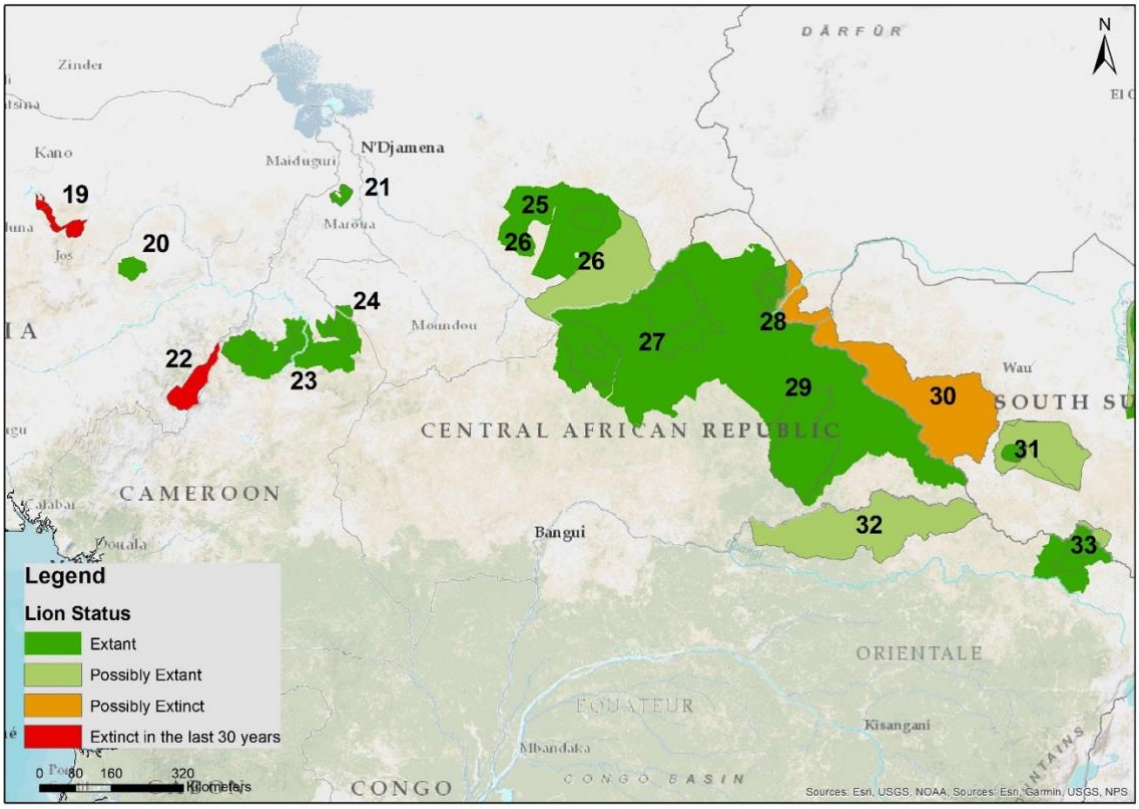

Fig. A7. Map of Central Africa showing the status of lions in Key Lion Areas. Identification labels (numbers) correspond to those in Table 1.1. These labels are referred to in square brackets hereafter. *Carte de l'Afrique centrale montrant le statut des lions dans les Zones clés pour le Lion. Les étiquettes d'identification (numéros) correspondent à celles du Tableau 1.1. Ces étiquettes sont mentionnées entre crochets dans la suite du texte.*

2.1 Lame-Burra/Falgore LCU [19]

The Lame-Burra/Falgore LCU covers two game reserves in Nigeria (4,390 km^2; see Fig. A7).

Lions: The only estimate of a lion population within the parks is by IUCN (2006a) who put the total population between 25 and 35 individuals. Henschel et al. (2010) recoded that lions were extirpated in the park and therefore this LCU was not included as a lion habitat patch by Riggio (2011).

2.2 Yankari LCU (Yankari Key Lion Area) [20]

The Yankari LCU is 3,084 km^2 in extent and is situated in eastern Nigeria (see Fig. A7). The national park covers a total area of 2,244 km² and is covered mainly by Sudan savanna vegetation. Originally created as a game reserve in 1956, Yankari was upgraded to a national park in 1991 and managed by the National Parks Service until 2006 when responsibility for the management of the reserve was handed back to Bauchi State Government.

Lions: Chardonnet (2002) and the IUCN (2006a) estimated 50 lions in the park. Using faecal DNA sampling, Tende et al. (2009) concluded that a population of at least 35 lions existed in the park, while Saidu (2010) estimated only 15 lions in the park. Henschel et al. (2010) recorded only 2 lions while doing a survey of the park, none of which responded to call-ins. The most recent best guess estimate for lions in Yankari is less than 10 individuals, probably about five individuals (Dunn pers. comm.). WCS (2022) report that in the first six months of 2022 no signs of lions were recorded in the park, suggesting that lion numbers are very low. It is possible that lions are poached on a regular basis in Yankari which could be why lions there have not increased, although the park is generally well secured with sufficient prey to support a relatively large lion population (Henschel pers. comm.).

Prey populations: There are no recent aerial survey estimates of suitable lion prey for Yankari although abundances of suitable lion prey species are reported to be high enough to support many more lions (Dunn pers. comm.). However, during aerial censuses of Yankari in 2006 and 2011, low wildlife abundances were recorded, and several thousand cattle, sheep and goats were sighted within the park boundaries (Omondi et al. 2006, Bergl et al. 2011; Table A4). This suggests that suitable lion prey numbers may not be as high as is suggested, but in 2011 could nevertheless have supported about 60 lions at a density of 2.6 lions/100 km^2.

Table A4. Large herbivore aerial survey estimates and densities (per 100 km^2) for Yankari National Park (Omondi et al. 2006, Bergl et al. 2011) and estimated ecological thresholds for lions based on current prey numbers (following Hayward et al. 2007). *Estimations de l'abondance des grands herbivores et densités (par 100 km^2) obtenues à partir de suivis aériens effectués dans le Parc National de Yankari (Omondi et al. 2006, Bergl et al. 2011) et seuils écologiques estimés pour les lions sur la base du nombre actuel de proies (d'après Hayward et al. 2007).*

	2006		2011	
Species	**Abundance**	**Density**	**Abundance**	**Density**
Buffalo	28	1.27	174	7.91
Bushbuck	7	0.32	-	-
Duikers and oribi	17	0.77	11	0.50
Hartebeest	68	3.09	69	3.14
Roan	75	3.41	171	7.77
Waterbuck	34	1.55	29	1.32
Cattle	8,228	374.00	3,022	0.14
Sheep and goats	666	30.27	900	40.91
Potential lion abundance			**59**	**2.6**

Management effectiveness: The apparently sharp decline of lions in Yankari following earlier surveys appears to have been caused by a combination of direct persecution and high levels of poaching of lion prey (Henschel et al. 2010). These observations agree with a report by the Born Free Foundation (2018), which uncovered a large illegal trade in lion body parts in the villages surrounding Yankari National Park. Furthermore, levels of illegal livestock grazing within the reserve remained high.

Yankari National Park has been managed by WCS since 2014 as part of a co-management agreement with Bauchi State Government (BASG). Under the terms of this agreement, WCS is responsible for the management of law enforcement and development of the law enforcement strategy including the supervision of rangers. Meanwhile, BASG is responsible for management of tourism and overall coordination of the reserve.

2.3 Waza LCU (Waza Key Lion Area) [21]

This LCU includes Waza National Park (1,700 km^2) and surrounding areas in Cameroon and totals 5,380 km^2 (see Fig. A7). The northern and eastern part of the park is located along the floodplain of the Logone River. The southern and western part of the park is open savanna on sandy deposits of the Lake Chad basin. Waza National Park was previously a rich wildlife habitat that was a popular tourist destination.

Lions: Chardonnet (2002) proposed a population of 70 lions in the park, like the estimate of Bauer and van der Merwe (2004) of 60 lions. The IUCN (2006a) report indicated about 50 individuals remaining in the park. The WAZA lion population was estimated at about 100 individuals in 1962 (Flizot 1962) and at 40 and 60 in 2002 (Bauer et al. 2003). Since then, steep declines have been observed. Tumenta et al. (2009) reported a dramatic decline in numbers to between 14 and 21 adults.

Tumenta et al. (2021) recently conducted a lion survey but did not record any lions at nine calling stations. At every calling station, however, human presence was recorded through the observation of flashing torches, the sound of water pumps and motor bikes. These results were alarming, especially given that in 2017 a survey recorded a positive response by lions at 75% of call-in stations (Tumenta, unpublished data). However, lion presence was confirmed during the 2021 survey by locating lion tracks, hearing roars during the survey and by direct sightings of lions by eco-guards during night patrols.

In summary, the Waza lion population has dropped from an estimated 40-60 lions in the late nineties (Bauer et al. 2003) to 14-21 adult individuals in 2009 (Tumenta et al. 2009) and was probably lower than 15 lions in 2021 (Tumenta et al. 2021).

Prey populations: Waza never supported an African buffalo population with the main prey for lions being western kob. During the Tumenta et al. (2021) survey, it was found that populations of western kob had declined dramatically throughout the park, along with all other prey species.

Management effectiveness: Recent observations in Waza National Park in early 2021 suggested that intrusions by fishermen and cattle herds have now become very frequent and persistent, threatening the unique habitat this national park offers to lions and the prey on which they depend (Tumenta et al. 2021). Transect surveys in 2021 found that human activities were the predominant sign left throughout the park, extending far into and throughout the park. Motorbike tracks were found across the core area of the park, transporting poachers and fishermen in and out of the park (Tumenta et al. 2021).

Fishing in permanent waterholes is a relatively new activity, but during the 2021 survey, fishermen and their family members were residing permanently at camps near several important waterholes. At one large waterhole, over 500 local people were observed (Tumenta et al. 2021). Given that this was happening during the dry season when water is scarce and only present in a few permanent waterholes in the park, their presence would most likely keep wildlife from coming to drink. The presence of many fishermen and pastoralists with high numbers of livestock in the park are contributing to the rapid degradation of the park's habitat and wildlife, creating competition for pasture and intensifying human-lion conflict (Tumenta et al. 2021).

Many of these are transhumance pastoralists moving into the park in the dry season to find grazing and influenced by extremist activities in the region. Pastoralists are often armed with firearms creating a tense and volatile situation in the park. At this stage, there is no co-management partner working with the Ministry of Forestry and Wildlife (MINFOF) in the park and the management of the park is at a very low point (Ruggiero *pers. comm*.). Securing such a partnership would seem to be an important next step to support the government in recovering the park and its lion population.

2.4 Bénoué Complex LCU (Bénoué Complex Key Lion Area) [22,23,24]

The Bénoué Complex (30,211 km^2) is located across northern Cameroon along a series of protected areas including Faro, Bouba Ndjida, and Bénoué national parks and surrounding hunting areas (Fig. A8). It is bordered in the west by Gashaka-Gumti National Park in Nigeria and in the east by Sena Oura National Park in Chad (see Fig. A7).

Wildlife is seemingly not as depleted here as in the rest of Central and West Africa, but cheetahs and African wild dogs are extirpated in the ecosystem (de Iongh et al. 2011). With the general demise of wildlife in the Central African Republic (Bouche et al. 2012), the Bénoué Complex was described by Riggio et al. (2013) as the only remaining potential stronghold for lions in Central Africa. However, Zakouma National Park has also been a stronghold for lions in the region for the last two decades (see below). Although the Bénoué Complex is still regarded as a stronghold for lions, its large size and lack of extensive surveys across its entire extent may mask gaps in our knowledge.

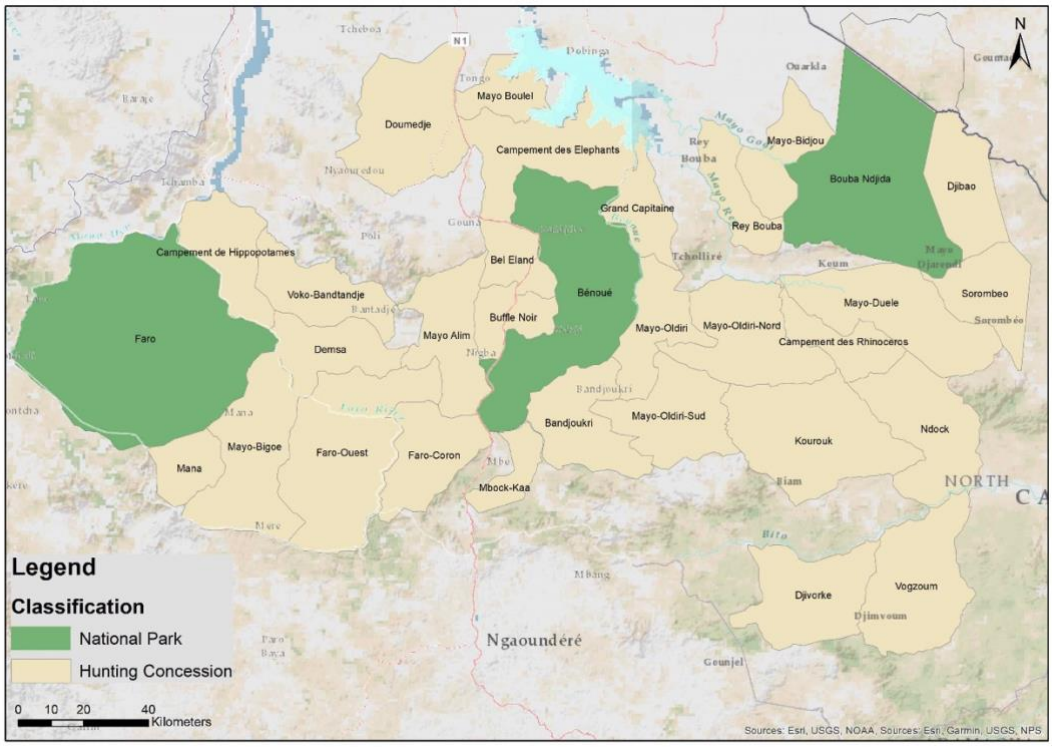

Fig. A8. National parks and hunting zones of the Bénoué Complex, Cameroon. *Parcs nationaux et zones cynégétiques du Complexe de la Bénoué, Cameroun.*

Lions: Chardonnet (2002) estimated that about 345 lions may reside in the Bénoué Complex, which he equated to 23,394 km^2 of protected areas. Bauer and van der Merwe (2004) gave a more conservative estimate of about 200 lions for the Bénoué Complex.

Bauer (2007) surveyed Bouba Ndjida National Park and determined an approximate density of 2.8 lions/100 km^2, resulting in a population of 60 lions in the park. Schoe (2007) surveyed Bénoué National Park in 2006/7 and determined a similar density of 2.3 lions/100 km^2 with a reserve estimate of 41 individual lions.

Based on track surveys conducted in all three national parks and representative areas in some of the hunting areas, Croes et al. (2011) derived density estimates of 1.8 lions/100 km^2 (1.17–2.45) in the national parks and 0.6 lions/100 km^2 (0.12–1.00) in the hunting zones. Based on these, Bénoué National Park was estimated to support 36 lions (23-49), Bouda Ndjida 63 lions (46-81) and Faro 38 lions (25-42). The estimate for all hunting zones combined was 81 lions (17-145), which resulted in a total of about 218 lions (111-317) for the Bénoué Complex (Croes et al. 2011).

This result was not expected based on ungulate prey densities that were more constant across both national parks and hunting areas. It was interpreted as indicative of a strong limiting impact of trophy hunting on lions in the hunting areas. At the time, Cameroon had allocated a high number of lions to its annual hunting quota (Croes et al. 2011).

Bauer et al. (2015) reported on a similar track survey of the Bénoué Complex and estimated that 249 lions occurred across it. However, in this study, the density of lions inside the national parks (0.99 lions/100 km^2) was almost the same as that in the hunting areas (1.07 lions/100 km^2). This resulted in a population estimate of only 72 (61-83) lions in the national parks and about 177 (170-184) lions in the hunting areas. It is worth noting that the number of lions hunted had declined year on year across the complex between the two studies. Given the amount of prey available a population of about 250 lions does not appear unreasonable and would clearly prioritise the Bénoué Complex as supporting the second largest northern lion population in 2015. This is a very important region in terms of the future for the northern lion and indicates clearly that this area should receive far greater conservation attention.

Prey populations: Extrapolating from an aerial survey covering 21,000 km^2 of the complex conducted in 2015 (Elkan et al. 2015), the amount of prey available could theoretically support about 550 lions at a density of about 2.6 lions/100 km^2 (Table A5). However, the area reportedly supports about 250 lions at a density of about 1.1 lions/100 km^2 (Bauer et al. 2015).

It should be noted, however, that 526,233 cattle were observed during the 2015 survey, most of which were present in the four national parks (eastern Faro, Bénoué, northern Bouba Njida and Sena Oura) and in hunting zones around the Bouba Njida-Sena Oura transboundary complex (Elkan et al. 2015). This was a greater than 20 times increase from the 2008 count when 25,264 cattle were observed (Elkan et al. 2015). Furthermore, human presence and access including dirt roads, footpaths, motorbike tracks, paved roads, transhumance tracks, cultivation, gold mining and settlements were similarly distributed in the parks and areas immediately surrounding them (Elkan et al. 2015). If left unchecked, these patterns would severely threaten the integrity of the Bénoué Complex leading to declines in lions and lion prey.

Surveys of the 'Yamoussa Landscape' in 2018 (7,455 km^2, Grossmann et al. 2018), which included Bouda Njida and Sena Oura, indicated that the area could potentially support about 250 lions (3.9 lions/100 km^2, Table A5).

Table A5. Larger herbivore and livestock aerial survey estimates and densities (per 100 km^2) for the entire Bénoué Complex (including Sena-Oura) in 2015 (21,742 km^2, Elkan et al. 2015), and for the Bouba Njida – Sena Oura transboundary complex in 2018 (7,500 km^2, Grossman et al. 2018), and estimated ecological thresholds for lions based on these prey numbers (following Hayward et al. 2007). *Estimations de l'abondance des grands herbivores et des têtes de bétail et densités (par 100 km^2) obtenues à partir de suivis aériens effectués sur l'ensemble du Complexe de la Bénoué (y compris Sena-Oura) en 2015 (21 742 km^2, Elkan et al. 2015), et pour le Complexe transfrontalier Bouba Njida - Sena Oura en 2018 (7 500 km^2, Grossman et al. 2018), et seuils écologiques estimés pour les lions sur la base de ces nombres de proies (d'après Hayward et al. 2007).*

	Bénoué Complex 2015		Bouba Njida-Sena Oura Complex 2018	
Species	**Abundance**	**Density**	**Abundance**	**Density**
Buffalo	1,697	8.08	1,471	22.63
Duikers	2,009	9.57	441	6.78
Eland	2,562	12.20	1,187	15.83
Giraffe	260	1.24	159	2.45
Hartebeest	4,124	19.64	4,939	75.98
Kob	10,350	49.29	2,704	41.60
Oribi	482	2.30	385	5.92
Reedbuck	6,058	28.85	4,723	72.66
Roan	3,098	14.75	1,959	30.14
Topi/Korrigum	151	0.72	389	5.19
Warthog	1,072	5.10	912	14.03
Waterbuck	2,051	9.77	1,309	20.14
Sheep and goats	28,789	137.09	16,245	249.92
Cattle	526,233	2505.87	100,889	22.63
Potential lion abundance	**557**	**2.60**	**254**	**3.90**

Management effectiveness: Collectively, bushmeat poaching, overgrazing and incursions associated with transhumance pastoralism constitute the most immediate threat to lions, other carnivores, and wildlife of the Bénoué complex. Transhumance has increased substantially in recent years due to growing insecurity in northern Cameroon, Bokoharam affected areas in Nigeria, and civil war in adjacent CAR from 2013 through to present. As a result, increased numbers of cattle herders now spend much of the year in and around the national parks with more than half a million livestock.

Primarily in response to address severe elephant poaching in northern Cameroon by Sudanese poachers, and to promote effective protected area management, in 2016 WCS signed a cooperative agreement between the governments of the Republic of Cameroon and the Republic of Chad to create the Bouba-Ndjida–Sena Oura transboundary complex (6,500 km^2). With funding primarily from KfW, WCS has worked with the governments of Cameroon and Chad to establish ground-based activities in both national parks to promote park protection and infrastructure, and to increase the capacity of park personnel.

A similar programme of support is being implemented in the Faro region of the complex, where AWF, Noé, and Conserve Global are working with the government and hunting operators and associations to secure and recover the Faro component of the complex. The Faro component, as with other protected areas in northern Cameroon, are threatened by cross-border cattle herding (transhumance), small-scale subsistence and commercial poaching, illegal fishing and gold mining in the Faro River and tributaries, and general natural resource extraction. Generally, Faro National Park is insufficiently

monitored by ecoguards employed by the Ministry of Forests and Fauna (MINFOF) and current support levels from AWF are below what is needed (Ruggiero pers. comm.).

The programme funded by the European Union entitled "Cameroon: Green Deal and Resilience in northern Cameroon", aims to increase the resilience of its northern regions. Funding for the Faro area is anticipated to improve natural resource protection generating benefits for rural communities. The lead applicant for this support in the Faro component are AWF, with Conserve Global and Noé as co-applicants.

2.5 Chad-CAR LCU

This LCU covers a vast region (440,260 km^2) of south-eastern Chad and the entire eastern part of the Central African Republic (see Fig. A7). Much of this LCU, however, does not necessarily represent the actual distribution or the conservation opportunity for lions within it. A revision of the LCU is thus proposed splitting the area into three Key Lion Areas, the Zakouma area (~50,000 km^2) in Chad, Northern CAR (~110,000 km^2), and the Chinko area (~85,000 km^2) in CAR (Fig. A9).

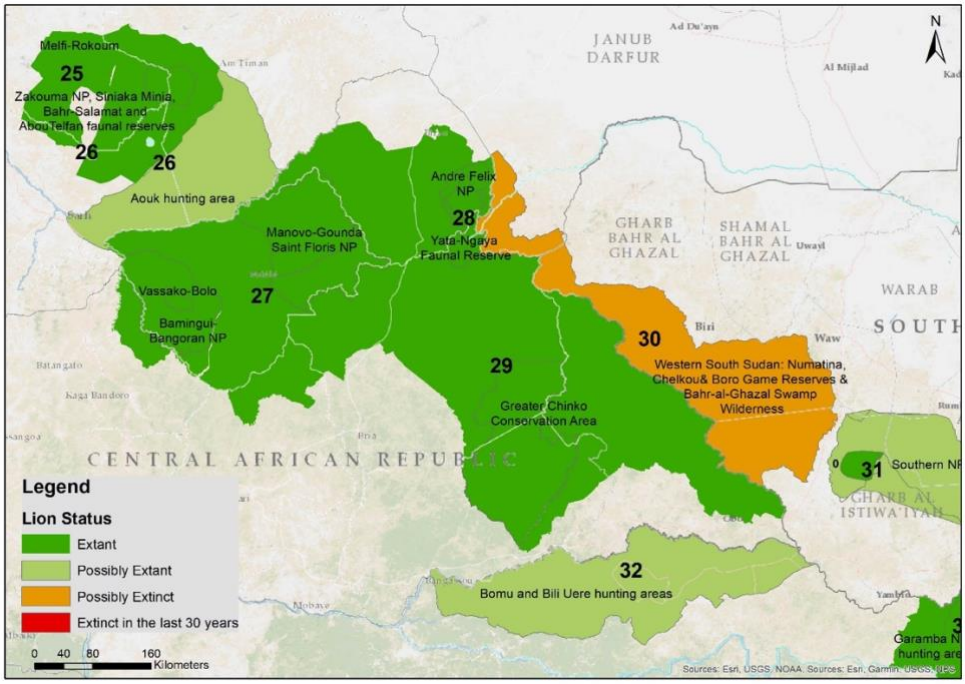

Fig. A9. Key protected areas in the Chad-CAR LCU, depicting the Greater Zakouma Landscape [25,26] in Chad, the Northern CAR [27,27] and Greater Chinko Conservation Area [29} in CAR, and neighbouring areas in South Sudan [30,31], and the Democratic Republic of Congo [32]. *Principales aires protégées de l'UCL Tchad-RCA, représentant le paysage du Grand Zakouma [25,26] au Tchad, le Nord de la RCA [27,27] et la Zone de conservation du Grand Chinko [29} en RCA, ainsi que les zones voisines du Soudan du Sud [30,31] et de la République démocratique du Congo [32].*

Lions: Chardonnet (2002) gave a very speculative total estimated population of 1,506 lions in this region, whereas Bauer and van der Merwe (2004) proposed a much more conservative estimate of 450 lions. Although Bauer et al. (2005) notes that Chardonnet (2002) had more information when making his estimates of lion populations across this region, it is likely that an almost complete dearth of any credible surveys resulted in estimates with no validity across this LCU. Believing that Chardonnet

(2002) had access to data across a wider area, the IUCN (2006a) report suggests a total lion population of 1,500 individuals across the LCU.

a) Zakouma Key Lion Area [25,26]

The Greater Zakouma Ecosystem is about 28,162 km^2 in extent and forms the key component of the Zakouma Key Lion Area. The area was classified as south-eastern Chad by Riggio (2011) and is one of the few intact Sahelian ecosystems left in Africa. The Zakouma Key Lion Area consists of Zakouma National Park (3,050 km^2) and Siniaka Mania (4,643 km^2), Bahr-Salamat (20,950 km^2) and Abou Telfan (1,100 km^2) faunal reserves, Melfi-Rokoum (4,260 km^2) controlled hunting area, and adjoining wildlife corridors (~10,000 km^2) totalling an area of about 50,000 km^2 (see Fig. A10).

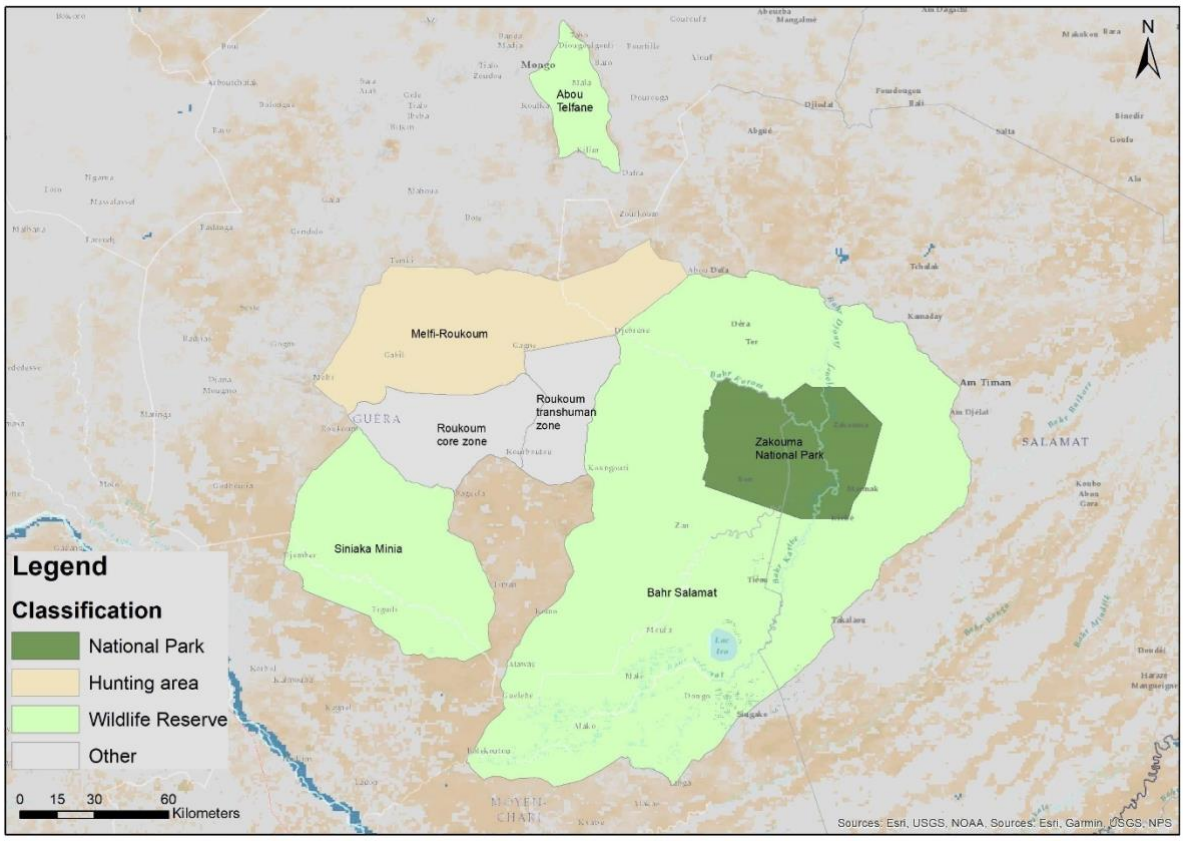

Fig. A10. Detailed map of the Greater Zakouma Ecosystem and the accompanying Melfi-Rokoum controlled hunting area in south-east Chad. *Carte détaillée de l'écosystème du Grand Zakouma et de la zone de chasse contrôlée de Melfi-Rokoum qui l'accompagne, dans le sud-est du Tchad.*

Lions: Vanherle (2011) monitored lion populations in a core area of Zakouma National Park from 2003 to 2006. Based on individual recognition and call-in surveys, about 140 lions were estimated to occur in the eastern 1,500 km^2 of the park. A follow up study in 2013 resulted in a lion population estimate of 110-130 individuals (Olléová & Dogringar 2013). By 2018, the lion population in Zakouma National Park had not increased, although prey numbers had increased substantially (African Parks 2022a). African Parks (pers. comm.) report that lions occur in Siniaka Mania and the corridor to Zakouma, and in the Melfi-Rokoum hunting.

Although no further lion population estimates have been released, African Parks reports that SECR with unstructured sampling data and individual ID of lions is being undertaken in the park.

Furthermore, presence/absence data is being collected across the entire Greater Zakouma Ecosystem through citizen science reports, human-wildlife conflict reports, and camera trapping in some areas. Once analysed these data should result in new insights into lion numbers and distribution across the ecosystem. Radio-telemetry studies have shown that the park's lions' range over a far large area than anticipated. Lions are therefore likely to be killed by pastoralists or poachers well beyond the boundaries of the park (African Parks 2022a).

Prey populations: Since African Parks took over the management of Zakouma in 2010, poaching has declined dramatically, and wildlife populations began to stabilise and are now increasing (see Table A6).

Table A6. Recent larger herbivore and livestock aerial survey estimates and densities (per 100 km^2) for Zakouma National Park in 2021 and the Zakouma Greater Ecosystem in 2019 (Potgieter et al. 2019, Fraticelli et al. 2021) and estimated ecological thresholds for lions based on these prey numbers (following Hayward et al. 2007). *Estimations récentes de l'abondance des grands herbivores et des têtes de bétail et densités (par 100 km^2) obtenues d'après les suivis aériens effectués dans le Parc National de Zakouma en 2021 et le Grand écosystème de Zakouma en 2019 (Potgieter et al. 2019, Fraticelli et al. 2021) et seuils écologiques estimés pour les lions sur la base du nombre de ces proies (d'après Hayward et al. 2007).*

	Zakouma Greater Ecosystem		Zakouma National Park	
Species	**Abundance**	**Density**	**Abundance**	**Density**
Buffalo	-	-	15,528	497.37
Duikers	1,849	8.59	-	-
Gazelle	86	0.40	-	-
Giraffe	193	0.80	1,546	-
Hartebeest	987	4.58	3,672	117.62
Kob	-	-	1,147	36.74
Kudu	319	1.48	-	-
Oribi	484	2.25	-	-
Reedbuck	-	-	1,106	35.43
Roan	941	4.37	845	27.07
Tiang	-	-	2,869	91.90
Warthog	1,946	9.04	254	8.14
Waterbuck	-	-	2,621	83.95
Sheep and goats	264,833	1230.18	555	17.78
Cattle	227,076	1054.79	2,935	94.01
Camels	59,900	278.24	-	-
Horses and donkeys	11,175	51.91	16	0.51
Potential lion abundance			**377**	**12.90**

Giraffe, buffalo, and other species have experienced little to no poaching during the past 10 years, and only 24 elephants have been killed since 2010. Based on herbivore numbers from aerial surveys conducted in the dry seasons of 2019 and 2021, the park might be expected to support about 370 lions with about 200 lions potentially occurring in the remainder of the Zakouma Key Lion Area (Table A6). However, these were dry season counts, with herbivore movements being very seasonal. Large numbers of wildlife move out of the park in the wet season. Consequently, it is wet season as opposed to dry season prey biomass that determines the numbers of lions that could be sustained. The potential lion density that the parks could sustain is therefore likely to be lower than that given in Table A6.

Overall, prey populations could theoretically support high densities of lions, but their annual migration patterns along with some anthropogenic influences seem to limit lion density in the park to about 3.5 to 4.1 lions/100 km^2. This is nevertheless the highest density of lions occurring in Central and West Africa and highlight the importance of the Zakouma Key Lion Area and the consistent conservation efforts of African Parks.

When lions leave the park (see Fig. A11), they enter an ecosystem with just over half a million livestock. This results in relatively high probability of persecution of lions outside the park and limits the size of the lion population in the park. Substantially lower herbivore numbers occur in the Roukom Core Zone and the Saniaka Mania Faunal Reserve when compared with the park (Potgieter et al. 2019, Fraticelli et al. 2021).

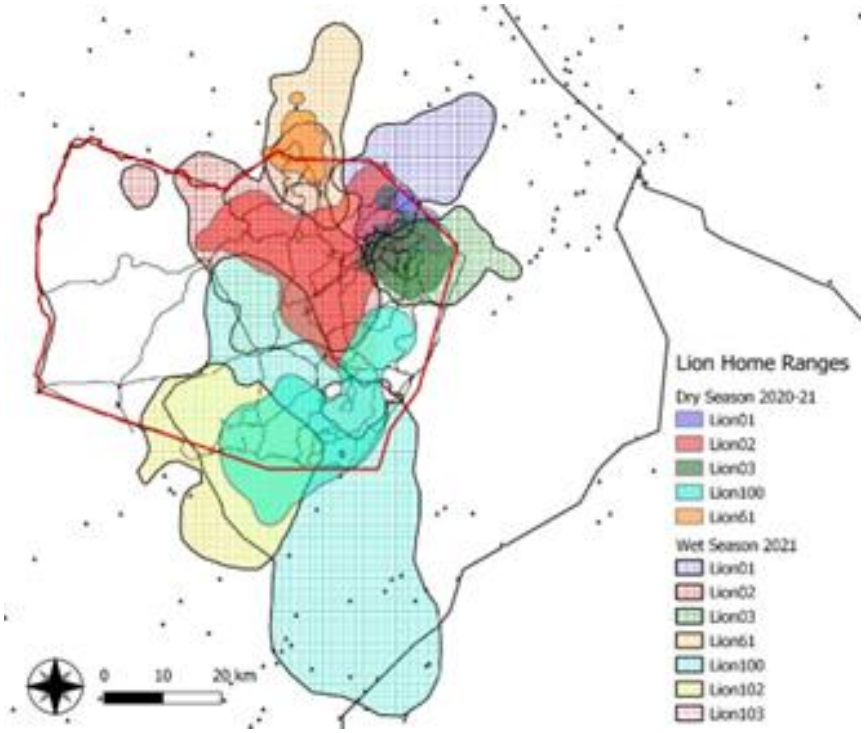

Fig. A11. Wet and dry season home ranges of seven radio-collared lions in and around Zakouma National Park, Chad, in the years 2020 and 2021 (reproduced from African Parks 2022a). *Domaines vitaux en saison humide et en saison sèche de sept lions équipés de colliers émetteurs dans et autour du Parc National de Zakouma, au Tchad, au cours des années 2020 et 2021 (reproduit à partir d'African Parks 2022a).*

Along with seemingly fewer lions in the west of the park seems to set a current cap on the lion population in the Zakouma Key Lion Area, although lions are now being increasingly recorded in the Siniaka-Minia Wildlife Reserve and may be responding to translocations of buffalo by African Parks into that area (African Parks 2022a). In time, lions may be able to reside in other areas of the Zakouma Key Lion Area and could potentially connect with lions in the Central African Republic via the Aouk hunting area. With Zakouma National Park as the core source population, this ~50,000 km^2 Key Lion Area is critical not only to the conservation of lions in Chad, but also as a key source population for lions across the Central African region.

Management effectiveness: Between 2002 and 2010, the elephant population in Zakouma was devastated by heavily armed poachers, who reduced the population by 90% from 4,500 to 450 over the eight-year period. During this time, there were also high levels of insecurity in the area. However,

in 2010, park management improved when African Parks signed a collaborative partnership agreement with the government to restore and manage Zakouma for a period of 10 years. By installing a professional law enforcement team, developing infrastructure, and engaging with local communities, security was restored to the park which paved the way for improvement throughout the Zakouma Key Lion Area. Wildlife numbers have continued to increase and by 2016, poaching was virtually eliminated in Zakouma National Park. To expand upon this success African Parks was invited in 2017 by the government to manage the Siniaka-Minia Wildlife Reserve and Bahr Salamat Faunal Reserve, including adjoining wildlife corridors, giving African Parks the mandate to manage the entire Greater Zakouma Ecosystem (28,162 km^2).

b) Northern CAR Key Lion Area [27,28]

Protected areas in northern CAR located along international borders with Chad and South Sudan offer a vast expanse (~110,000 km^2) of natural landscapes with a very low human population density typically of less than 0.5 inhabitants/km^2 (Roulet 2007). The districts of Bamingui-Bangoran and Vakanga in Northern CAR cover an area of about 105,000 km^2 of which around 51,060 km^2 are protected areas (Fig. A9). The protected area region of Bamingui comprises: Bamingui-Bangoran National Park (10,700 km^2) with Vassako-Bollo Reserve at its centre and Gribingui-Bamingui Reserve to the west. The Presidential Park Awakaba joins Bamingui-Bangoran in the east. Manovo-Gounda-St Floris National Park (17,400 km^2) is joined to the North by the l'Aouk-Aoukale Reserve.

Although the area has great potential for wildlife conservation, commercial poaching and wildlife trafficking, civil unrest, gold mining, degradation of habitat (by grazing primarily) and encroachment with livestock have resulted in significant declines of wildlife in the area (Elkan 2017). The vast area and relative lack of access have made the area vulnerable to incursions from neighbouring countries and a refuge for multiple rebellions.

Lions: Although no formal surveys have been conducted, conservationists working in the Northern CAR Key Lion Area estimate that between 20 and some tens of individual lions remain in the area (Hunter pers. comm.). Since March 2020, WCS has recorded 12 independent observations in both national parks and the area in between (WCS 2022). There are also reports giving an estimate of about 35 lions in the Gounda protected area, specifically in the vicinity of Andre-Felix National Park (Marav pers. comm).

Prey populations: Over the last two decades, several aerial surveys were conducted across a 63,657 km^2 area of Northern CAR including all the protected areas (Renaud et al. 2006, Bouché et al. 2010, Elkan et al. 2017). Intensive conflict and civil war broke out in 2013 and although a peace agreement was signed in 2018, insecurity continues through to the present. In particular, the 2017 survey found scant presence of buffalo, giant eland, and the highly endangered northern giraffe Kordofan subspecies (Table A7), which is likely to be the last remaining population in CAR (Elkan et al. 2017). All herbivore species were found to have experienced dramatic declines compared to the populations' levels observed in 2005 and 2010, except for roan antelope and bushbuck that were observed to have remained stable since the previous aerial survey in 2010 (see Table A7).

Due to sparse prey populations, especially buffalo, it is hard to estimate how many lions the area might support, however, a density of about 0.2 to 1.0 lions/100 km^2 is likely to be possible in areas where wildlife is more concentrated. Even though human density is very low in the region, large numbers of livestock occur, with over 250,000 recorded in 2010 (Bouché et al. 2010). People and livestock move

widely in pursuit of grazing in the region and in 2017 about half as many livestock were recorded in the region (Elkan et al. 2017; Table A7).

Table A7. Recent larger herbivore and livestock aerial survey estimates and densities (per 100 km^2) for Northern CAR in 2010 and 2017 (Elkan et al. 2017) and estimated ecological thresholds for lions based on these prey numbers (following Hayward et al. 2007). *Estimations récentes de l'abondance des grands herbivores et des têtes de bétail et densités (par 100 km^2) obtenues d'après les suivis aériens effectués dans le nord de la RCA en 2010 et 2017 (Elkan et al. 2017) et seuils écologiques estimés pour les lions sur la base de ces effectifs de proies (d'après Hayward et al. 2007).*

	2010		2017	
Species	**Abundance**	**Density**	**Abundance**	**Density**
Bongo	<100	0.20	-	-
Buffalo	4,048	7.94	*<15	0.03
Bushbuck	1,503	2.95	1,150	2.25
Duikers	>6,000	11.76	4,200	8.24
Giant eland	1,588	3.11	*38	0.07
Giraffe	162	0.32	*2	0.00
Hartebeest	2,811	5.51	425	0.83
Kob	416	0.82	-	-
Oribi	1,237	2.43	600	1.18
Reedbuck	248	0.49	-	-
Roan	1,065	2.09	1,000	1.96
Warthog, forest hog and bushpig	5,727	11.23	1,900	3.73
Waterbuck	198	0.39	2	-
Sheep and goats	27,110	53.16	11,575	22.70
Cattle	224,359	439.92	114,425	224.36
Camels	391	0.77	-	-
Horses and donkeys	-	-	400	0.78
Potential lion abundance	**1,526**	**2.40**	**186**	**0.30**

*Minimum observed – not a survey extrapolation

Management effectiveness: Northern CAR still held an estimated 63,000 elephants in 1979 but intense poaching in the 1980s decimated elephants and rhinos were eliminated in the 1980s. The threats to wildlife and protected areas in Northern CAR remain very challenging and insecurity is high. Ivory poaching and trafficking, and commercial bushmeat hunting involves insurgents, other armed groups and armed horsemen from northern Sudan and Chad. Furthermore, unregulated, and illegal extraction of oil, gold and diamonds occurs in protected areas, sometimes by armed militias. Nomadic pastoralism places pressure on protected areas and is a source of retaliatory and pre-emptive killing of carnivores as well as of poaching of prey species inside parks.

Despite these challenges, the situation is starting to improve. Following the outbreak of armed conflict in CAR in 2012-13, which spread across the entire country, peace agreements and political processes have taken hold in 2019 and continued through 2020. These processes are helping to stabilise the country and have created recent opportunities for long term conservation planning and management. To that end, in December 2018, the Wildlife Conservation Society signed a 25-year Private Public Partnership agreement with the CAR Government that provides WCS with the mandate of delegated planning and management of more than 110,000 km^2 in the Northern CAR complex. This is highly significant for the region, with the potential for lions and general wildlife recovery likely to be

facilitated by abundant rainfall, intact watersheds, intact habitat over vast areas, and very low, resident human densities (WCS 2022).

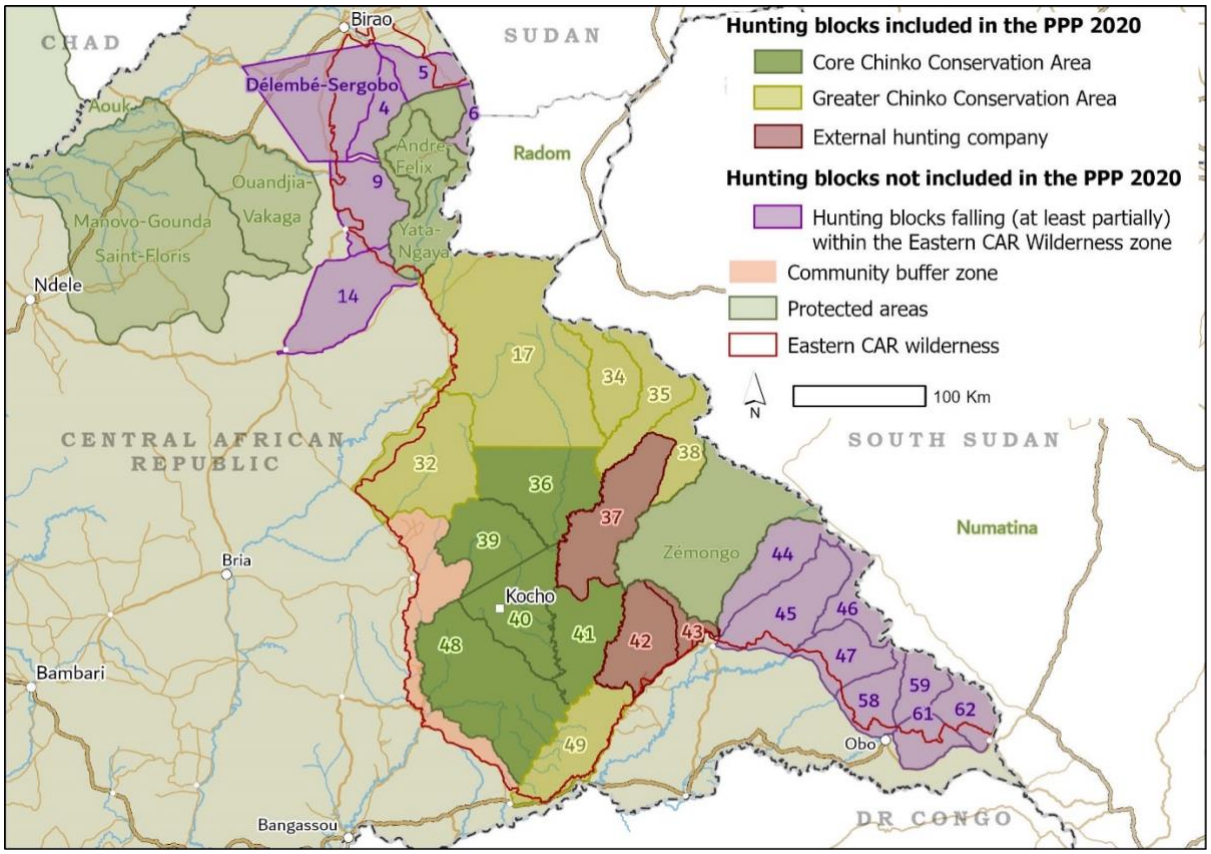

Fig. A12. Various core protected areas and hunting blocks in the highly connected Eastern CAR Wilderness (reproduced from African Parks 2022b). *Divers cœurs d'aires protégées et blocs de chasse dans la région sauvage bien connectée à l'est de la RCA (reproduit à partir d'African Parks 2022b).*

c) Chinko Key Lion Area (Eastern Central African Wilderness) [29]

The Eastern CAR Wilderness Zone offers suitable lion habitat of more than 100,000 km^2 throughout Chinko River basin and adjacent regions in the Eastern CAR into the Western regions of South Sudan. Potential core protected areas here include: the core and greater Chinko Conservation Area (Chinko-Mbari River Core Area), André-Felix National Park and Yata-Ngaya Faunal Reserve in CAR. Almost the entire area in eastern CAR is gazetted as hunting zones, faunal reserves, or national parks, and is thus officially designated for wildlife conservation (see Fig. A12). The areas are largely connected by suitable habitat although wildlife populations are low in some areas (Aebischer pers. comm.).

Wildlife populations in CAR have been hunted widely and there is a heavily organised and militarised illegal wildlife trade that is able to move through porous borders. There are several cases of well-documented massacres of elephants (Bouché et al. 2012).

Lions: The only area in this entire region where lions have been surveyed is in a 6,000 km^2 core area in the Chinko Conservation Area. Track count and camera trap surveys did suggest a sharp decline in lion numbers from 2012 (158 lions) to 2017 (43 lions in about 10,800 km^2) due to the invasion of pastoralists (Aebischer et al. 2020). Then, by 2021, it was estimated that lion density had increased by 33% since 2017 to about 108 lions across a 16,621 km^2 lion prevalence area (African Parks 2022b). It

should be noted that these populations estimates cannot be verified as they are extrapolations from a 6,000 km^2 sampling area.

Although organised poaching groups are present in the area, the main driver of the lion population decrease is likely to be from fluxes in transhumance pastoralism. At times, massive groups of heavily armed cattle herders migrate from the Sahel southwards through the eastern CAR (Aebischer et al. 2020). The influx of cattle and herders, and accompanying criminal elements, takes place each dry season from November-April and is intensifying due to climatic variability in the Sahel and severe overexploitation of its natural resources. On their path, large swaths of habitat are burnt, cut down or over-grazed, and animals are poached opportunistically. Lions suffer from direct killing for body parts, poisoning, retaliations, protection from lion attacks on cattle and/or the depletion of key prey species such as buffalo.

Prey populations: Chinko Conservation Area previously housed thousands of buffaloes, elephants, and lions but experienced significant decreases (as much as 95%) in wildlife populations during the 1980s–2000s because of cattle grazing, the ivory trade, and poaching. Thus, up until about 2016, the Chinko Conservation Area had become largely overrun by pastoralists with livestock causing declines in lion and prey numbers (Aebischer et al. 2020).

Since 2017, the increased protection efforts have seemingly resulted in a steady increase in key lion prey species. Buffalo, waterbuck, giant eland, hartebeest, and lowland bongo have increased in numbers by about 36% (African Parks 2022b). However, due to thickly wooded savanna, there have yet not been any aerial surveys of the conservation area, with key ungulate and large carnivore annual estimates since 2017 being made by track surveys (African Parks 2022b, Aebischer pers. comm.).

A tentative conclusion is that the Chinko Conservation Area could potentially expect an increase from a density of about 0.6 lions/100 km^2 to about 3.8 lions/100 km^2 over an area of 17,000 km^2 based on current estimates of prey abundance (see Table A8). However, lions must be adequately secured from persecution by pastoralists and other anthropogenic threats. The potential exists for lions to range widely across the Eastern CAR Wilderness Zone north to the North CAR Key Lion Area and the Andre Felix National Park, and east into western South Sudan, if core areas and connectivity can be maintained in the landscape (Aebischer pers. comm.).

Table A8. Key herbivore track survey estimates and densities (per 100 km^2) for the Chinko Conservation Area in 2020 (African Parks 2022b, Aebischer pers. comm. 2020) and the estimated ecological threshold for lions based on these prey numbers (following Hayward et al. 2007). *Estimations de l'abondance d'herbivores clés d'après un suivi des traces et densités (par 100 km^2) pour la Zone de Conservation de Chinko en 2020 (African Parks 2022b, Aebischer comm. pers. 2020) et seuil écologique pour les lions, estimé sur la base de ces effectifs de proies (d'après Hayward et al. 2007).*

Species	Abundance	Density
Buffalo	3,388	19.78
Bongo	1,654	9.66
Eland	862	5.03
Hartebeest	128	0.75
Roan	1,106	6.46
Waterbuck	1,580	9.23
Potential lion abundance	**637**	**3.80**

Management effectiveness: In 2014, Chinko Conservation Area (19,846 km^2) was established by the government of the CAR who signed a management agreement with African Parks to enable law enforcement in this wilderness, which may yet be designated as a faunal reserve or national park. The vision was to transform the park, to enable stability to return, wildlife to recover and to improve people's livelihoods.

Since 2017 the conservation area has experienced significant improvement, expanding the area free from threats associated with transhumance pastoralism despite growing pressure. By the end of the 2019-2020 dry season, African Parks achieved keeping 23,800 km^2 of the Chinko Conservation Area free from transhumance incursions and estimates its core protection zone actively kept free of human incursions at about 17,600 km^2, up from about 5,000 km^2 in 2017. Currently, while African Parks actively manages an area of about 24,300 km^2 covering five hunting blocks, the area they influence now stands at about 64,000 km^2 and is referred to as the Greater Chinko Conservation Area (Aebischer pers. comm.; Fig. A13).

Fig. A13. Map of the Chinko Core and Greater Chinko conservation areas managed and influenced by African Parks in eastern Central African Republic (reproduced from African Parks 2022b). *Carte des zones de conservation du cœur de Chinko et du Grand Chinko gérées et influencées par African Parks dans l'est de la République centrafricaine (reproduit à partir d'African Parks 2022b).*

2.6 Southwestern Sudan LCU [30,31]

The Southwestern LCU in South Sudan covers a large portion of the southern half of the country west of the Nile River (358,150 km^2) and includes Southern and Shambe national parks (see Fig. A7). Southern National Park was established in 1939 and covers an area of 23,000 km^2. Shambe National Park (620 km^2) lies just west of the Nile system and includes the park and a large area of wetlands

northwest of the park. This wetland maintains significant water throughout the year and includes populations of buffalo, giraffe, roan, and elephant, as well as high numbers of livestock.

Lions: Chardonnet (2002) gave a "highly speculative" estimate of 364 lions in the LCU based on bibliographical references from the 1980s, deductive cartography, and personal communications. Whereas Bauer and van der Merwe (2004) simply mention that an "absence of information" occurs for the region. No population estimates are available for Southern National Park, with a recent camera trap survey, positive spoor and some anecdotal observations confirming lion presence in the park (FFI 2022). While this is encouraging, populations are likely to be very low given the low prey availability (Elkan pers. comm.). Shambe National Park and surrounds are not reported to support any resident lions at present but may be an area for potential lion recovery in the future.

Prey populations: In the past, Southern National Park was recognised as one of the richest parks in Sudan in terms of biological diversity and large mammal abundance. In 1980, the park could have supported about 2,600 lions at a density of 9.9 lions/100 km^2 based on aerial survey estimates of prey abundance. At the time, the park and its immediate surroundings were estimated to house about 75,000 buffalo, over 15,000 elephants, 15,000 hartebeest and 168 white rhinos (Boitani et al. 1981). Then, few human habitations were recorded in the park and not a single head of domestic livestock.

After more than twenty years of civil war, an aerial survey of the park in 2007 covered 26,711 km² at a relatively similar low sampling intensity of about 2.7% to the 1980 surveys (Fay et al. 2007; see Table A9). A follow up survey was conducted in 2009-2010 (Grossman et al. 2010; see Table A9). By then, rhinos were extirpated, and ungulates had declined to the point where they would not been able to support a lion density of no more than about 1 lion/100 km². Only one group of elephants and no buffalo were observed.

Table A9. Suitable lion prey aerial survey estimates done in 1980 (Fay et al. 2007) and repeated in 2007 and 2010 for Southern National Park (Grossman et al. 2010) and estimated ecological thresholds for lions based on these prey numbers (following Hayward et al. 2007). *Estimations de l'abondance des proies du Lion obtenues par suivi aérien en 1980 (Fay et al. 2007) et répété en 2007 et 2010 pour le Parc National du Sud (Grossman et al. 2010) et seuils écologiques estimés pour les lions sur la base de ces nombres de proies (selon Hayward et al. 2007).*

	Late wet season 1981		Early dry season 2007		Dry season 2010	
Species	**Abundance**	**Density**	**Abundance**	**Species**	**Abundance**	**Density**
Buffalo	60,850	227.90	-	-	-	-
Bushbuck	269	1.01	-	-	-	-
Duikers and dik-dik	570	2.13	-	-	-	-
Giant eland	118	0.44	165	0.62	416	15.61
Giraffe	1,325	4.96	-	-	-	-
Lelwel hartebeest	8,132	30.46	1,070	4.01	1,029	3.85
Uganda kob	472	1.77	329	1.23	-	-
Oribi	538	2.01	247	0.93	-	-
Bohor reedbuck	685	2.57	-	-	-	-
Roan antelope	1,043	3.91	865	3.24	-	-
Waterbuck	2,580	9.66	-	-	-	-
Warthog	2,213	8.29	906	3.39	1,441	5.40
Cattle			12,556	0.05	60,981	228.39
Sheep & Goats			124	0.46	1,544	5.78
Potential lion abundance	**2,641**	**9.90**				

Although some recce flights were conducted in 2015/16 during the recent armed conflict (2013-2018), these were not done at sufficient intensity for abundance estimates of lion prey species, but further declines in prey along with persecution were likely to have driven lion populations to critically low numbers (Elkan et al. 2017). Shambe National Park may have potential as a Key Lion Area although it contained an extremely high number of cattle and many pastoralists when last surveyed in 2010 (Grossmann et al. 2010; see Table A10). The survey covered a total area of 40,321 km^2 and found sufficient prey to potentially support a small lion population in the future, although this is unlikely given the very high levels of livestock in the area.

Management effectiveness: When aerial surveys recommenced in 2007 (and were repeated in 2010), there had been no proper wildlife management in place in Southern or Shambe national parks since the civil war started almost three decades earlier (1985-2005, Fay et al. 2007). Subsequently the government of Southern Sudan began to deploy rangers and initiate patrols in the past few years. With support of GEF, WCS and the Wildlife Service of South Sudan established basic infrastructure (Park HQ) in the eastern sector of the Southern National Park in 2011. Wildlife protection training, equipment, and operational support, monitoring and community outreach efforts have been implemented since then. FFI worked in the western area of Southern Park in 2011-13 and then withdrew due to lack of funding. The recent armed conflict that broke out in December 2013 and raged throughout the country through 2018, continuing to destabilise many areas, heavily impacted areas around Southern National Park.

Table A10. Suitable lion prey aerial survey estimates from 2010 in the Shambe National Park and surrounding areas (Grossmann et al. 2010). *Estimations de l'abondance des proies du Lion par suivi aérien en 2010 dans le Parc National de Shambe et ses environs (Grossmann et al. 2010).*

	Dry season 2010	
Species	**Abundance**	**Density**
Giraffe	574	1.42
Uganda kob	1,317	3.27
Bohor reedbuck	1,553	3.85
Roan antelope	1,148	2.84
Tiang	878	2.17
Cattle	223,949	555.70
Sheep & Goats	31,708	78.67

In 2020, there was no infrastructure within Southern National Park to support its effective management, such as roads or functional headquarters/patrol posts and there was also no active patrolling. Despite the heavy fighting in the country, WCS continued to maintain basic patrolling and support operations in the eastern sector of Southern National Park. FFI reengaged in the western sector of the park in 2019. Both, FFI and WCS worked with the government, coordinating efforts over the years, and have started implementing park management in parts of the park. WCS withdrew from Southern Park in 2022. Following years of renewed heavy conflict, South Sudan entered a period of comparative stability in 2020.

2.7 Garamba-Bili Uéré LCU

The Garamba-Bili Uéré LCU falls completely within the Democratic Republic of Congo (DRC) and covers 131,640 km^2. It includes one of Africa's oldest parks, Garamba National Park (5,133 km^2) and surrounding hunting zones (9,662 km^2). To the west lies the Bili-Uéré Protected Area Complex on the borders of Central African Republic (CAR) and South Sudan. Due to the distance between the two

areas, each is designated here as two separate protected areas: the Bili-Uéré Complex and the Garamba Key Lion Area (see Fig. A14 and A15).

Lions: Chardonnet (2002) estimated a total of 400 lions within the LCU. The IUCN (2006b) report provides an estimate of 100 to 250 lions across the entire LCU. However, these estimates are all likely to have been overly hopeful.

a) Bili-Uéré Complex [32]

The Bili-Uéré reserves (43,750 km^2) were designated in 1976 and represent the largest contiguous protected area in DRC (Fig. A14). The Bili-Uéré complex consists of two protected areas comprised of three areas: Bomu Reserve Part 1 West (6,590 km^2) and Part 2 East (4,152 km^2), and the Bili-Uéré Hunting Area (33,010 km^2; Fig. A14).

Lions: Chardonnet (2002) estimated 220 lions for the Bomu/Bili Uéré hunting areas. The African Wildlife Foundation suggested that up to 50 lions may occur in the Bomu/Bili Uéré hunting area (Maputla pers. comm.). However, given very low prey numbers, this is likely to be a considerable overestimate with a focussed lion survey being required (Elkan pers. comm.).

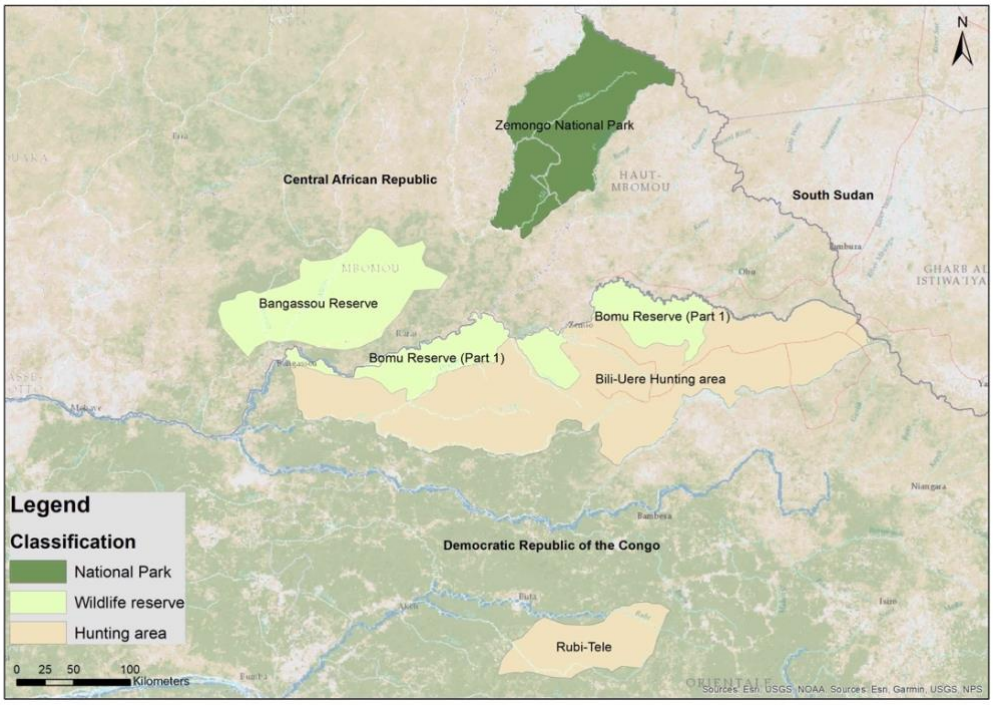

Fig. A14. The Bili-Uéré protected area complex in northern Democratic Republic of Congo and nearby protected areas. *Le complexe d'aires protégées de Bili-Uéré dans le nord de la République démocratique du Congo et les aires protégées voisines.*

Prey populations: An aerial survey covering an area of 47,177 km^2 was conducted in the dry season of 2013. So little wildlife was recorded that wildlife estimates could not be computed. Buffalo, bongo, red-river hog, Defassa waterbuck, bushbuck, giant forest hog and various duikers were recorded to be present with extensive suitable natural habitat (Table A11; Elkan et al. 2013). Human activity was however widespread and settlements, camps and small-scale agriculture were recorded inside the protected areas. Cattle were found in the eastern portion of Bili-Uéré in the savanna zone and they were the most abundant mammal observed (Elkan et al. 2013).

Observations during surveys in November 2021 (late wet season) and April 2022 (dry season) found wildlife encounter rates to be very low, although elephant, bongo and buffalo were observed to use the savanna area (Elkan et al. 2022). Transhumance pastoralism was observed in several zones throughout the landscape as well as heavy gold mining pressure in the western parts. It should be noted that none of the surveys were done at high sampling intensity being largely reconnaissance flights. Nevertheless, without extrapolation, about 5,000 livestock were recorded in each survey (Elkan et al. 2013, 2022; Table A11). Due to the lack of abundance estimates for lion prey species, no potential lion abundance is given, but the potential for lions in the system is very low (Elkan pers. comm.).

Table A11. Recent suitable lion prey aerial survey estimates for 2013 and 2022 over the Bili-Uéré protected area complex (Elkan et al. 2013, 2022). *Estimations récentes de l'abondance des proies du Lion obtenues par suivi aérien pour 2013 et 2022 dans le complexe d'aires protégées de Bili-Uéré (Elkan et al. 2013, 2022).*

	Total individuals observed (minimum count)	
Species	**2013**	**2022**
Buffalo	35	28
Bongo	21	8
Bushbuck	3	1
Duikers	19	73
Giant forest hog	1	-
Oribi	1	-
Red river hog	21	63
Sitatunga	-	1
Waterbuck	2	-
Warthog	123	32
Cattle	4,820	4,090

Management effectiveness: The complex is the largest protected area in the DRC and was designated in 1974 as a hunting area (Domaine de chasse). Therefore, it receives the lowest level of protection under DRC law and should be subject to the 'regulated and monitored exploitation' of wildlife and human habitation can also be permitted. Bomu is designated as a 'réserve de faune' (strict nature reserve) or 'réserve totale de faune'. It is technically one protected area but consists of two 'parts' and falls under a level of protection concurrent with IUCN Category 1b. In a 'réserve de faune', the 1982 hunting act prohibits the hunting, killing, or capturing of wildlife and human habitation.

In 2015, AWF, ICCN, and Maisha initiated an EU funded conservation, protected area management, and security programme to establish the first substantial conservation effort in the Billi-Uéré-Mbomu protected area landscape. Due to limited budget, efforts were focussed on attempting to bring wildlife conservation and protection to a core of about 10,500 km^2. However, patrol efforts from 2015 to the present have largely been limited to the southern half of this block (~5,000 km^2).

While poaching of elephants and other large mammals is reported to be low in the core area, there has not been any effort yet to curtail village hunting of medium-small wildlife species, even in the core (Elkan et al. 2022). This has resulted in a minimal conservation presence across Bili-Uéré-Mbomu. When combined with regional conflict dynamics and transhumance pressures, which have resulted in further poaching, this has contributed to wildlife population declines across this area. At present the Bili-Uéré complex is not likely to be a suitable area for lion recovery.

b) Garamba Key Lion Area [33]

Garamba National Park was designated in 1938 and declared a World Heritage Site in 1980. This critically important landscape has a tragic past and is often referred to as ground zero in the elephant poaching wars in Africa. Garamba National Park covers 5,133 km^2, with the adjacent domaines de chasse covering 9,662 km^2 (Fig. A14). It is situated in the north-eastern DRC bordering South Sudan. Once home to 22,000 elephants in the 1970s, militarised poachers reduced the population to fewer than 1,200 today; and the northern white rhinos were poached to local extinction in the early 2000s. During three decades from the 1980s to 2000s, Garamba was overrun with rebel forces and heavily militarised poachers, leaving human and environmental devastation in their wake.

Lions: Chardonnet (2002) estimated 180 lions for the Garamba complex. Bauer and Van Der Merwe (2004) did not estimate lion numbers in the Bili-Uéré hunting areas but estimated a population of 150 individuals in the Garamba complex. African Parks indicated that only about 19 lions existed in the park in 2017. However, in 2021, Vogel (African Parks *pers. comm*.) extrapolated results from a smaller survey area to estimate a total of 83 (45-136) lions in the park based on call-up surveys. Lions are also confirmed to be present in the Azande, Gangala-na-Bodio and Mondo-Missa hunting zones. Villagers adjacent to Lantoto National Park (1,547 km^2), contiguous with Garamba on the South Sudan side, report still hearing lions in the area in 2021, but the habitat here is not likely to be suitable for lions and their presence here is yet to be established (Elkan *pers. comm.*).

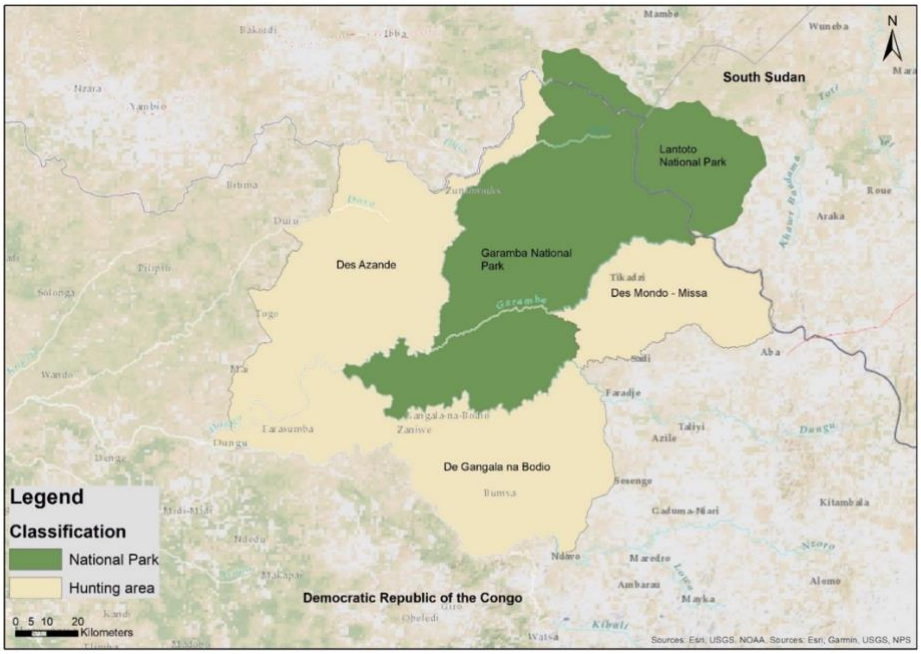

Fig. A15. Map of the Garamba Complex in north-east DRC indicating the position of Garamba National Park relative to surrounding hunting zones in DRC, and Lantoto National Park in South Sudan. *Carte du Complexe de la Garamba dans le nord-est de la RDC indiquant la position du Parc National de la Garamba par rapport aux zones cynégétiques environnantes en RDC et au Parc National de Lantoto au Soudan du Sud.*

Prey populations: Based on aerial surveys of a core 3,490 km^2 (23%) of the Garamba Complex in 2021, lion prey species continued to recover with about 9,000 buffalo in this part of the park (Table A12; Ngoma et al. 2021). Based on the 2021 survey result, the core area of the park could potentially support a density of about 9 lions/100 km^2 or about 330 lions, if human sources of lion mortality were

controlled. The Azande hunting area to west of the parks seems to have reasonable prey base and good habitat and could hold potential for lions to expand into (Elkan pers. comm.).

Table A12. Aerial survey estimates and densities (per 100 km^2) suitable lion prey for 2012 and 2021 in 3,490 km^2 of the Garamba Complex (African Parks 2022c) and the estimated ecological thresholds for lions based on these prey numbers (following Hayward et al. 2007). *Estimations de l'abondance des proies des lions et densités (par 100 km^2) obtenues par suivi aérien en 2012 et 2021 dans 3 490 km^2 du Complexe de la Garamba (African Parks 2022c) et les seuils écologiques estimés pour les lions sur la base de ces nombres de proies (d'après Hayward et al. 2007).*

	2012		2021	
Species	**Abundance**	**Density**	**Abundance**	**Density**
Buffalo	5975	171.20	8454	242.23
Bongo	-	-	16	0.46
Giraffe	16	0.46	54	1.55
Hartebeest	430	12.32	1126	32.26
Kob	2841	81.40	3434	98.40
Oribi	5	0.14	38	1.09
Reedbuck	20	0.57	184	5.27
Roan	5	0.14	47	1.35
Waterbuck	682	19.54	1796	51.46
Warthog	529	15.16	1566	44.87
Potential lion abundance	**293**	**8.40**	**334**	**9.60**

Management effectiveness: Movement of the Lord's Resistance Army into northern DRC and south-eastern CAR from 2005 had a significant destabilizing effect to Garamba and the region. In combination with a minimal conservation presence across Bili-Uéré over recent decades, these regional conflict dynamics are suspected to have driven major poaching pressure across this area. Over three decades from the 1980s to 2000s, Garamba was overrun with rebel forces and heavily militarised poachers (including northern Sudanese), leaving human and environmental devastation in their wake.

Nevertheless, African Parks signed an agreement in 2005 to manage Garamba with the *Institut pour la Conservation de la Nature* (ICCN). In January 2016, African Parks renewed its management agreement for Garamba for an additional 10 years. This includes three adjacent hunting zones, namely Azande (4,052 km^2), Gangala na Bodio, (3,773 km^2) and Mondo Missa (1,827 km^2) where lions are occasionally observed (Vogel pers. comm.).

A-I.3 North-East Africa – Overlap Zone

Protected areas in South Sudan east of the Nile River, and especially Ethiopia, (Fig. A16) host a mixture of lions with both northern and southern ancestry (Bertola et al. 2022). Although lions in these two countries may have been effectively separated from lions in northern Kenya and Uganda by equatorial rain forests in the past, there is no longer any geographic barrier to lions in this region. The scant genetic data that is available is not equivocal on which subspecies predominates in the region (Bertola pers. comm.).

What is known is that both subspecies seem to occur and that protected areas throughout eastern South Sudan and Ethiopia are challenged by the inundation of transhumance and resident pastoralists and their livestock. Furthermore, the level of attention from the conservation community here is more akin with that of Central and West Africa. Thus, until better genetic information is available, lion populations in the mixture zone should be considered as a separate conservation entity. Consequently, specific conservation actions should target these populations.

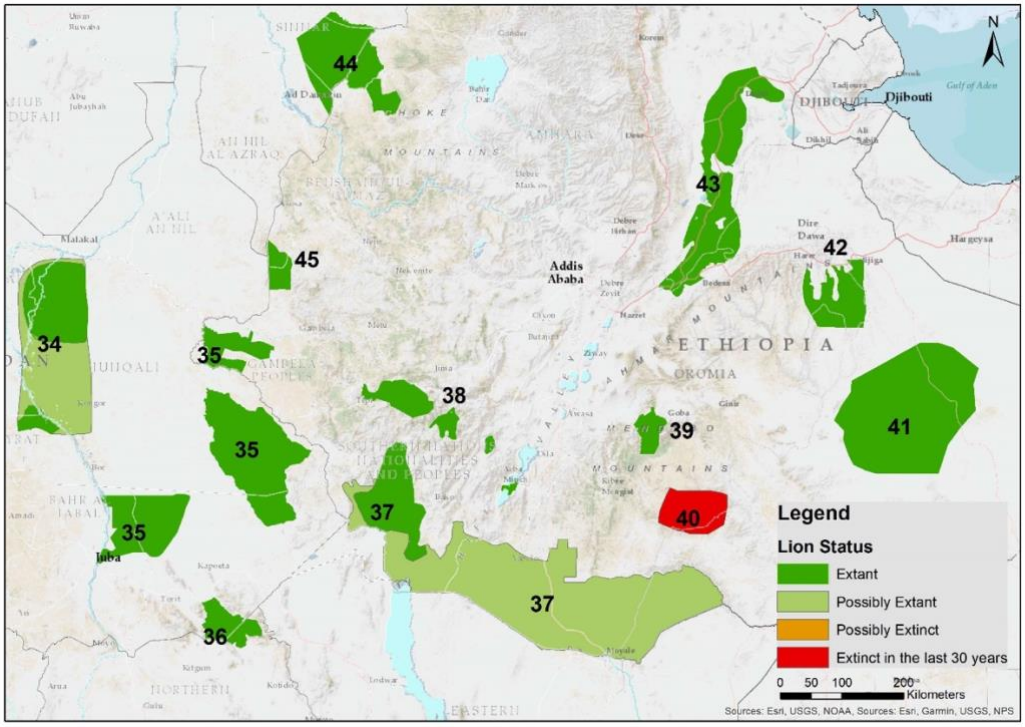

Fig. A16. Map of the protected areas where lions are reported to occur within the Overlap Zone in South Sudan and Ethiopia including far northern Uganda. *Carte des aires protégées où l'on signale la présence de lions dans la Zone de chevauchement au Soudan du Sud et en Éthiopie, y compris l'extrême nord de l'Ouganda.*

3.1 Boma-Gambella LCU (Boma-Gambella Key Lion Area) [35]

This vast ecosystem (~200,000 km^2) includes Badingilo (8,935 km^2) and Boma (22,800 km^2) national parks and the Zeraf Game Reserve and the Sudd wetlands (see Fig. A16). The area also includes the Loelle proposed protected area on the border with Kenya. Across the border in Ethiopia the ecosystem is linked to Gambella National Park (5,016 km^2) and extends to the area of Omo National Park (Fig. A16).

The area supports the second largest migration of ungulates in Africa with the white-eared kob's migration route extending over about 160,000 km^2**.** The area can also be referred to as the White Nile

Ecosystem. In addition, there are several critical and currently unprotected wildlife migration corridors. These include the white-eared kob corridor between Boma and Badingilo and the tiang corridor between Badingilo and the Sudd grasslands (Elkan et al. 2016, see Fig. A17).

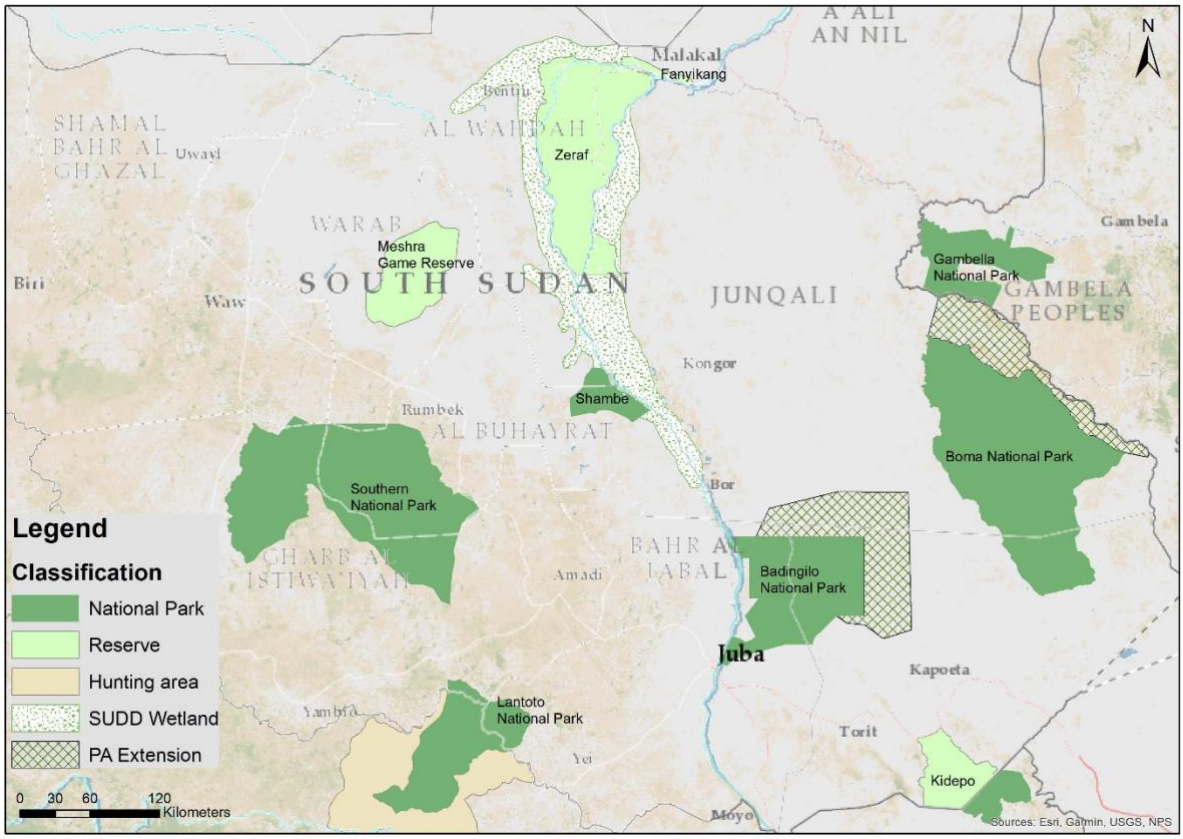

Fig. A17. The Boma-Bandingilo-Sudd landscape in South Sudan houses the second largest ungulate migration in Africa and is one of the most important locations for lion conservation in North-East Africa. *Le paysage de Boma-Bandingilo-Sudd au Soudan du Sud abrite la deuxième plus grande migration d'ongulés en Afrique et est l'un des sites les plus importants pour la conservation du Lion en Afrique du Nord-Est.*

Lions: WCS engaged in park support in Badingilo and Boma national parks (2007-2021). During this period, lion sightings were made during surveillance flights, surveys, and ground patrols in the parks and surrounding areas and corridors, as well as in the Sudd area. Armed conflict has eased in recent years. Greater access then allowed camera traps to be deployed in 2019-20. Lions were captured on camera traps on 55 occasions between October 2019 and December 2019. In a landscape protection strategy complied by WCS in 2020, several priority areas of lion activity were identified including the central third of Boma National Park and along the border with Ethiopia, and areas in Bandingilo National Park and proposed community conservancy areas to the south (WCS 2020, Elkan pers. comm.; see Fig. A18). As many as 100 lions may occur in this area (Elkan pers. comm.).

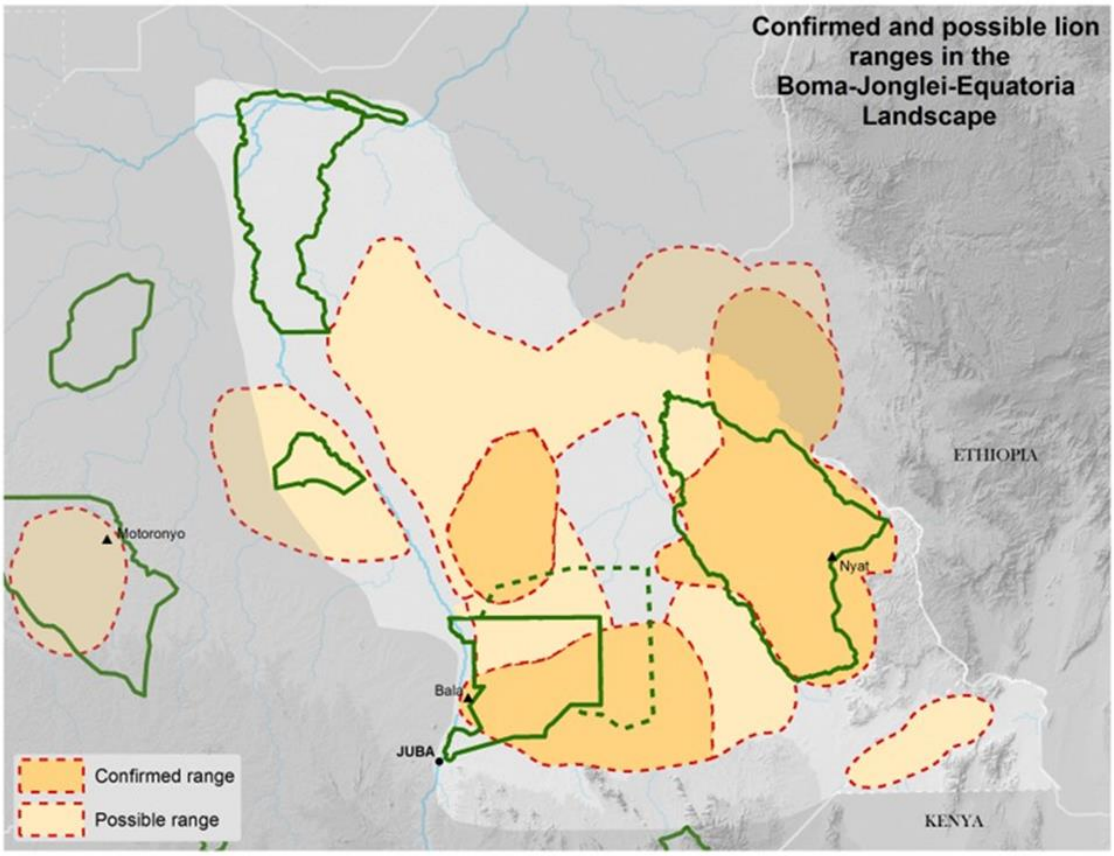

Fig. A18. Confirmed and possible range of lions across the Boma-Gambella lion recovery area in South Sudan (reproduced from WCS 2020). *Répartition confirmée et possible des lions dans la zone de rétablissement des lions de Boma-Gambella au Soudan du Sud (d'après WCS 2020).*

Although no survey estimates are available, small populations of lions are also reported to occur in Gambella (Yirga et al. 2021). There are some recent records, mainly of lion fatalities, in the vicinity of the Zeraf Game Reserve. Poachers encounter lions here periodically and indicate that they have no reason to kill them (Agency for Conservation and Development 2022).

Prey populations: Aerial surveys in 2007 over about 120,000 km^2 of the Boma-Badingilo-Sudd area indicated that there were still very large numbers of migratory wildlife species remaining in Southern Sudan, which included white-eared kob, tiang and Mongalla gazelle (Fay et al. 2007). The area surveyed included Boma National Park and the Sudd aera (comprising the Jonglei area, Zeraf Game Reserve, the Sudd wetland, and parts of Shambe Reserve). This area is also known as the Lotilla block (see Table A13).

When compared with surveys in 1980 (Boitani et al. 1980) this mass of migratory wildlife was still pretty much intact. However, species like buffalo, hartebeest, and other more sedentary species were drastically reduced. Lion sightings from the air were also much lower than in 1980. Together, the white-eared kob, tiang, and Mongalla gazelle make up one of the largest mammal land migrations in the world containing what was estimated to be about 1.2 million animals (Fay et al. 2007). This is the second largest land mammal migration in Africa after the Serengeti-Mara ecosystem. Each year hundreds of thousands of white-eared kob, Mongalla gazelle, tiang and reedbuck merge in Badingilo

in the wet season for breeding before migrating north and east towards the Sudd and Boma National Park and across the border to Gambella National Park in Ethiopia (see Fig. A16).

Table A13. Area survey results for ungulates across the Sudd-Boma region of South Sudan in the dry seasons of 1980 and 2007. Due to difference in areas counted, direct comparisons between each survey are not possible (Elkan pers. comm.). *Résultats des suivis des ongulés dans la région Sudd-Boma au Soudan du Sud pendant les saisons sèches de 1980 et 2007. En raison des différences dans les zones comptées, les comparaisons directes entre suivis ne sont pas possibles (Elkan comm. pers.).*

	Dry Season 1980		Dry Season 2007		
Species	**Boma**	**Jonglei**	**Boma**	**Jonglei**	**Lotilla**
Buffalo	11,179	8,518	-	10,178	-
Bushbuck	-	461	58	-	-
Common eland	7,839	-	231	-	-
Common duiker	-	99	-	31	-
Grant's gazelle	1,811	-	2,540		-
Mongalla gazelle	21,678	55,032	22,430	221,265	34,938
Giraffe	9,028	6,025	404	-	-
Lelwel hartebeest	47,148	65	115	-	-
White-eared kob	849,365	2,035	695,940	11,242	49,190
Uganda kob	-	-	-	35	-
Lesser kudu	170	-	318	-	-
Nile lechwe	-	11,924	-	4,291	-
Oribi	2,264	1,553	433	70	-
Beisa oryx	396	-	664	-	-
Bohor reedbuck	29,857	15,207	2,050	10,994	-
Roan antelope	3,085	2,087	-	-	-
Steenbok	1,981	-	-	-	-
Nile sitatunga	-	200	-	603	-
Tiang	25,442	117,531	404	153,918	1,138
Waterbuck	2,462	2,284	-	177	-
Warthog	4,868	-	173	142	-
Common zebra	29,460	4,533	-	-	-
Cattle	93,815	466,694	197,166	582,298	
Sheep & Goats	54,817	96,696	56,580	46,388	

Aerial surveys were undertaken of various blocks of South Sudan (2008, 2010, 2013). Country wide surveys were planned for 2014 had to be suspended due to the outbreak of armed and political conflict in December 2013, which expanded throughout the country. Despite the conflict, an aerial survey of parts of Boma and Badingilo and Loelle areas was conducted in 2015, along with recce flights of the Southern National Park, parts of Shambe National Park and the Sudd. Other areas were deemed too dangerous to access (Elkan et al. 2016). These surveys conducted in 2015 showed that wildlife numbers in Boma-Bandingilo were still high, but likely lower than 2007 levels (Table A14). There were signs, however that poaching and commercial wildlife trafficking were increasing, as well as illegal mining, timber harvesting and charcoal production (Elkan et al. 2016).

During aerial surveys from 2007 to 2015, lions were recorded at various locations across the mass ungulate migration routes. Lions do not typically breed successfully in predominantly migratory systems and thus no potential lion numbers are given here. However, the total mass abundance of ungulates in the Boma-Bandingilo, the Zeraf Game Reserve and the Loelle potential protected area should be able to support a large lion population, a minimum of 250 lions being likely.

Table A14. Aerial survey results for ungulates across Boma, Bandingilo and the Loelle area (8,000 km^2) in South Sudan in the dry season of 2015 (Elkan et al. 2016). *Résultats des suivis aériens des ongulés à travers Boma, Bandingilo et la zone de Loelle (8,000 km^2) au Soudan du Sud pendant la saison sèche de 2015 (Elkan et al. 2016).*

	Boma West and Bandingilo southeast		Loelle potential protected area	
Species	**Abundance**	**Density**	**Abundance**	**Density**
Beisa oryx	114	0.54	993	12.41
Common eland	49	0.24	15	0.19
Giraffe	-	-	-	-
Grant's gazelle	229	1.10	7,363	92.04
Lesser kudu	345	1.66	146	1.83
Mongalla gazelle	4,819	23.17	-	-
Bohor reedbuck	1,965	9.45	-	-
White-eared kob	387,732	1864.09	-	-
Cattle	44,553	214.20	85,609	1070.11
Sheep & Goats	49,545	238.20	221,984	2774.80

Management effectiveness: Continuous armed conflict has severely impacted the lives of communities in and around protected areas in South Sudan, including in Badingilo and Boma for several decades. WCS worked in South Sudan from 2007-21, implementing the Boma-Jonglei-Equatoria Landscape Programme, and continued operations despite the armed conflict from 2013 through to the present. The programme's strategic objectives focussed on Boma and Badingilo national parks protected area management, park infrastructure and operations, wildlife protection and anti-trafficking, sustainable land and natural resource management, conflict mitigation and security, and sustainable community-based livelihood options.

Boma National Park was subjected to insecurity from a local militia fighting with the government starting in 2011 and increasing through mid-2013 with full combat. The park warden and 6 officers were killed in May 2013 and the Wildlife Service/WCS operations base at the park HQ was overrun and looted. WCS and Ministry of wildlife operations were re-established in Boma in August 2013, after the government retook military control of the area. Though security has improved in recent years, all warring parties have yet to join the peace agreement.

The Badingilo National Park operations base was also overrun by rebels and looted in September 2016. Throughout the years of armed conflict and continuing through 2021, WCS maintained basic operations, wildlife protection, surveillance, and infrastructure management operations, despite the armed conflict, as well as large scale tribal violence between Dinka, Nuer, and Murle ethnic groups.

In August 2022, the government of the Republic of South Sudan signed a 10-year agreement with African Parks that covers both parks.

3.2 Kidepo Valley LCU (Kidepo Valley Key Lion Area) [36]

This region contains two connected LCUs in the border region between South Sudan and northern Uganda totalling 7,520 km^2. In South Sudan, the Kidepo Valley-Sudan landscape covers 5,122 km^2 with the largest conservation area being the Kidepo Game Reserve (~2,000 km^2). In Uganda, the Kidepo Valley-Uganda landscape covers 2,398 km^2 including Kidepo Valley National Park (1,442 km^2) and adjacent Karenga Community Wildlife Area (956 km^2) (see Fig. A16). Kidepo Valley National Park was established in 1962 and consists of two large valleys, Narus and Kidepo, surrounded by mountains.

Lions: Chardonnet (2002) and Bauer and van der Merwe (2004) proposed a population of 25 lions in the Uganda portion of the region and Chardonnet (2002) estimated a total of six lions in Kidepo Game

Reserve, South Sudan (back then still Sudan). Based on lion surveys in Kidepo Valley National Park, Uganda, 58 lions were estimated to reside in the region (Dricuru & Siefert 2005). Following this, Omoya et al. (2014) found that many areas in the park had low prey populations due to poaching and thus only sampled secure areas with some accessibility. The largest group of lions (4) was recorded in in the western part of the park with the survey result estimating 132 (± SE 77) lions after extrapolating results to the whole park.

Prey populations: During a dry season aerial count of South Sudan's Kidepo Game Reserve, few signs of large-bodied ungulates were recorded, and the area was heavily settled by agro-pastoralist communities (Table A15; Grossmann et al. 2008). The area surveyed (530 km^2) was in the south adjacent to Kidepo Valley National Park in Uganda. The reserve's intact habitat and proximity to the Kidepo National Park in Uganda hold some promise for recovery of prey populations in the future.

Table A15. Results of a dry season reconnaissance survey of Kidepo Game Reserve in South Sudan (Grossmann et al. 2008) and a dry season aerial survey for ungulates across Kidepo Valley National Park and adjacent Karenga Community Wildlife Area in Uganda (Kidepo Landscape Uganda; Wanyama et al. 2014). Lion potential abundance was calculated following Hayward et al. (2007). *Résultats d'un suivi de reconnaissance dans la Réserve de Faune de Kidepo au Soudan du Sud pendant la saison sèche (Grossmann et al. 2008) et d'un suivi aérien des ongulés en saison sèche dans le Parc National de la Vallée de Kidepo et l'Aire de faune communautaire adjacente de Karenga en Ouganda (Paysage de Kidepo Ouganda ; Wanyama et al. 2014). L'abondance potentielle des lions a été calculée d'après Hayward et al. (2007).*

	Wildlife observations Kidepo Reserve (2008)	Kidepo Landscape Uganda 2014	
Species	**Counts**	**Abundance**	**Density**
Buffalo	-	8,419	350.79
Dik-dik and duiker	16	-	-
Hartebeest	1	2,544	106.00
Oribi	1	292	12.17
Reedbuck	-	399	16.63
Warthog	2	789	32.88
Waterbuck	-	390	16.25
Zebra	-	425	17.71
Cattle	12	222	9.25
Potential lion abundance		**235**	**11.80**

In Kidepo Valley National Park surveys were influenced by wildlife populations leaving the park in the wet season and then concentrating in the park in the dry season (Wanyama et al. 2014). Although buffalo and hartebeest numbers were high in 2014, there were few other large mammals, with low counts of zebra and eland (Table A15). With the high numbers of buffalo and hartebeest, the park could theoretically support about 200 lions at a high density of about 12 lions/100 km^2. There were no cattle in the park with low numbers in the Karenga Community Wildlife Area.

Management effectiveness: Kidepo Reserve in South Sudan has extremely low prey numbers, and high levels of threats, and therefore little chance of lion presence or recovery (Grossmann et al. 2008). However, with improved management, lions could potentially disperse from the Ugandan side in the future, but before then, prey populations would need to increase substantially, and human communities would need to be sensitised to the presence of lions and other large carnivores (Elkan pers. comm.).

The declaration of Uganda's Kidepo Valley as a national park did not stop all hunting of wildlife and traditional hunts. However, because poachers were using traditional weapons, their impacts on the

wildlife were limited. Following the defeat of Idi Amin in the late 1970s and the civil wars in Uganda during the 1980s, together with the activities of the Lords Resistance Army in northern Uganda in the 1990s and early 2000s, arms proliferated in the region and poaching of wildlife is often carried out with AK47 machine guns. This makes it much more difficult for the Uganda Wildlife Authority (UWA) to protect the large mammal species found here. Regular cattle rustling occurs between Southern Sudan and northern Uganda with rustlers moving through Kidepo Valley National Park with their cattle and this also leads to poaching as well as a risk of disease being brought in by the cattle (Elkan pers. comm.).

Nevertheless, in 2014, the park had a high density of buffalo and hartebeest and was reported by Omoya et al. (2014) to support about 130 lions. Even if this is an overestimate due to extrapolation, the park could be a regionally highly significant location for lions within the northeast mixture zone. Further genetic information should determine the exact genetic makeup of the population and follow up surveys should be conducted to determine how lions are doing in the park.

3.3 South Omo and Borana LCU (South Omo Key Lion Area) [37]

The South Omo and Borana LCU complex in south-western Ethiopia (~45,000 km^2) include Borana, Omo (4,068 km^2) and Mago (2,220 km^2) national parks, Tama and Chelbi wildlife reserves, Omo West, Borana and Murle controlled hunting area, Yabello Sanctuary, and non-gazetted areas around these (see Fig. A15).

Lions: Chardonnet (2002) suggested a population of 141 lions in Omo and Mago national parks, Tama wildlife reserve, and Omo West controlled hunting areas. He also suggested 281 lions in a population across Yabello Sanctuary, Chelbi Wildlife Reserve, and Borana and Murle controlled hunting areas, and 120 lions in non-gazetted areas surrounding those parks. Bauer and van der Merwe (2004), however, indicated that lions were present in Omo and Mago national parks but that they could not estimate numbers. They did, however, estimate that about 100 lions existed in the Borana controlled hunting area. Most recently, Yirga et al. (2021) estimated the area to support <200 lions.

Management effectiveness: African Parks is currently in conversation with the Ethiopian government to potentially take over the management of Omo and Gambella national parks (African Parks pers. comm.).

3.4 Kafa-Chebera-Maze-Nechisar Key Lion Area [38]

This area in southwestern Ethiopia includes Chebera Churchura (1,250 km^2), Maze (210 km^2) and Nechisar (750 km^2) national parks and the Kafa Biosphere Reserve (2,193 km^2) and surrounding areas (Fig. A15).

Lions. Reports are sparse with lion numbers across all parks estimated at less than 100 (Yirga et al. 2021). In 2009 a small group of 15 lions were estimated in and around the Nechisar National Park (Yirga et al. 2014).

Management effectiveness: the prospects for lions in this potential Key Lion Area will require a more concerted effort on the part of government and potentially NGO partners. Lion presence is seemingly sparse necessitating an assessment of the area and the development of a lion recovery plan across several protected areas.

3.5 Bale LCU [39]

The Bale LCU is located across the Bale Mountains National Park (2,150 km^2) and surrounding wildlife reserves and controlled hunting areas in south-central Ethiopia (Fig. A15). Presently, lions are confirmed to reside only in the Harenna Forest part of this LCU.

Lions: Chardonnet (2002) provides a population estimate of 97 lions in this region. Bauer and van der Merwe (2004) propose a more conservative estimate of 50 lions. Gebretensae and Kebede (2022) estimate about 50 lions in the LCU, which is in line with Yirga et al. (2021).

3.6 Welmel-Genale LCU [40]

This LCU covers 6,800 km^2 in a non-gazetted area of southern Ethiopia (Fig. A15).

Lions: Neither Chardonnet (2002) nor Bauer and van der Merwe (2004) provide a lion population estimate for the region. Gebretensae and Kebede (2022) estimate that about 100 lions still occur in the area but Bauer (pers. comm.) doubts that an important lion population exists there.

3.7 Ogaden LCU [41]

This LCU covers a region of eastern Ethiopia (35,370 km^2) including the Eastern Hararghe controlled hunting area (6,629 km^2; Fig. A15).

Lions: Chardonnet (2002) notes a population of 50 lions residing in the area, while Bauer and van der Merwe (2004) estimated a much larger population of 250 individuals. Without any solid information to work with, Yirga et al. (2021) estimated that the region might support less than 100 lions, which is similar to the estimate of 100 by Gebretensae and Kebede (2022).

3.8 Babile [42]

The Babile Elephant Sanctuary (6,982 km^2) is a protected area in eastern Ethiopia (Fig. A15).

Lions: Yirga et al. (2021) estimated that fewer than 25 lions occurred in the protected area.

3.9 Awash LCU [43]

The Awash LCU spans the Awash National Park (850 km^2) and its associated wildlife reserves and controlled hunting areas in central Ethiopia (15,160 km^2; Fig. A15).

Lions: Chardonnet (2002) proposed a large population of 423 lions in the region whereas Bauer and van der Merwe (2004) did not estimate lion numbers for this LCU. The IUCN (2006b) give a population estimate of less than 50 individuals, which is like more recent estimates by Yirga et al. (2021) and Gebretensae and Kebede (2022).

3.10 Dinder-Alitash Key Lion Area [44]

Dinder National Park (10,000 km^2) is a national park and biosphere reserve in eastern Sudan and is connected to Ethiopia's Alitash National Park (2,666 km^2), which is contiguous with the 1,800 km^2 Bejimiz National Park (Fig. A15). The area was not listed by the IUCN (2006a, b) as a lion conservation unit (LCU).

Lions: In 2018, Bauer et al. (2018) conducted a lion survey in Dinder National Park. They estimated the lion population size at 157 (±26), and the spotted hyaena population at 180 (±18) individuals. These numbers are possibly a bit too optimistic, since data from the core zone were extrapolated to inaccessible areas that are less well protected, including the entire southern half of Dinder National

Park. This is corroborated by the fact that they only found lions in the core area ~1000km^2 areas of the park. In this core area of the park Mohammed et al. (2019) estimated a population of 30-82 lions (Table 1.1).

Prey populations: Populations of migrant grazers, including tiang, roan antelope, waterbuck, and reedbuck are present. These species are under pressure as land outside the park, across which they migrate, has been converted to farmland. Game counts between 1971 and 2001 showed precipitous decline in most large mammal species, with the population of waterbuck falling by 85%, reedbuck by 72%, and oribi by 68%. Other species have been extirpated in Dinder since it was gazetted, including African bush elephant, black rhinoceros, hippopotamus, Tora hartebeest, Nubian giraffe, Soemmerring's gazelle, and the Nile crocodile.

Management effectiveness: Dinder and Alitash national parks are both threatened by encroachment from cattle herders who are being displaced from their traditional grazing lands by the expansion of crop agriculture, through the fundamental cause of expanding regional human populations.

3.11 Mao-Komo [45]

This district has no protected area status and is 4,260 km^2 in extent and borders South Sudan, south of the Dinder-Alitash complex (Fig. A15).

Lions: No surveys exist for lions for the park with Yirga et al. (2021) suggesting the area supported less than 100 lions.

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APPENDIX A-2

RECOMMENDED MONITORING FRAMEWORK FOR LIONS IN WEST AND CENTRAL AFRICA

Across the vast expanse of the protected area network in which the northern lion exists, lion monitoring and surveys are currently largely unsatisfactory in almost every Key Lion Area. Appendix A-I should be referred to for a summary of lion surveys at each Key Lion Area. Based on the outcomes of a workshop to evaluate lion survey methods held in South Africa in April 2022 (funded by the Lion Recovery Fund) a series of recommended lion surveys approaches were forthcoming. Below, a few key steps or components of a lion survey and monitoring design are discussed:

A-2.1 Step 1: Delineate a grid

Delineate a grid for each Key Lion Area where lions still occur or could occur. A grid cell size of 15x15 km was recommended by Henschel et al. (2012) for the W-Arly-Pendjari Complex. This grid size was chosen to approximate the mean seasonal home-range size of lions from studies in West and Central Africa, of approximately 200 to 500 km² (Schoe 2007, Sogbohossou 2011), and thus provide information on species distribution at a scale relevant to park managers. The same size grid was also used successfully in lion surveys conducted in Luengue-Luiana National Park in Angola (Petracca et al. 2019). Grids should also be delineated for sites where lions are thought to be extinct, but where there is a realistic chance of reintroducing them.

A-2.2 Step 2: Annual occupancy assessment

For presence/absence or spoor transect surveys, every lion sign (spoor, scat, carcasses, visual observations) should be identified and mapped. For each core area within a Key Lion Area, it would be useful if a wildlife monitoring team was employed, supplied with necessary equipment, supplies and a reliable vehicle. Each monitoring team should include a park ranger to offer security and local knowledge, a junior level biologist or local student to collate and manage all samples and data, and 2–4 trackers or scouts.

Trackers/scouts should be people from the local communities well suited to locating all types of lion signs. The biologist/student would also ideally be sourced from the local communities and provided with opportunity and support to study at a formal institution of that country. The lion monitoring teams should spend most of their time actively pursuing lion signs or lion observations in the field, along with similar observations of other large carnivores and specific key prey species. They could, therefore, also collect data for spatially explicit mark-recapture surveys or long-term individual monitoring.

Whatever approach is followed, having a dedicated team to undertake this task is very valuable. If resources are not available for year-round monitoring, then survey teams could be assembled to undertake surveys over a shorter time-period. To complete an annual occupancy assessment, an annual survey of the Key Lion Area recoding presence/absence of lions in a systematic fashion should be undertaken.

In Kenya, Broekhuis et al. (2022) used a single-season false-positive occupancy model that accounted for multiple detection methods, which in their case included sightings and a questionnaire-based

survey. In Angola, Petracca et al. (2019) used a hierarchical, community-based occupancy model, which allowed for estimation of species-level and aggregated community-level effects (Zipkin et al. 2009, Zipkin et al. 2010).

With the appropriate model, the outcome would be an annual occupancy-based distribution map and co-variate analysis of factors affecting the probability of lion, other large carnivores, and key herbivore presence across the protected area/complex. If substrate was suitable, the predominant sign collected for lions would likely be tracks. However, for occupancy modelling at a yearly base, all kinds of data, including (documented) chance observation by tourists or local people could be used if properly collected.

A-2.3 Step 3: Lion population survey design

Additional to an annual occupancy assessment, managers should then choose what survey technique to use to estimate lion abundance. This does not have to be done every year but should be repeated at least once every three years. The options for survey methods include:

Option 1: wherever possible, the preference would be to collate records of identified individuals into a (Bayesian) SECR (spatially explicit capture recapture) model to estimate abundance. To collect data, the lion monitoring team could routinely or deterministically collect all lion and large carnivore scat for genetic analysis to individual level. A limitation here would be transport and analysis of samples. This could however be overcome with the necessary investment and collaboration agreements between Range States. The team would also photograph all lions that were observed opportunistically or during random or structured searches. Additionally, lions could be lured in using systematic call-ups with the goal of photographing each lion for individual recognition (following Western et al. 2022).

Here, monitoring could be yearlong (e.g. for the collection of chance observations) or scheduled into deterministic surveys planned for specific times during the year. When lions are located, a series of close-up photographs would be taken using a digital single lens reflex (DSLR) cameras and most probably a 100–400 mm lens of sufficiently low aperture to capture clear images including at night (see Western et al. 2022). The photographs would be used to identify individuals based on their unique whisker vibrissae spots and other distinguishing features (Pennycuick and Rudnai 1970), excluding individuals under the age of one year based on phenotypic features (Ferreira and Funston 2010, Miller et al. 2016), assign gender based on secondary sexual characteristics, and finally build capture histories (for details see Elliot et al. 2020).

Within the distribution of the northern lion, there has recently been an increasing effort to fit GPS radio-collars on lions. This is currently done largely to inform managers about the areas of lion activity within each protected area/complex. However, once lions are radio-collared, this would allow the lion monitoring teams to follow up and observe the lions as often as possible. Given sufficient effort, this could lead to the identification of all the individual lions in particular groups and allow their life histories to be tracked over time. The process tends to start off slowly, but given sufficient commitment it would be possible, at least in some instances, to investigate key lion demographic parameters, such as juvenile and adult survival rates (Vinks et al. 2021), as well as group size, dispersal patterns, etc.

Option 2: should lion monitoring be feasible with camera traps, there are a few designs that could be used. Generally, however, a typical design would cover about 800–1,000 km², overlaid with a grid of

10–20 km² cells at a time. Ideally, the same grid would be used across the northern lion's range to facilitate comparability of the data. Cell size should ensure that individual lions will be detected in multiple cells. A single camera, or pair of cameras, would be placed in each grid cell in a location that maximises the likelihood of lions moving past (for example, along a game trail or road, near a waterhole etc.), and accounting for logistics such as access. Several survey areas, each of approximately 800–1,000 km², would need to be identified per protected area/complex.

Cameras should be left to run for 8–12 weeks depending on a priori assumptions of lion density (longer in low density areas), and rangers/staff should download images and check camera integrity approximately every 2 to 4 weeks for the monitoring period. Data should be archived at a central location and analysed using standard analytical software. All events of wildlife/non-wildlife would be documented so that all data are available for future analysis. Pictures of people may need to be deleted depending on local customs and arrangements. From each camera trap survey, the goal would be to:

a. Generate data on distribution, occupancy and hopefully density for large carnivores, i.e., lions, leopards, cheetah, African wild dogs and spotted hyaenas.
b. Generate relative abundance indices where possible for main lion prey species.
c. Log all records of illegal activity (presence of poachers, pastoralists, cattle etc., especially within protected areas, but respecting possible privacy legislation).
d. Compile noteworthy records such as of unusual or poorly known species.
e. Integrate camera trap data with patrol data on illegal activity and sightings of large mammals currently collected by rangers and archived (e.g. within the Spatial Monitoring and Reporting Tool [SMART] program, or equivalent).

All camera-trapping should be undertaken with the cooperation of park staff, with a focus on training key personnel in the entire process, and rangers will be trained to monitor cameras and collect data on a regular basis.

Option 3: if the resources or opportunity to undertake SECR type surveys do not exist, an alternative approach would be to conduct spoor surveys. These should be done over as large an area as possible with adequate coverage of as many grid cells as possible. To minimise variance, these surveys should ideally be run until about 30 track events have been recorded (see Funston et al. 2010, Winterbach et al. 2016). To reach a target of about 30 track events per survey, areas might need to be sampled several times to accumulate sufficient data. See Funston et al. 2010 for details on how to conduct spoor surveys.

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