4 · *Conservation Status of the African Buffalo: A Continent-Wide Assessment*

D. CORNELIS, P.C. RENAUD, M. MELLETTI, D. FONTEYN, H. BONHOTAL, M. HAUPTFLEISCH, A. ASEFA, T. BREUER, L. KORTE*, P. SCHOLTE, P. ELKAN, E. KOHI, S. MWIU, S. NGENE, P. OMONDI, S.P. TADJO, T. PRIN, A. CARON, H.H.T. PRINS AND P. CHARDONNET

Introduction

In this chapter, we provide an update on the distribution and abundance of the African buffalo at the scale of the entire African continent. For this purpose, we conducted a literature search to uncover published information. We also carried out an extensive survey of national and international agencies and field experts in the 37 countries that are within the buffalo's distribution range.

We collected abundance data from 163 protected areas or protected area complexes for the period 2001–2021. These data are mainly based on aerial counts using standardized methods, and occasionally on estimates provided by experts. We also obtained information on the presence of buffalo in 711 localities (inside and outside protected areas) for the period 2001–2021. These data and metadata were compiled in a database that is available upon request (Cornélis et al., 2023).

We present the distribution and abundance of each of the four subspecies of African buffalo. We are naturally aware that the validity of the 'subspecies' concept is under debate, and we refer to Chapters 2 and 14 for a discussion about the number of subspecies and their status. For the

* The views expressed are solely those of the authors and do not necessarily represent the views of the institutions represented.

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

sake of consistency with earlier studies on buffalo distribution (East, 1998; Cornélis et al., 2014), our results are presented in accordance with the latest IUCN subspecies range (IUCN SSC Antelope Specialist Group, 2019). Therefore, maps of this chapter reproduce the geographical boundaries of the four subspecies published by the IUCN Red List of Threatened Species (IUCN SSC Antelope Specialist Group, 2019). Although clearly delineated on paper, the boundaries between subspecies' distribution ranges are in fact blurry on the ground. In case of inconsistency or doubt about the assignment of a population to a 'subspecies' (especially in transitional areas), we explicitly acknowledge this in the text.

Historical Distribution

Endemic to the African continent, the buffalo is one of the most successful mammals in terms of geographical distribution, abundance and biomass. Its range covers almost all natural ecosystems south of the Sahara. It mainly inhabits savannas with high herbaceous biomass, but also occupies dry shrubland as well as grassy clearings in dense tropical rainforests, and can live at altitudes above 2500 m, such as in Aberdare National Park in Kenya. The African buffalo penetrates arid biomes where surface water is permanently available. Overlaying the African buffalo's current continental range with mean annual rainfall (Figure 4.1) shows that 95 per cent of the buffalo's range comprises areas with more than 450 mm of rainfall (min: 150 mm; max: 4000 mm).

African buffalo formerly occupied the entire savanna zone stretching between Senegal, Gambia and Guinea and Ethiopia and Eritrea, and from there south to the Cape of Good Hope, with the exception of drylands. African buffalo did not colonize islands such as Zanzibar or Mafia, although they did colonize Bioko Island (Equatorial Guinea), from where they were extirpated sometime between 1860 and 1910 (Butynski et al., 1997).

There is no palaeontological evidence of the presence of the African buffalo in North Africa or the Nile Valley to the north of Khartoum (Prins and Sinclair, 2013). In North Africa, the aurochs (*Bos primigenius*; wild ancestor of domestic cattle) occupied a similar niche (Gautier, 1988), perhaps preventing the buffalo's spread to the north. Buffalo could have expanded their range in eastern and southern Africa during the last ice age due to the extinction of possible competitors, such as *Pelorovis antiquus* and *Elephas reckii* (for more details on evolution see Chapter 2; Klein, 1988, 1994; Prins, 1996).

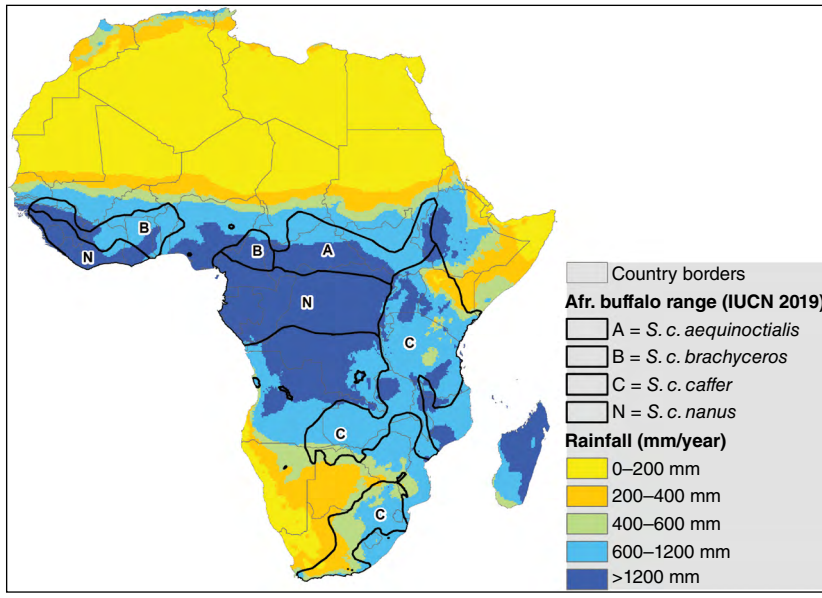

Figure 4.1 African buffalo distribution range in relation to average rainfall for 1970–2000. Sources: Fick and Hijmans (2017) and IUCN SSC Antelope Specialist Group (2019).

Present Distribution

In areas of high human densities, people and their activities caused large discontinuities to arise in the historical distribution of African buffalo (Figure 4.2). Although according to our estimates its population remains above 500,000 individuals, and has been above that level since at least the last human generation (East, 1998; Cornélis et al., 2014), the species' distribution range has been severely reduced since the nineteenth century. As there were no reliable estimates of its total population prior to the assessment undertaken by East (1998), we cannot determine whether the current population is smaller than that which existed prior to the Great Rinderpest epidemic of the 1880s (e.g. Prins, 1996; Prins and Sinclair, 2013). The shrinkage of the species' range was the result of the combined effects of anthropogenic impacts such as rangeland conversion, poaching, disease outbreaks and political unrest, and climatic events such as droughts. At present, most savanna populations (i.e. the three subspecies except *S. c. nanus*) are confined to protected areas (including trophy hunting areas).

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

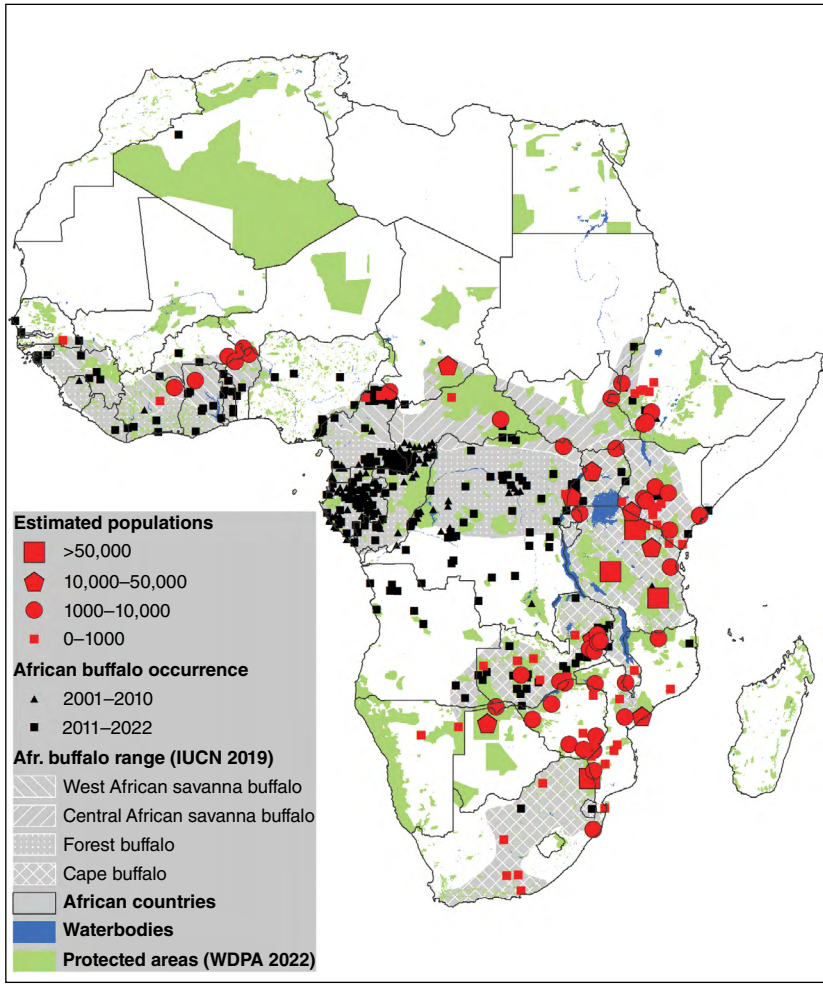

Figure 4.2 Continental distribution and abundance of African buffalo. The two classes of occurrence (2001–2010 and 2011–2022) refer only to the date of the source and do not signify a change in status between classes. Note that in certain other chapters of this book, the West African savanna buffalo and the Central African savanna buffalo are considered together and are referred to as the 'Northern savanna buffalo'. Sources: UNEP-WCMC and IUCN (2022) and IUCN SSC Antelope Specialist Group (2019).

Since the nineteenth century, the expansion of livestock has gradually generated direct competition for space and resources and has led to large and destructive epidemics in African buffalo populations. Exotic rinderpest was historically the most devastating disease for buffalo populations

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

throughout Africa, leading to extreme reductions in population densities and local extinctions. The most severe population collapse occurred in the 1890s, with mortality rates estimated at 90–95 per cent across the continent (Sinclair, 1977; Prins and van der Jeugd, 1993; Winterbach, 1998). This was followed by other episodes throughout the twentieth century. The World Organization for Animal Health (WOAH, formerly OIE) declared rinderpest eradicated in Africa in 2011 (last case reported in 2001). Rinderpest was the first animal disease to have been globally eliminated, and the second disease after human smallpox to have been globally eradicated. Both diseases are caused by viruses. During the twentieth century, efforts to limit the transmission to cattle of several pathogens, such as foot and mouth disease (FMD) and trypanosomiasis (Taylor and Martin, 1987), also actively reduced the geographic distribution of buffalo in several countries due to large-scale culling operations and the erection of veterinary fences.

Outright competition for range use and overexploitation by all sorts of poachers including local pastoralists also were important drivers behind the degradation of the buffalo's status (e.g. Prins, 1992; Prins and De Jong, 2022; Scholte et al., 2022).

Recent climate fluctuations, such as the droughts that affected Sahelian and Sudanese regions at the end of the 1960s and southern Africa in 1992 (Dunham, 1994; Mills et al., 1995; Chapter 8), have also strongly affected buffalo populations over the past few decades. Finally, yet importantly, armed conflicts, the feeding of armies and labourers during peacetime, the traffic of weapons and the bushmeat trade have strongly contributed to the reduction of buffalo populations in some areas (e.g. Prins et al., in review).

West African Savanna Buffalo (*S. c. brachyceros*)

In the 1970s and 1980s, this subspecies still locally occurred in Sahelo-Sudanian savannas and gallery forests, including those found in south-eastern Senegal, northern Côte d'Ivoire, southern Burkina Faso, Ghana, northern Benin, the extreme south of Niger, Nigeria (very locally), the northern part of Cameroon and Central African Republic (west of Chari River) (East, 1998). It is worth noting that the West African savanna buffalo (Figure 4.3) was (and still is) therefore also found in Central Africa, which underlines the inconsistency of this appellation (Figures 4.4 and 4.6).

Presently, most known populations remain in five main strongholds. Two of these are complexes hosting national parks (NP) and neighbouring trophy hunting areas: (1) W–Arly–Pendjari NPs (WAP) in

(a)

(b)

Figure 4.3 West African savanna buffalo in W National Park, Niger. © Daniel Cornélis.

Burkina Faso–Benin–Niger; and (2) Bouba N'djidda–Bénoué–Faro NPs in Cameroon. The remaining three strongholds are single NPs: (3) Niokolo-Koba NP in Senegal; (4) Comoé NP in Côte d'Ivoire; and (5) Mole NP in Ghana. In the other protected areas of the above-mentioned

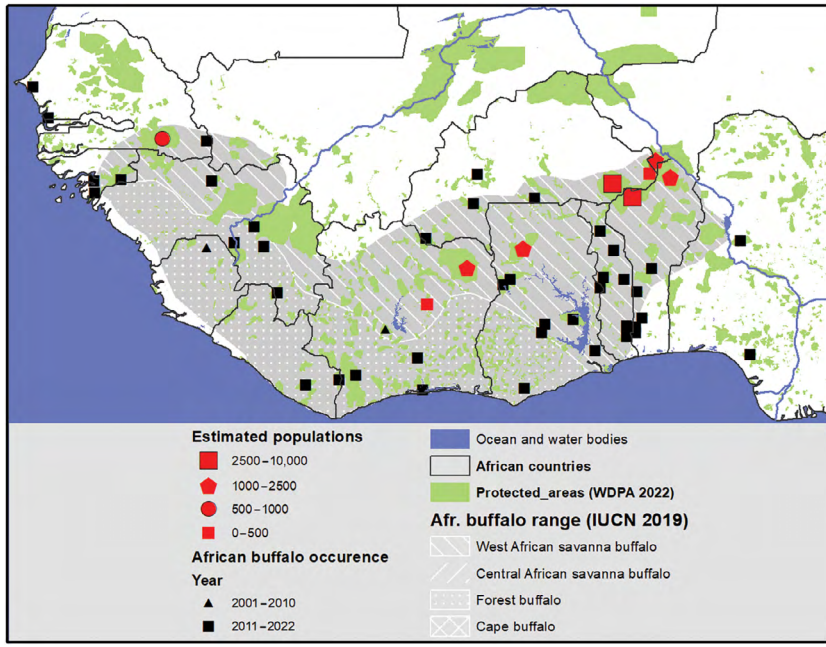

Figure 4.4 Distribution and abundance of African buffalo in West Africa. Sources: UNEP-WCMC and IUCN (2022) and IUCN SSC Antelope Specialist Group (2019).

countries, and in Nigeria, Togo and Sierra Leone, the presence of buffalo is limited to a few scattered residual populations. At present, the populations in the remaining strongholds are isolated from each other and the distribution of the West African savanna buffalo has shrunk overall. A positive finding emerging from our investigation is that the buffalo populations inside four of these five strongholds are, when compared with 2013 figures, either constant (Niokolo-Koba NP) or increasing (Comoé NP, WAP complex, Mole NP). On the downside, the populations in Northern Cameroon appear to be decreasing.

Central African Savanna Buffalo (*S. c. aequinoctialis*)

This subspecies still locally populates Central African countries within the Sahelo-Sudanian savannas and gallery forests: southeast Chad, northern Central African Republic (east of Chari River), northern Democratic Republic of Congo (DRC), south-east Sudan and western Ethiopia (Figures 4.5 and 4.6). The subspecies is now extinct in Eritrea. Most presently known populations remain in two main strongholds: Zakouma

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

Figure 4.5 Central African savanna buffalo in Zakouma National Park, Chad. © Daniel Cornélis.

NP in Chad and Garamba NP in DRC. In Ethiopia, the decline of several populations has been offset by the recent discovery of several populations outside the known range (see Ethiopia section below).

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

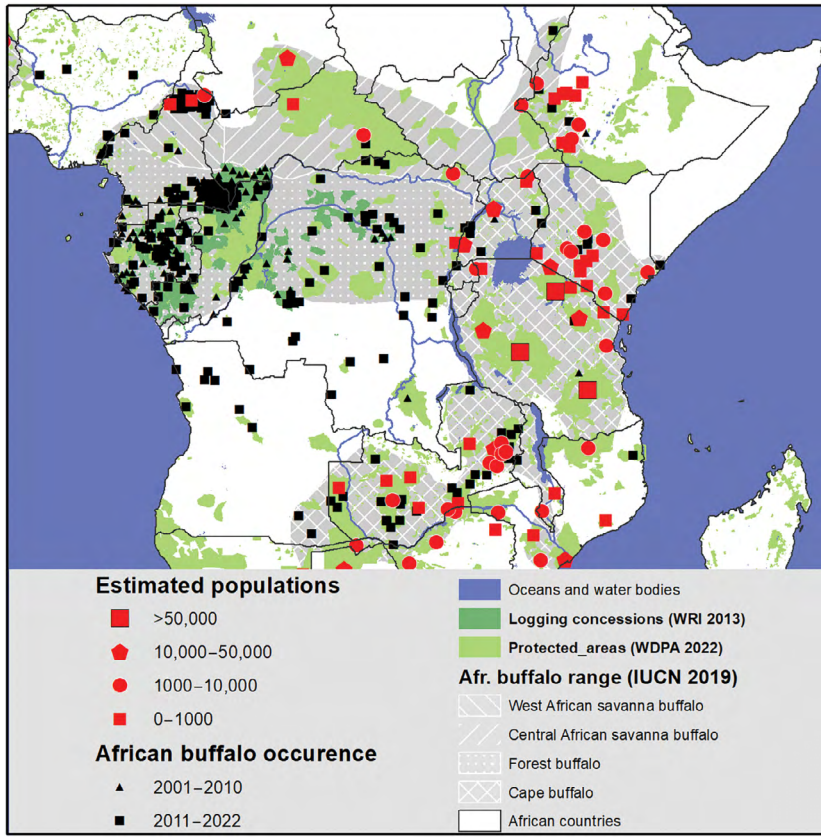

Figure 4.6 Distribution and abundance of African buffalo in Central and Eastern Africa. Sources: UNEP-WCMC and IUCN (2022) and IUCN SSC Antelope Specialist Group (2019).

Forest Buffalo (*S. c. nanus*)

The distribution range of the forest buffalo comprises two separate regions in West and Central Africa (Figures 4.4, 4.6 and 4.7). In West Africa, fragmented and isolated populations persist in the relict rainforest belt, while the population's stronghold is located in the Central African countries of the Congo Basin (Cornélis et al., 2014; IUCN SSC Antelope Specialist Group, 2019). In the Congo Basin, forest buffalo occur in the south of the Central African Republic, western Uganda, Democratic Republic of Congo, Republic of Congo, southern Cameroon, Equatorial Guinea and Gabon.

In West Africa, the subspecies persists in Benin, Ghana, Guinea, Guinea-Bissau, Côte d'Ivoire, Liberia, Nigeria and Sierra Leone (see below). Forest

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

(a)

(b)

Figure 4.7 Forest buffalo in Odzala National Park, The Republic of Congo. © Christophe Morio, with permission.

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

(a)

(b)

Figure 4.8 (a) Cape buffalo in Ngorongoro Conservation Area, Tanzania. © Christophe Morio, with permission. (b) Cape buffalo in Okavango Delta (Botswana). © Emily Bennitt, with permission.

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

buffalo are highly associated with forest clearings and riverine forests (Prins and Reitsma, 1989; Blake, 2002; Melletti et al., 2007, 2008; Bekhuis et al., 2008; Korte, 2008a). In several poorly explored areas, gaps remain in the scientific knowledge of the distribution and status of forest buffalo.

Contrary to the savanna buffalo, recent estimates of the population size of forest buffalo are available only for a few areas in the Congo Basin and their accuracy is low. Indeed, unlike aerial surveys carried out in savanna areas, surveys methods in forest environment are currently unable to provide reliable population estimates. Such estimates may become available for a larger number of sites once more appropriate techniques are implemented, such as distance sampling via camera

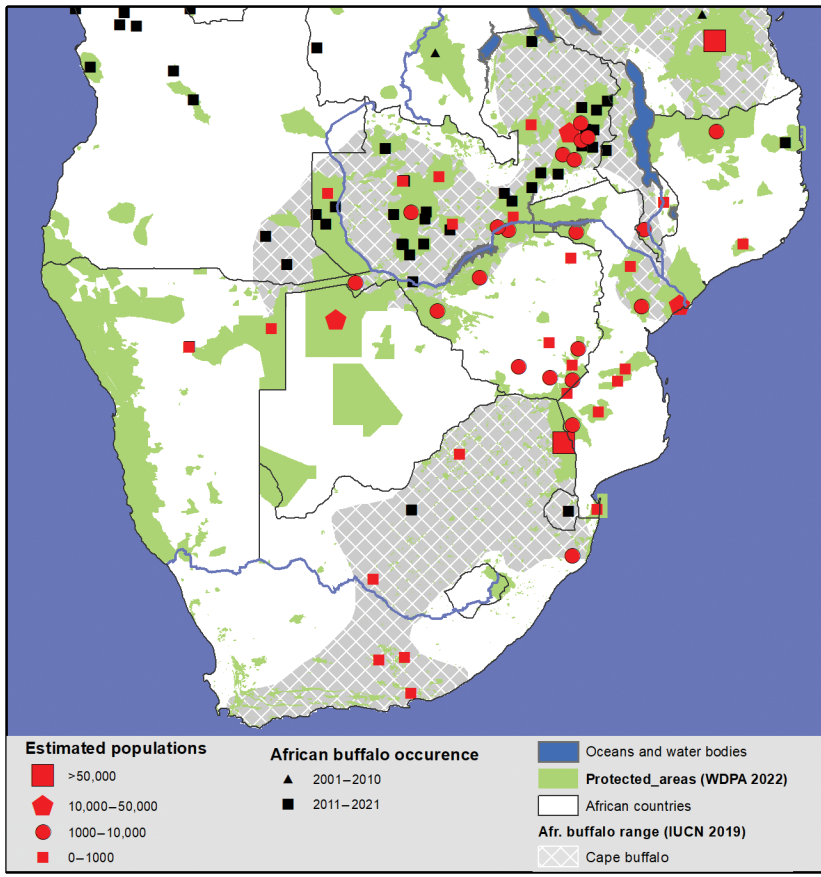

Figure 4.9 Distribution and abundance of African buffalo in southern Africa. Sources: UNEP-WCMC and IUCN (2022) and IUCN SSC Antelope Specialist Group (2019).

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

traps, capture–mark–recapture methods using genetic fingerprinting, and methods to formally capture information from local experts (e.g. indigenous people and local communities living in the rainforests).

Cape Buffalo (*S. c. caffer*)

The Cape buffalo's range encompasses East and Southern Africa and covers 17 countries (Figures 4.6, 4.8 and 4.9). In East Africa, Cape buffalo populations occur in southwestern Ethiopia, southern Somalia, Uganda, Kenya, Tanzania, Rwanda and Burundi. In southern Africa, this subspecies is distributed in Mozambique, Malawi, Zambia, southwest Angola, north-east Namibia, northern Botswana, Zimbabwe and South Africa. The current population in Eswatini (formerly known as Swaziland) was reintroduced after extirpation.

Abundance Per Country

West Africa

Burkina Faso

West African savanna buffalo formerly occurred widely in the open woodlands of the Niger basin and southern districts (Sidney, 1965; East, 1998). Starting from the 1980s, the population has been restricted to the southernmost areas of the country. At the national level, the buffalo population comprises around 6000 individuals. Their presence is recorded in six different localities, all conservation areas (national park, protected forest, game ranch or trophy hunting area). The largest populations are located in the eastern conservation areas: Arly complex with about 4950 individuals (0.5 ind./km^2) and W Burkina Faso complex with about 300 animals (0.8 ind./km^2) (Ouindeyama, 2021). The presence of buffalo is reported in central and western conservation areas (Nazinga Game Ranch, Bougouriba, Comoé-Lareba and Tuy Mouhoun areas) but in very low densities and isolated populations (Dahourou and Belemsobgo, 2020). In Nazinga Game Ranch, the total population is around 150 individuals (PAPSA, 2018).

After a period of growth between 2003 and 2015 (from ~4800 to ~8900 individuals; Bouché et al., 2003, 2015), buffalo populations of eastern conservation areas recently faced a strong population decline (~5300 individuals; Ouindeyama et al., 2021). Due to the severe worsening of the security situation, the protected areas are facing an increase in threats of banditry, adding new forms of violent interactions with protected area management teams.

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

Côte d'Ivoire

West African savanna buffalo formally occurred throughout the northern region (Sidney, 1965; East, 1998), but their populations have collapsed and are now isolated in a few protected areas. The main population is located in Comoé NP with an estimated 1450 individuals (0.1 ind./km^2; OIPR, 2019), which has increased slightly since 2010 (then about 900 individuals; N'Goran et al., 2010) and 2016 (1200 individuals; Bouché, 2016). The presence of buffalo has been recorded in Lamto and Marahoué NPs, but their numbers were not reported and are thought to be very low. Interestingly, a population of about 300 individuals was reported in N'Zi River Lodge Voluntary Nature Reserve near Bouaké (2.1 ind./km^2) and is known to be growing (Louis and Karl Diakité, personal communication, 2021).

The few observations of the forest buffalo subspecies are reported from the residual blocks of forest in the south of the country. This holds especially for Tai NP, where transect counts gave an estimated population size of ~500 individuals (0.09 ind./km^2) in 1999–2004, with lower estimates based on transect dung counts of ~200 individuals (Hoppe-Dominik et al., 2011). In striking contrast, recent detailed surveys only reported indirect signs, suggesting a collapse of the buffalo population (Tiedoue et al., 2019, 2020).

Between 2019 and 2021, a wildlife survey on foot was conducted throughout Côte d'Ivoire (ONFI, 2021). The data from this survey for African buffalo came mainly from indirect observations (tracks and dung) for which the risk of confusion with livestock was considered high (Gilles Moynot, ONFI, personal communication), and therefore are not included here.

Benin

West African savanna buffalo ranged in the past throughout the northern region (East, 1998), but populations are now restricted to Pendjari and W-Benin complexes (both complexes include the eponymous NPs and surrounding trophy hunting areas). The Pendjari complex has an estimated population of about 7200 individuals (1.2 ind./km^2), while in the W-complex some 1500 buffalo were counted (0.2 ind./km^2; Ouindeyama et al., 2021). The three main aerial surveys conducted over the last two decades in northern Benin show that buffalo populations have doubled since the early 2000s (2003: ~4600 individuals; 2015: ~8200 individuals; 2021: ~8650 individuals; Bouché et al., 2003, 2015; Ouindeyama et al., 2021).

Records of forest buffalo mainly refer to old observations located in the centre and southern sectors of Benin (PAPFCA, 2007; Sinsin et al., 2010). The last observations of forest buffalo were reported during a

ground survey carried out in the Forest of Agoua (Central Benin) in 2013 in which about 100 individuals scattered over 12 herds were seen (Natta et al., 2014). Further investigation is needed because buffalo are regularly observed in several spots in the southern and central parts of the country (Félicien Amakpe, personal communication).

Gambia

No recent information was received from this country. To our knowledge, the West Africa savanna buffalo subspecies is now extinct in Gambia (Jallow et al., 2004).

Ghana

Buffalo formerly occurred throughout Ghana, with the West African savanna buffalo in the northern and eastern savannas, and the forest buffalo in the southwestern forests (Sidney, 1965; East, 1998). The species is now restricted to a few protected areas.

The major surviving population of the savanna buffalo occurs in Mole NP with an estimated 1400 animals (0.3 ind./km^2; Hauptfleisch and Brown, 2019), and an increasing trend during the last decade (from about 700 individuals: Bouché, 2006). Small populations persist in the following savanna protected areas: Bui National NP (~60; 0.03 ind./km^2), Yerada–Kenikeni Forest Reserve (~30; 0.03 ind./km^2), Kyabobo NP (~50; 0.1 ind./km^2), Digya NP (~120; 0.03 ind./km^2) and Bomfobiri Wildlife Sanctuary (~30; 0.6 ind./km^2) (David Kpelle, Ghana Forestry Commission, personal communication). Some individuals also have been spotted in the Kogyae Strict Nature Reserve (Danquah et al., 2015) and Kalakpa Reserve (Afriyie et al., 2021).

The status of the forest buffalo is unclear. Its presence was reported in Subri River Forest Reserve in 2011 (Buzzard and Parker, 2012), but more recent information does not exist.

Guinea

African buffalo once occurred widely, with the West African savanna buffalo in the north intergrading to the forest buffalo in the south-west and south-east. It has been eliminated in most of its former range by overhunting and habitat destruction (East, 1998) and remains in pockets of relict populations spread throughout the country. The savanna buffalo

is known to be present in Haut Niger NP (Nefzi, 2020) and Moyen-Bafing NP (Wild Chimpanzee Foundation, 2021); however, without numerical information. Forest buffalo is present in Ziama Biosphere Reserve, the largest primary rain forest of the country, next to Liberia (Nefzi, 2020). It has also been observed recently in Tokounou, Tiro and Nialia subprefectures (Catherine André, personal communication), but no numerical estimates are available. However, we suspect that both savanna and forest subspecies may be present elsewhere in the country.

Guinea-Bissau

Intermediate forms between the West African savanna buffalo and the forest buffalo formerly occurred widely in the forest–savanna mosaic of Guinea-Bissau (East, 1998). The species still occurs widely in the south and is reasonably common in some areas, for example Cufada Lagoons Natural Park, Cantanhez Forest (da Silva et al., 2021) as well as Boe Region (Coppens, 2015), but no numerical estimates are available. No information was found from the northern part of the country.

Liberia

Only forest buffalo are known to occur in Liberia. In this country, the African buffalo was reported to occur sparsely in the 1960s (Sidney, 1965). A national survey carried out in 1989/1990 recorded the presence of the species in poorly accessible and high-altitude forests of the south-east and north-west (Anstey, 1991 cited by East, 1998). The contraction of its distribution range in recent decades appears to be due to civil war, unrest and widespread poaching. We have no recent information on its status, except observations by camera traps in the Grebo-Krahn NP forest in 2020 (Wild Chimpanzee Foundation; www.youtube.com/watch?v=QtYUSk53p2Q).

Niger

In the early twentieth century, West African savanna buffalo occurred in the south-western tip of Niger (Niger River basin and along parts of the Nigeria border; East, 1998). It has since disappeared from most of its former range and survives only in the W-Niger complex (W-NP and Tamou Total Reserve), where the last population estimate was about 350 individuals (0.1 ind./km^2; Ouindeyama et al., 2021). A

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

comparison with aerial counts conducted over the past two decades suggests a strong reduction in numbers since 2015 (2003: ~1200 individuals; 2015: ~1100 individuals; 2021: ~350 individuals; Bouché et al., 2003, 2015; Ouindeyama et al., 2021).

Nigeria

In the early twentieth century, the African buffalo was reported to be very common throughout Nigeria, from coastal evergreen forests (forest buffalo subspecies) to shrubby savannas in the north of the country (savanna buffalo subspecies). During the 1960s, the same author reports its occurrence in all suitable habitats, except for the southern coastal districts (Sidney, 1965). In the late twentieth century, East (1998) reported populations reduced to small, generally declining populations in a few protected areas.

For the West African savanna buffalo, the findings reported by East in 1999 still apply in 2022. The subspecies maintains an extremely limited distribution in northern Nigeria with a presence recorded only in three sites that are far from each other: Yankari Game Reserve, Kainji Lake NP and Gashaka Gumti NP (Andy Dunn, Naomi Matthews and Stuart Nixon, personal communication). The prospects for restoring the populations of Kainji Lake NP are poor due to their isolation from other populations and to the insecurity prevailing when this book went to press. Gashaka Gumti NP borders Faro NP in Cameroon, where about 600 individuals were estimated to occur (Elkan et al., 2015). A transfrontier conservation strategy could pave the way for the restoration of a viable buffalo population in Gashaka Gumti NP when the political and security contexts on both sides of the border so allow.

The forest buffalo was once widespread in most southern areas of Nigeria (Sidney, 1965), but has been eliminated from most of its former range and reduced to small, generally declining populations in a few protected areas (East, 1998). To date, this subspecies seems mainly localized in Cross River NP (4000 km^2), where presence was reported from 2001 to 2019 (Eniang et al., unpublished data; Eniang et al., 2017; Bassey, 2019). In this NP bordering Cameroon, only 131 records of forest buffalo were reported for all years combined during line transect surveys (namely, in 2001, 2005, 2009, 2013; Eniang et al., 2017). Only one forest buffalo observation was reported in the Mbe Mountains corridor (linking the Afi Mountain Wildlife Sanctuary and the Okwangwo Division of Cross River NP) during a 2019 year-round anti-poaching

patrol (Eban, 2020). Buffalo presence was recently reported in Okomu NP in south-central Nigeria (Akinsorotan et al., 2021). In other words, the forest buffalo is near to extinction in Nigeria.

Senegal

West African savanna buffalo were formerly widespread in the southern savannas of this country (East, 1998). The Senegalese buffalo population seems to have been isolated from other populations for some time (Sidney, 1965). Nowadays, populations have drastically declined and most buffalo are now only located in Niokolo–Koba NP. This protected area, where buffalo populations reached about 1000 individuals in the late 1960s (Dupuy, 1971) now hosts about 500 buffalo (0.06 ind./km^2; Rabeil et al., 2018). These figures are quite similar to those observed 12 years earlier (~500 individuals (0.05 ind./km^2), Renaud et al., 2006). Some buffalo are present in the private fenced reserves of Bandia (ranging from 80 to 134 individuals; 3 ind./km^2; Raymond Snaps, personal communication; Holubová, 2019) and Fathala (40; 1.7 ind./km^2; Holubová, 2019). The Bandia buffalo originated from 10 individuals translocated from Niokolo–Koba NP in 2000. It is worth noting that a relict population of savanna buffalo can still be found in the Faleme trophy hunting area (Philippe Chardonnet, personal communication).

Sierra Leone

Forest buffalo may still have occurred until a decade ago, mainly in the north of the country in 2009 and 2010 (Brncic et al., 2015). No recent information is available from this country.

Togo

Until the mid-1950s, the African buffalo was found in most parts of the country (Baudenon, 1952). Although classified as West African savanna buffalo, this author observed an important morphological gradient across the country, with black-coated buffalo in the north and red-coated buffalo in the south. According to East (1998), African buffalo survived in small to moderate numbers in the country's protected areas until the early 1990s, but were expected to be close to extinction in the late 1990s.

From our investigations, it appears that African buffalo are still present in small numbers in several protected areas. In the two northern

regions (Savanne and Kara), small populations were reported in Oti–Kéran NP (MERF, 2013) and Djamdè Faunal Reserve (MERF, 2014). In the Central Region, observations were made in Fazao–Malfakassa NP (Atsri et al., 2013) and Abdoulaye Game Faunal Reserve (MERF, 2017). Further south in the Plateaux Region, Amou Mono classified forest (MERF, 2016) and Togodo complex of protected areas (GIZ, 2017) also host small numbers.

Central Africa

Cameroon

Buffalo formerly occurred more or less throughout the country, except for the more arid parts of the far north (Sidney, 1965), with the West African savanna buffalo in northern and central Cameroon and the forest buffalo in the southern forests, which cover about half the country's area (East, 1998). In Cameroon, the savanna buffalo is now restricted to conservation areas in the North Region. In contrast, the forest buffalo is still present in forest areas sparsely populated by humans, especially in the South and East provinces, and to a lesser extent in the south-west province.

At the beginning of the twentieth century, West African savanna buffalo used to be common in the Logone floodplain, Far North Cameroon. However, in 1935, the African buffalo was already rare in the area, and no longer occurred when Waza NP was created in 1968 (Scholte, 2005). Remaining buffalo are located in the Bouba Ndjidda–Bénoué–Faro complex (North Province) with an overall estimated number of 2500 individuals (0.11 ind./km^2; Elkan et al., 2015 for Bénoué and Faro; Grossmann et al., 2018 for Bouba Ndjidda). It is hard to evaluate the proportion of animals within national parks or trophy hunting areas, but the last surveys (2015, 2018) tend to show that Bouba Ndjidda and Faro NPs still host buffalo, while for Bénoué, all individuals were spotted in the trophy hunting areas and none in the national park. The general trend seems to show a decrease in the population, estimated at 4000 individuals in 2008 (0.18 ind./km^2; Omondi et al., 2008).

Over the past 15 years, the presence of the forest buffalo was reported in most of the protected areas and numerous logging concessions.

In south-west and north-west provinces (border with Nigeria), buffalo are present in Korup NP (Astaras, 2009) and were also sighted in a logging concession located north of the park. Further north, buffalo presence was reported in the Black Bush Area of Waindow in 2014

(Chuo and Angwafo, 2017). These buffalo populations appear to be more scattered and isolated as they are surrounded by areas of high human population density. In this respect, it should be noted that no observations of buffalo have been reported recently in the West, Littoral and Central provinces, all of which are heavily populated. However, it is plausible that buffalo populations remain in the northern part of Central Province in the triangle formed by the Mpem-Djim, Mbam-Djerem, and Deng-Deng NPs. The presence of buffalo was observed there in a logging concession in 2004 (Cornélis et al., 2023).

In the South province, buffalo are present in Campo–Ma'an NP (650 km^2), where population sizes were estimated by Bekhuis et al. (2008) with 20 individuals only (densities 0.01–0.04 ind./km^2) and by Van der Hoeven, de Boer and Prins (2004) at 0.07–1.27 ind./km^2. The presence of buffalo was also reported in several logging concessions located on the periphery of the park (Cornélis et al., 2023). Further east, forest buffalo also were reported in a logging concession located north of Mangame Wildlife sanctuary.

In the south-eastern end of the country (East Province), forest buffalo are present in Dja Biosphere Reserve (Bruce et al., 2017, 2018) and have been sighted in several logging concessions located south of the reserve over the past 15 years (Cornélis et al., 2023). Forest buffalo were reported in Nki and Boumba-Bek NPs in 2015 (Imbey et al., 2019; Ngaba and Tchamba, 2019; Hongo et al., 2020) and Lobeke NP (Gessner et al., 2013). The area surrounding these three protected areas is almost entirely allocated to logging. The presence of buffalo also has been reported in many logging concessions over the past 15 years (Cornélis et al., 2023).

Central African Republic

The Central African Republic (CAR) is the only country where three subspecies of buffalo occur.

The West African savanna buffalo subspecies used to be widespread in the west of the country next to the border with Cameroon, although its West African name looks odd in a Central African country. Nowadays, information is lacking about this subspecies in CAR, but it is certainly and by far the least represented of the three subspecies present in CAR. It may be reasonable to think that buffalo are present next to the Cameroon border because there are Trophy Hunting Areas (*Zones d'Intérêt Cynégétique*) on the Cameroon side with buffalo quota and offtake.

Central African savanna buffalo were historically widespread in all Central African savannas (East, 1998). Presently, residual buffalo populations are apparently restricted to the far Northern complex (Bamingui–Bangoran and Manovo–Gounda St Floris NPs and surrounding trophy hunting areas) and in the Southeast complex (Chinko Basin).

In the Northern complex, the population numbers declined from ~19,000 individuals (0.3 ind./km^2) in 1985 (Douglas-Hamilton et al., 1985) to ~13,000 (0.2 ind./km^2) in 2005 (Renaud et al., 2005), after which it collapsed to 13 individuals only in 2017 (Elkan et al., 2017). Given the level of insecurity in the region, it may have now gone extinct.

In the Southeast complex, buffalo populations strongly declined between 2012 and 2017 due to the invasion of the area by transhumant herders from South Darfur, Sudan (Aebischer et al., 2020). Conservation efforts undertaken by African Parks since 2014 have reversed the trend in the Chinko conservation area (6000 km^2), where the buffalo population was estimated at over 4000 buffalo in 2022 (Thierry Aebischer, personal communication).

The huge uninhabited wilderness areas in between those residual complexes are composed of trophy hunting areas where buffalo were present and hunted before the 2012 war started. However, no recent information on buffalo presence or abundance is available.

Although a large part of potential suitable areas has not been surveyed recently, the conservation status of the Central African savanna buffalo should be considered as under major threat in the Central African Republic (see also Scholte et al., 2022).

Forest buffalo are mainly localized in the south-west tip of the country, covered by rainforests. Over the past 15 years, the presence of the forest buffalo was reported in all protected areas and most of the logging concessions of this region (Cornélis et al., 2023). Buffalo are encountered in the Dzanga-Sangha Protected Area complex, including recent records in the Special Reserve of Dzanga-Sangha (Melletti et al. 2007 Beudels-Jamar et al., 2016). Forest buffalo were also reported from the south-east part of the country, where forest and savanna intermingle: Bangassou forest (Roulet, 2006) and the thick riverine forests of the upper Mbomou River (Philippe Chardonnet, personal communication).

Chad

Central African savanna buffalo were formerly widespread in the south of the country from Lake Chad to Salamat (Sidney, 1965). However, buffalo were extirpated from most of their original range by agricultural and livestock

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

expansions as well as drought (East, 1998). The largest population, estimated at ~15,500 individuals (5 ind./km^2), is located in Zakouma NP (Fraticelli et al., 2021). In this protected area, the buffalo population tripled in 15 years, showing an average annual growth rate of 7 per cent. In January 2022, 905 buffalo were translocated from Zakouma NP to restock the nearby Siniaka-Minia wildlife reserve (Naftali Honig, personal communication).

The last survey in Sena Oura NP did not encounter any buffalo (Elkan et al., 2015). Some buffalo were reported in the far south province of Logone Oriental near Monts de Lam and Baïbokoum in 2021 (Matuštíková, 2021), suggesting that buffalo populations of Bamingui-Bangoran/Manovo-Gounda St Floris in the Central African Republic and of Bouba N'djidda complex in Cameroon could have some connection through southern Chad.

Democratic Republic of Congo

Forest buffalo seem to be widespread in the Democratic Republic of Congo (DRC; informally known as 'Congo-Kinshasa'), but with a patchy distribution because DRC is one of the most densely populated countries in the Congo Basin. This may be due to a combination of both human pressure (e.g. poaching, meat harvesting for logging camps and for other extractive industries) and a lack of knowledge.

In the south-western section of the DRC forest block (Maï-Ndombe and Equateur Provinces), the presence of buffalo was reported in Tumba-Ledima Reserve (ICCN and WWF, 2016a) and Ngiri Triangle Reserve (T. Breuer, personal observation). The presence of the forest buffalo was recorded during the forest management surveys of many logging concessions over the past 15 years, particularly in the western and south-eastern parts of Mai-Ndombe Province (Cornélis et al., 2023).

In the south-central section of the DRC forest block (north of Kasai and Sankuru provinces, south of Tshuapa Province), forest buffalo were recently reported in Salonga NP (Bessone et al., 2020) and the Tshuapa–Lomami–Lualaba landscape (John Hart, personal communication). Although highly possible, the presence of buffalo was not reported (to our knowledge) from Sankuru Reserve.

In the south-east section of the DRC forest block (Maniema and South Kivu Provinces), forest buffalo were reported in Kahuzi–Biega NP (Spira et al., 2018), Kasongo and Pangi priority areas (ICCN and WWF, 2017a), the Itombwe NR (ICCN and WWF, 2016b) and in the Luama–Kivu region (ICCN and WWF, 2017b).

In the north-central section of the DRC forest block, the presence of buffalo has been confirmed in a dozen places of Tshopo Province over the last 15 years by several studies (van Vliet et al., 2012; Nebesse, 2016) and forest management surveys (Cornélis et al., 2023). Further west, its presence was recorded in Abumonbazi Reserve (province of Nord-Ubangi; ICCN and WWF, 2015a) and in a logging concession ('09/11-Baulu') located south of Lomako–Yokokala Reserve (north of Tshuapa Province; Cornélis et al., 2023).

In the eastern section of the DRC forest block, forest buffalo were reported north of Maiko NP (Naomi Matthews and Stuart Nixon, personal communication) and in the southern section of Virunga NP (Mikeno Sector; Hickey et al., 2019). Further north (Ituri province), buffalo were reported in Okapi Wildlife Reserve (Madidi et al., 2019).

Interestingly, the presence of buffalo also has been reported south of the current 'official' (IUCN SSC Antelope Specialist Group, 2019) range of the forest buffalo, in trophy hunting areas: Bombo Lumene (ICCN and WWF, 2017c), Bushimaie (ICCN and WWF, 2016c), and Swa-Kibula (ICCN and WWF, 2015b) as well as in Mangai Nature Reserve (ICCN and WWF, 2015c) and Kaniama Elephant Refuge (ICCN and WWF, 2016d). The taxonomic status of these populations is unclear.

Central African savanna buffalo formerly occurred on the edge of the dense forest along the northern and eastern borders of the country (East, 1998). Much hunted and regularly infected with rinderpest, buffalo populations became isolated in Garamba NP (Northern border), where Sudanese meat hunters reduced the population from 53,000 in 1976–83 to 26,000 in 1995 (East, 1998). Nowadays, Garamba NP and adjacent trophy hunting areas (~14,800 km^2) host about 9400 buffalo (0.6 ind./km^2; Ngoma et al., 2021). The population in Garamba NP may have increased slightly from some 6000 individuals in 2012 (Bolaños, 2012) with improved protection of the park. Population estimates in Bili–Uere NP are unknown, but most probably low with a few small groups left (Elkan et al., 2013b; Jef Dupain, personal communication, 2018).

Cape buffalo – in the east of the DRC, along the border with Uganda, the central plains of Virunga NP are host to a population of savanna buffalo located in a zone of introgression between several subspecies and which we have assigned to the 'caffer' subspecies. The population of Virunga NP has decreased from about 2100 individuals in 2010 (Plumptre et al., 2010) to about 600 (Wanyama et al., 2014).

In the southern savannas, the population of Upemba NP is less well monitored, but we think it is very small as only 15 individuals were spotted in 2009 (Vanleeuwe et al., 2009). East (1998) stated that buffalo were eliminated from the Kundelungu NP population and we have not received any contradicting information.

Equatorial Guinea

There is evidence of the former widespread occurrence of forest buffalo on Bioko Island, Equatorial Guinea, but no indication of a surviving population was found during 4.5 months of field surveys there between 1986 and 1992 (Butynski et al., 1997). Due to overhunting, buffalo were probably already extirpated from the island between 1860 and 1910.

In the mainland region of the country, the forest buffalo formerly occurred throughout Mbini (Rio Muni). It has been eradicated from parts of its range but seems to have survived locally within the remaining forested areas, including Monte Alen NP until the end of the 1990s (East, 1998).

Gabon

Gabon is a sparsely populated country, 88 per cent of which is covered by equatorial forests. The country is home to a largely preserved biodiversity. Thirteen national parks were created in 2002 and protected areas cover 15 per cent of the country (41,000 km^2). About half of the country (~142,000 km^2) is dedicated to logging (WRI, 2013). Forest buffalo populations are widely distributed in Gabon both inside and outside protected areas, including logging and oil concessions (Prins and Reitsma, 1989). Except for Akanda NP, located 30 km north of Libreville, the presence of the forest buffalo has been documented in all of the national parks over the past 15 years (Christy et al., 2008; Vanthomme et al., 2013; Nakashima, 2015; Hedwig et al., 2018). For this country, we reviewed 42 reports of biodiversity inventories conducted on foot by international forestry consultancy companies in logging concessions between 2000 and 2017 (unpublished and confidential reports). Almost all of these inventories recorded evidence of buffalo presence. These observations are supported by recent surveys conducted in several logging concessions using camera traps (Houngbégnon, 2015; Nunez et al., 2019; Fonteyn et al., 2021; Naomi Matthews and Stuart Nixon, personal communication).

Estimates of buffalo populations were carried out in a forest–savanna mosaic area of Lopé NP (North sector 70 km^2) where Korte (2008b) estimated about 300 individuals in 18 herds with a density of 5 ind./km^2. In forest areas at Lopé NP, White (1994) estimated a density of 0.42 ind./km^2. In the Réserve de Faune de Petit Loango, Morgan (2007) found a density of 1.7 ind./km^2. Prins and Reitsma (1989) reported a forest buffalo density of 0.51 ind./km^2, but absolute numbers could not be established reliably.

Republic of Congo

Republic of Congo (informally known as 'Congo-Brazzaville') is a sparsely populated country, 70 per cent of which is covered by equatorial forests. The central part of the country is made up of the so-called Bateke plateaus, which are covered with savanna grassland and riverine forests.

In the northern part of the country, which is very sparsely populated, the forests of the Congolese basin are home to widely distributed buffalo populations. Forest buffalo are present in all of the protected areas: Odzala-Kokoua NP (Chamberlan et al., 1995), Nouabalé-Ndoki NP (Blake, 2002), Ntokou-Pikounda NP (Malonga and Nganga, 2008), and Lac Tele Reserve (Devers and Van de Weghe, 2006). Between these protected areas, upland forests are allocated to logging. For this area, we reviewed 10 biodiversity survey reports conducted between 2005 and 2019 by international forestry consultancy companies in 10 logging concessions (unpublished and confidential reports). All of them recorded evidence of buffalo presence. In northern Congo, Blake (2002) recorded densities between 0.01 and 0.04 ind./km^2 at Nouabalé-Ndoki NP, while Chamberlan et al. (1995) estimated the buffalo population of Odzala-Kokoua NP at around 500 individuals (0.4 ind. km^2).

From the central part of the country, little information is available on the presence of forest buffalo in the savannas and gallery forests of the Bateke Plateau. However, Mathot et al. (2006) report buffalo presence in the Lessio-Luna Wildlife Sanctuary bordering the Lefini Reserve.

In the southern part of the country, forest buffalo are present in Conkouati-Douli NP (Devers and Van de Weghe, 2006) and Kouilou Department (Orban et al., 2018). In Niari and Lekoumou Departments, the biodiversity survey reports conducted in the logging concessions between 2005 and 2019 on foot also reported evidence of buffalo presence.

East Africa

Burundi

A resident population of cape buffalo has been living for a long time and continues to do so today in the narrow strip of Ruvubu NP, Eastern Burundi (Nzigidahera et al., 2020).

Ethiopia

African buffalo populations have long been restricted to the south-western and western parts of the country, along the borders of Kenya, South Sudan and Sudan (Sidney, 1965). East (1998) reported that the main populations can be found in Omo and Mago NPs. Buffalo do also occur in montane forests and swampy wetlands, such as in the Chebera Churchura (Megaze et al., 2018) and Gambella NPs (TFCI, 2010; Rolkier et al., 2015). Currently their distribution is largely confined to protected areas with a total estimated population of about 15,000 (around 5000 *S. c. aequinoctialis* and 10,000 *S. c. caffer* – Table 4.1).

Ethiopia is a contact zone between the Cape buffalo and the Central African savanna buffalo where the two subspecies intergrade. The presence of intermediate phenotypes and the absence of geographical barriers make classification difficult. For the sake of consistency with earlier studies on buffalo distribution (East, 1998; Cornélis et al., 2014), our results are presented in accordance with the current IUCN subspecies range (IUCN SSC Antelope Specialist Group, 2019), but this is one of the areas where the 'subspecies concept' loses meaning for African buffalo.

The largest population of Cape buffalo is found in Chebera Churchura NP (~5200 animals; Megaze et al., 2017). Significant populations are also found in other formally protected areas, such as Omo NP (~800 animals; Tola, 2020), Mago NP (~850 animals; Tsegaye, 2020). In addition, about 2000 buffalo are estimated to be in the Tama wildlife reserve that connects Omo and Mago NPs (Girma Timer, personal communication). Finally, the Weleshet-Sala controlled trophy hunting area holds about 1100 individuals (Kebede et al., 2011).

Significant populations of Central African savanna buffalo are found in Gambella NP (~1400 animals; TFCI, 2010). Reports from two newly established national parks indicate the presence of about 1700 buffalo in Maokomo Nature Reserve (Wendim, 2015). The presence of several hundred buffalo was also confirmed by a count in Dati Wolel NP (Gonfa et al., 2015), but the population estimate is not reliable. Buffalo

observations were also recently reported from Alatash NP along the border with Sudan (Bauer et al., 2018).

During the last decade, several Central African savanna buffalo populations have been reported north-east of their earlier established (IUCN SSC Antelope Specialist Group, 2019) distribution range. Two Controlled Hunting Areas (CHAs) hold a reasonable number of buffalo: Haro Aba Diko CHA (~900 individuals; Kebede and Tsegaye, 2012) and Beroye CHA (~600 individuals; Kebede et al., 2013). A population of at least 60 buffalo was reported in Didessa NP (Wendim, 2018) and a herd of seven animals was repeatedly observed in Jorgo-Wato National Forest Priority Area (Jebessa, 2015; Erena et al., 2019). Finally, Lafto Forests area hosts about 340 buffalo (Dandena and Dinkisa, 2014). Yet we repeat that 'subspecies' designation in this country is shaky due to intergradation.

Kenya

The Cape buffalo was formerly widespread throughout southern and central Kenya, and on isolated, forested hills and mountains in the north. In the 1990s, the population became largely confined to protected areas, except in Laikipia and Lamu districts (East, 1998). The status of buffalo in Kenya has recently been updated during a national wildlife census undertaken between April and July 2021. Several aerial total counts covered nearly 60 per cent of Kenya's land mass (Waweru et al., 2021). Results show that the Cape buffalo is distributed in almost all of the wildlife ecosystems surveyed, except in the northern counties of Mandera, Wajir, Turkana as well as the Nasolot-Kerio Valley ecosystem. About 41,700 buffalo were counted.

In Kenya, seven conservation areas host populations of over 1000 buffalo, respectively, Maasai Mara ecosystem (~11,600), Tsavo ecosystem (~8000), Lake Nakuru NP (~6500), Laikipia–Samburu–Marsabit ecosystem (~6300), Lamu–Lower Tana and Garissa ecosystem (~3000), Meru ecosystem (~2600) and Naivasha–Nakuru ranches (~1500). These seven ecosystems account for about 95 per cent of Kenya's total buffalo population. Three conservation areas contain a few hundred buffalo, namely Nairobi NP (~1000), Amboseli–Magadi ecosystem (~500) and Ruma NP (~400). Small populations occur in other protected areas, such as Athi–Kapiti ecosystem, Mwea National Reserve, Shimba Hills National Reserve and Oldonyo Sabuk NP. Other populations have not been estimated over the years because the technique of aerial surveys is not well suited for dense forests and nature of the terrain of Aberdares,

Mount Kenya, and Mount Elgon forested areas or Forest Reserves such as Mukogodo, Ngare Ndare Arabuko Sokoke and Boni Dodori. For this reason, but also because some buffalo strongholds were not surveyed under optimal visibility conditions (e.g. Lamu–Lower Garissa and Tana River Ecosystem with about 13,800 buffalo in 2015), the above-mentioned figure for the Kenyan population of buffalo is likely underestimated.

According to the latest national census (Waweru et al., 2021), buffalo in Kenya are now largely confined to protected areas. In the Mara ecosystem, 70 per cent of all buffalo were found in the Maasai Mara National Reserve, while the remaining 30 per cent were recorded from the Maasai Mara community conservancies. In the Tsavo ecosystem, 80 per cent of the buffalo population was found inside the protected areas. In the Laikipia–Samburu–Marsabit–Meru ecosystem, 69 per cent of the population was counted in ranches, 27 per cent in the protected areas and 3 per cent in community/settlement areas.

In Kenya, buffalo populations suffered a sharp contraction in the 1990s because of severe drought and the very last rinderpest events. For example, the Mara population was reduced from 12,200 to 3100 by the 1993–94 drought (East, 1998) and has since shown good recovery (~11,600 animals in 2021). The buffalo population in Nakuru NP has recovered and has consistently increased from about 2200 buffalo in the year 2000 to the current population of about 6400 individuals at a density of 51.3 buffalo/km^2 (a continental record for the present; Lake Manyara National Park in Tanzania reached nearly twice as much: Prins and Douglas-Hamilton, 1990). In contrast, the Tsavo population decreased from an estimated 34,600 in 1991 to 5500 in 1997 (East, 1998) with no strong evidence of recovery so far (~8000 in 2021). Although the Kenyan population shows a cumulative increase of about 40 per cent between 2008 and 2021, recovering the numbers from the early 1990s (approximately 95,000 buffalo) is challenging in a context of increasing competition with humans and cattle for resources (water, space and forage; Waweru et al., 2021). The effects of the 2022 drought with some heavy buffalo mortality in, for example, Lewa Downs (Susan Brown, personal communication), were not yet known when we finalized this chapter.

Rwanda

The Cape buffalo formerly occurred at high densities in Akagera and Volcanoes NPs. The population of Akagera NP, estimated to number 10,000 in 1990 (East, 1998), subsequently declined due to the 1994

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

genocide and political unrest. The park also faced a two-thirds reduction in size to about 1120 km^2. Since 2002, buffalo numbers have been increasing again, reaching ~3400 individuals in 2019 (Macpherson, 2019).

In Volcanoes NP, a dung count undertaken in 2004 suggested a population of ~900 (2.0 ind./km^2; Owiunji et al., 2005). We are not aware of more recent surveys, but given the excellent protection of Volcanoes NP, as testified by the increasing number of mountain gorillas, we assume that the number of buffalo remained constant. In contrast, the buffalo was reported extinct at Lake Kivu shore and nearby forests (including Gishwati–Mukura) as well as Nyungwe NP (Cockar, 2022).

Somalia

The Cape buffalo formerly occurred in the south of the country in areas with permanent water along the lower Shebelle and lower Juba Rivers (Fagotto, 1980). At the end of the twentieth century, agricultural settlement and hunting pressure eliminated the buffalo from most of its former range, except in the Bushbush NP area (now Lag Badana NP), where it occurred in good numbers (East, 1998). Buffalo presence was recently reported in Lag Badana National Park and surrounding areas in Jubalan (Gedow et al., 2017), but the total number was not reported.

South Sudan

Sidney (1965) reported that large herds of Central African savanna buffalo were commonly found in grassy plains. Although variations in numbers could be found, the subspecies population was very healthy in South Sudan, with probably several tens of thousands of individuals. Small migrations between the rainy and dry seasons were also observed. East (1998) also reported large populations of several thousand individuals in the main South Sudan protected areas (Boma NP and Shambe Nature Reserve), but warned that meat hunting pressure was very high. This declining trend appears to remain in process. Fay et al. (2007) recorded ~10,200 buffalo in the protected areas of Southern Sudan (mainly in Zeraf and Sambe game reserves), while aerial reconnaissance surveys spotted only 285 individuals in 2013 and none in 2016 (Elkan et al., 2013a, 2016). From this we infer that the conservation status of the Central African savanna buffalo should be considered under major threat in South Sudan.

Sudan

The Central African savanna buffalo is historically present in the south-eastern tip of Sudan along the border with Ethiopia. Bauer et al. (2018) reported observations of African buffalo in the Dinder–Alatash trans-boundary protected area (13,000 km^2; Sudan and Ethiopia) during five field trips undertaken between 2015 and 2018.

Tanzania

Although once common throughout the country, the range of the Cape buffalo covered less than half its area of distribution at the end of the last century, with an estimated population of 342,000 individuals (East, 1998). Tanzania today is still the country with by far the largest number of buffalo, with an estimated population of at least 240,000 individuals. The country has established a dense network of protected areas covering slightly more than 30 per cent of the land surface area (MNRT, 2021) and implementing a range of nature conservation models with both (i) consumptive use of wildlife in Game Reserves, Game Controlled Areas and Wildlife Management Areas (WMAs) and (ii) non-consumptive use of wildlife in National Parks and Ngorongoro Conservation Area.

Tanzania is the only country with single populations of buffalo exceeding 50,000 individuals (Figure 4.6). There are three of these strongholds: (i) the Serengeti Ecosystem (~23,700 km^2) in the northern part of the country hosts a population of about 69,000 individuals (TAWIRI, 2021a), (ii) the Selous–Mikumi Ecosystem (~74,000 km^2) in the south-east of the country has a population of about 66,800 individuals (TAWIRI, 2019a) and (iii) the adjacent Katavi–Rukwa and Ruaha–Rungwa Ecosystems (~83,000 km^2) located in the west-centre of the country hold a population of about 53,000 individuals (TAWIRI, 2022).

Nearby the Serengeti Ecosystem, the Tarangire–Manyara Ecosystem (~15,500 km^2) also hosts an important buffalo population, estimated at about 19,000 individuals (TAWIRI, 2020). Mkomazi NP (~2800 km^2) in the north-east supports about 600 individuals (TAWIRI, 2019b). Saadani NP and Wami Mbiki WMA on the coast host about 1000 individuals (Edward Kohi, personal communication). By contrast, the last census undertaken in West Kilimanjaro–Lake Natron Ecosystem (~10,000 km^2) reported a population of 46 buffalo only (TAWIRI, 2021b), a very low number largely due to cattle encroachment (Prins and De Jong, 2022).

In the north-western part of the country, the Malagarasi–Muyovozi Ecosystem hosts an important buffalo population, estimated at about 28,300 individuals (Edward Kohi, personal communication). The recently created Burigi–Chato NP (2200 km^2) west of Lake Victoria along the border with Rwanda has a small number of buffalo, as well as Rubondo Island NP in Lake Victoria (Edward Kohi, personal communication). At the northwestern tip of the country, Ibanda Kyerwa NP (200 km^2) supports about 215 buffalo (Edward Kohi, personal communication).

Finally, several mountainous and/or densely forested areas host buffalo populations of which the recent numbers are unknown: Arusha NP and Mount Meru Forest Reserve, Kilimanjaro NP and Udzungwa Mountains NP. Therefore, given these knowledge gaps, the estimates provided for Tanzania should be considered as minimum values.

In 2022, the conservation status of buffalo in Tanzania is uneven. On the positive side, (i) not only is Tanzania the only country holding single populations of over 50,000 buffalo, but there are three of these populations in the country; and (ii) several ecosystems show positive trends with growing buffalo populations, for example Serengeti Ecosystem. On a more worrying side, the overall national trend of buffalo is on the decrease due to (i) severe encroachment by livestock tending to replace buffalo in several ecosystems (Prins, 1992; Musika et al., 2021, 2022; Prins and De Jong, 2022) and (ii) steady agricultural expansion and associated settlements.

Uganda

The Cape buffalo was formerly widespread in large numbers in savannas, with putative intermediates with the forest buffalo in the southwest (Greater Virunga Landscape) (East, 1998). However, genetic samples so far have not yet recognized these putative hybrids in Uganda (see Chapter 3). It is noteworthy that western Uganda is a zone of introgression between several subspecies where the taxonomy is subject to controversy.

Cape buffalo are now confined to three conservation areas. In Queen Elizabeth NP (2110 km^2), the most recent survey reported ~15,800 buffalo (Wanyama et al., 2014) and the population seemed to be increasing from the ~10,300 reported in 2010 (Plumptre et al., 2010). In Murchison Falls NP and surrounding wildlife reserves (5030 km^2), an aerial survey undertaken in 2016 resulted in an estimate of ~15,200 buffalo (Lamprey et al., 2020), and the population also seemed to be increasing (from ~9200 in 2010 (Rwetsiba and Nuwamanya, 2010). Finally, in Kidepo NP and Karenga Community Wildlife area (2400 km^2), the last survey

reported ~7500 individuals, mainly located inside the park (~6600; Wanyama et al., 2019). The trend is also up in Kidepo NP (from ~3800 in 2008 to ~6600 in 2019; WCS Flight Programme, 2008). These three conservation areas (together ~9400 km^2) host a population of about 38,500 buffalo (4 buffalo/km^2). Smaller populations were also recently reported in Lake Mburo Conservation Area (1290 km^2 with ~1500 buffalo; Kisame et al., 2018a) and Pian Upe Wildlife Reserve (no estimate; Kisame et al., 2018b). Hence, the total number of Cape buffalo in Uganda is now about 40,000 head, which compares very favourably to the estimate of about 22,000 a few decades ago (East, 1998).

The presence of forest buffalo was recently confirmed in Semuliki NP in 2020 (Naomi Matthews and Stuart Nixon, personal communication). No forest buffalo presence was reported from Mgahinga Gorilla NP since 2003 (Hickey et al., 2019) or from Kibale NP from 2013 to 2021 (Rafael Reyna-Hurtado and Jean-Pierre d'Huart, personal communication). In the latter park, records of buffalo inside the forest are related to savanna buffalo coming from Queen Elizabeth NP through the Dura corridor.

Southern Africa

Angola

Apart from the arid coastal strip in the southwest, African buffalo formerly occurred very widely, with the Cape buffalo in the south and intermediate forms with the forest buffalo in the north (East, 1998). During the civil war (1975–2002), thousands of buffalo were slaughtered by the Angolan army for food. Since the 2000s, buffalo populations have remained low due to widespread poaching, habitat degradation, human encroachment and the presence of land mines. However, very little information is available on the status of buffalo in this country, especially in the central plateau and the northern and eastern regions.

Cape buffalo are still relatively common in the south-eastern parts of Angola, especially in the Mucusso region and in Mavinga and Luengue-Luiana NPs (Funston et al., 2017; Beja et al., 2019; Petracca et al., 2020), but their actual numbers have not been assessed. Naidoo et al. (2014) report frequent movements of Cape buffalo between Angola and Namibia, particularly along the northern banks of the Okavango River, and west of the Cuando River. Large herds (over 1000 animals) were also reported to aggregate in the southeast of Luiengi–Luiana NP along the Kwando River just before the rainy season (Roland Goetz, personal communication).

In the northern Quiçama region, there were an estimated 8000 so-called 'forest buffalo' prior to the civil war of 1975–2002 (Braga-Pereira et al., 2020). During the war, uncontrolled poaching severely reduced the populations, which are now confined to a few small herds in Quiçama NP (Groom et al., 2018), Luando Natural Integral Reserve (Elizalde et al., 2019) and Cangandala NP (David Elizalde, personal communication). Although surprising at this latitude, recent photographs of buffalo taken by camera traps in Quiçama NP and Luando Natural Integral Reserve confirm the presence of buffalo that phenotypically correspond to the forest buffalo (David Elizalde, personal communication). Outside protected areas, recent sightings of buffalo were reported in the north-western section of the country, in the region of Mussera (Zaire Province), Quissafo-Ndalatando and Cassoxi (Cuanza Norte Province), and in the Pingano Mountains (Uige Province) (David Elizalde, personal communication).

Botswana

Cape buffalo are found only north of 20° S in the Okavango–Chobe region and wildlife movements are constrained by veterinary fences erected to control the spread of livestock diseases. In a 2018 aerial total count covering northern Botswana (~103,700 km^2, including Moremi Game Reserve, Chobe NP, Makgadikgadi Nxai Pan NP and surrounding WMAs), the buffalo population was estimated to be some 28,500 individuals (Chase et al., 2018). For the record, a similar survey undertaken in 2010 reported an estimate of 39,600 individuals (Chase, 2011), while East (1998) reported about 27,000 head. It thus appears that the population is fairly constant.

Eswatini (Swaziland)

Cape buffalo were reintroduced in Swaziland, where the indigenous population was extirpated (Tambling et al., 2016). They now occur in the Mkhaya Private Game Reserve (~20 animals, 0.2 ind./km^2; Tal Fineberg, personal communication, 2021).

Lesotho

Buffalo was extirpated from this country (Tambling et al., 2016), but historically it had occurred here even though it was no longer present a few decades ago (East, 1998).

Malawi

In the late 1990s, the Cape buffalo was confined to protected areas such as Lengwe, Kasungu and Nyika NPs as well as Nkhotakota and Vwaza Marsh Game Reserves. Their population was estimated at about 1850 individuals (East, 1998).

To our knowledge, buffalo occur today in Majete and Nkhotakota Wildlife Reserves as well as Liwonde and Kasungu NPs. In Majete Wildlife Reserve, where 306 buffalo were reintroduced between 2006 and 2010, the buffalo population was estimated at ~1800 individuals in 2020 (Sievert and Adenorff, 2020). Between 2016 and 2017, over 100 buffalo were moved from Majete Wildlife Reserve and Liwonde NP to Nkhotakota Wildlife Reserve as part of a rehabilitation programme undertaken by African Parks. Similarly, 80 buffalo were translocated from Liwonde to Kasungu NP in 2022 as part of a restoration programme (African Parks, personal communication).

Mozambique

Cape buffalo populations occurred throughout the country until the 1970s, but suffered greatly from 25 years of war (independence war 1964–1974 then civil war 1977–1992) (East, 1998). Buffalo are well present in the northern part of the country (Niassa and Cabo Delgado Provinces). In Niassa Special Reserve, they were successively estimated at 6800 (2009), 6200 (2011) and 7100 (2014) individuals (Craig, 2011a; Grossmann et al., 2014a), with a density surprisingly more than five times lower than in the neighbouring Selous complex in Tanzania. In Quirimbas NP and adjacent areas, aerial sample counts undertaken in 2011 and 2014, respectively, reported 0 and 88 buffalo observations with no population estimate (Craig, 2011b; Grossmann et al., 2014b). We did not obtain figures for the buffalo occurring in the Chipanje Chetu community-based natural resource management initiative (6500 km^2) north-west of Niassa Special Reserve, and for the numerous hunting blocks outside the reserve in the two northern provinces.

Further south, in Zambezia Province, Gilé National Reserve embarked on a restoration programme by reintroducing extinct large mammal species such as buffalo: 67 buffalo were reintroduced in 2012 and 2013–2020 from the Marromeu complex (the National Reserve and numerous trophy hunting areas) and Gorongosa NP, then 47 buffalo from the trophy hunting areas within the Niassa Special Reserve (Chardonnet et al., 2017; Fusari et al., 2017). The population in the now Gilé NP was estimated at

about 139 individuals in 2017 (Macandza et al., 2017). Mahimba Game Reserve, north bank of Zambezi River, would also host around 850 individuals (Grant Taylor, personal communication). In Tete Province, an aerial survey conducted in 2014 south and north of Lake Cahora Bassa and Magoe NP including the Tchuma Tchato community programme reported 4300 buffalo (Grossmann et al., 2014c).

The largest African buffalo population of Mozambique is located south (right bank) of Zambezi River (Manica and Sofala Provinces). At the mouth of the Zambezi River into the Indian ocean (the famous Zambezi delta), the open floodplains of the Marromeu Game Reserve and surrounding trophy hunting areas ('*Coutadas*') host about 21,300 individuals according to the latest aerial total count (Macandza et al., 2020). Gorongosa NP was restocked between 2006 and 2011 with 186 buffalo from Kruger and Limpopo NPs (Carlos L. Pereira, personal communication). An aerial total count conducted in 2020 reported 1200 buffalo (Stalmans and Peel, 2020). Finally, the trophy hunting areas located northwest of Gorongosa NP likely hold about 1000 buffalo (Willie Prinsloo, Joao Simoes Almeida and Grant Taylor, personal communication).

The Great Limpopo Transfrontier Conservation Area lies in South-Central and Southern Mozambique. In its northern section (Inhambane Province), a restoration programme has been underway since 2017 in Zinave NP, where the buffalo was extinct, with the reintroduction of 250 buffalo from Marromeu Reserve and surrounding trophy hunting areas (Mike La Grange, personal communication). A 2021 Zinave census reported 479 buffalo in the core sanctuary area (Antony Alexander, personal communication). Further south (Gaza Provinces), Banhine NP is estimated to host about 200 buffalo (Joao Simoes Almeida, personal communication). The Chicualacuala trophy hunting areas, located along Gonarezhou NP (Zimbabwe) also contain around 800 buffalo, but this figure is variable because the population undertakes seasonal migrations through Gonarezhou NP (Anthony Marx and Joao Simoes Almeida, personal communication). Finally, two areas adjacent to Kruger NP (South Africa) also host significant buffalo populations. The first is the Limpopo NP, with a population estimated around 5000 based on the 2018 census (Antony Alexander, personal communication). The second is the Great Lebombo Conservancy (including Sabie Game Park) with around 2000 buffalo (Joao Simoes Almeida, personal communication).

In the south-eastern tip of the country (Maputo Province), around 250 buffalo have been reintroduced in the Maputo Special Reserve

since 2016 and their population is estimated at 300 (Antony Alexander, personal communication). Finally, around 50 individuals are present in Namaacha Catuane Community Area (close to the borders with Eswatini and South Africa; Joao Simoes Almeida, personal communication).

Buffalo are also present in numerous *fazendas do bravio* (private game ranches) and *Coutadas* (State-owned protected areas leased and managed by the private sector for hunting tourism). Most of these areas are unfenced, so nearly all buffalo in Mozambique are wild and free-ranging.

Overall, the buffalo has been experiencing a spectacular post-civil-war recovery in Mozambique since 1992, mainly by reintroductions where the species had become extinct, and by reinforcements of rump populations. In recent years, buffalo translocations have been conducted frequently in Mozambique. Some of the buffalo originate from South Africa, but most are indigenous, coming from trophy hunting areas within the Marromeu complex and the Niassa Special Reserve.

Namibia

Because the availability of perennial water is a key requirement for African buffalo, much of Namibia is not suitable for naturally occurring populations of Cape buffalo, except for the Caprivi Strip in the south and the area along the border with Angola in the north. As with probably all African buffalo populations, those in Namibia were drastically reduced during the 1890s rinderpest epidemic. Small herds survived along the perennial rivers of the far north-eastern Kavango East and Zambezi regions (Martin, 2002). By 1934, their distribution had spread somewhat west and southwards to include what is now known as Kavango West, and small seasonal populations in Ohangwena, Omusati and Oshikoto regions (Shortridge, 1934). Any further natural expansion was halted by the erection of a veterinary control fence in the 1960s to protect commercial cattle ranching from the central north southwards. The only exception to the present day has been the reintroduction of two isolated herds in the Waterberg Plateau Park and the Nyae-Nyae communal conservancy. In Waterberg, the founder population of 48 individuals were sourced gradually between 1981 and 1991 from the disease-free Addo Elephant NP population in South Africa at a rate of approximately four a year, while four animals were added to Waterberg from a zoo in then Czechoslovakia in 1986, and 11 from Willem Prinsloo Game Reserve in South Africa, also in 1986 (Martin, 2008). The location of the herd on the plateau

bordered by sandstone cliffs does not allow the buffalo to move from the plateau. In Nyae-Nyae, 30 individuals from a natural population in the area were fenced off in 1996. Only one individual tested positive for FMD, and was destroyed (Martin, 2008). The Waterberg population has grown to at least 800 individuals, and the Nyae-Nyae population to about 250 head, both considered disease-free (Kenneth Uiseb, personal communication). The Zambezi and Kavango populations move freely into and from Angola and Botswana within the Kavango–Zambezi (KAZA) transboundary conservation area (Naidoo et al., 2014). The current estimate in Namibia's portion of KAZA is 7500 individuals based on a 2019 aerial census (Craig and Gibson, 2019). This represents a steady increase from 4500 in 2014 and 5500 in 2015 (Craig and Gibson, 2014, 2015).

South Africa

Cape buffalo were historically present throughout the country except for the arid western section. Free-ranging Cape buffalo were extirpated from their former range and are now totally confined within fenced areas (except Kruger NP along the Zimbabwe and Mozambique borders). At the end of the 1980s and beginning of the 1990s, the total number of buffalo in the country was about 50,000 head (East, 1998). Based on the data collected, the present buffalo population stands at an estimated 121,000 heads, distributed between national parks (~40,000; 28 per cent), game parks (~26,000; 10 per cent) and privately owned game farms (~75,000; 62 per cent) (Chapter 14; Cornélis et al., 2023).

About 96 per cent of the national parks' population is located in Kruger NP (~32,800; Ferreira et al., 2021). The rest are located in the following national parks (Ferreira et al., 2021): Addo (~450), Mokala (~500), Marakele (~250), Mountain Zebra (~90) and Camdeboo (~30). Populations in the parks are fairly constant despite population controlling factors such as bovine tuberculosis and the effects of droughts (see Chapter 8).

Several private game reserves (Sabi Sand, Klaserie, Thornybush, etc.) set alongside the unfenced western boundary of Kruger NP (the so-called 'APNR' – Association of Private Nature Reserves, 1800 km^2 together with the NP named 'Greater Kruger') also host about 6000 buffalo (Mike Peel, personal communication). This complex as a whole (~21,000 km^2) therefore hosts a population of approximately 58,000 buffalo. Further south in KwaZulu–Natal, Hluhluwe–Imfolozi Park (960 km^2) carries about 6400 buffalo (Dave Druce, personal communication).

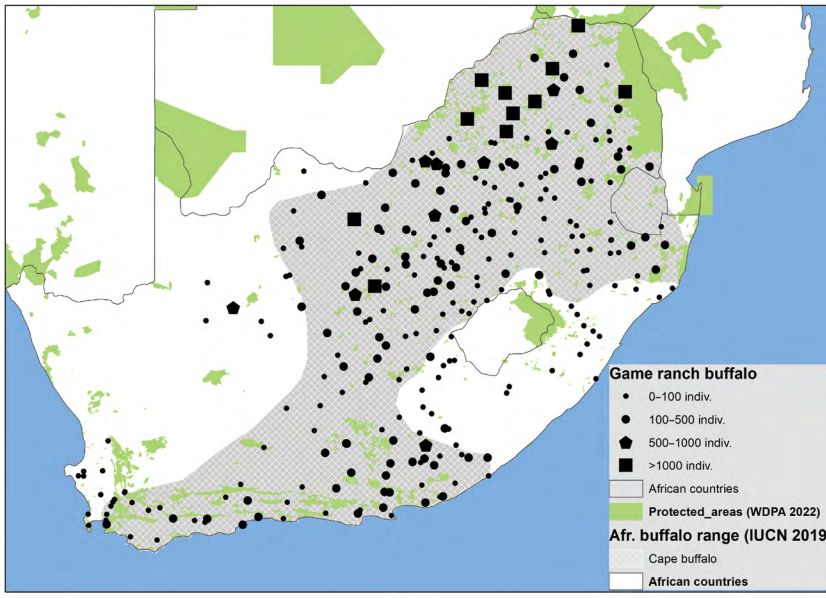

Figure 4.10 Distribution and abundance of African buffalo in private care (game ranches) in South Africa. Sources: UNEP-WCMC and IUCN (2022), IUCN SSC Antelope Specialist Group (2019) and South African Veterinary services (personal communication).

Buffalo in private care (privately owned game ranches) number about 75,000 individuals in 2022 (Peter Oberem, personal communication; Chapter 14). This population is distributed among 3144 game properties (2980 of which contain disease-free buffalo). About half (53 per cent) of the game ranches that hold buffalo are located in Limpopo Province, followed by North West Province (12 per cent) and Free State (11 per cent) (Figure 4.10). Many of these enclosed subpopulations are intensively managed (i.e., with intensive and selective breeding; Chapter 14); they are from an IUCN Red List assessment point of view supernumerary (cf. Tambling et al., 2016), but some of the relatively untrammelled populations can still be of importance for restocking wilderness areas.

Zambia

Nowadays, the Cape buffalo in Zambia is largely confined to national parks and trophy hunting areas that in this country are named Game Management Areas (GMAs), with populations estimated around 40,000

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

in the late 1990s (East, 1998). According to the latest available estimates, the buffalo population in this country has remained constant since then. The bulk of the population (~30,000) is located in the Luangwa Valley ecosystem (32,800 km^2), mainly North and South Luangwa NPs and surrounding GMAs (DNPW, 2016). Important populations (~6400 over 45,000 km^2) also occur in the Kafue ecosystem, mainly (97 per cent) in Kafue NP (Busanga Plains, Chunga and Ngoma Headquarters, and areas adjacent to Mufunta and Kasonso Busanga GMAs; DNPW, 2019). The Zambian section of the Lower Zambezi ecosystem hosts about 4800 buffalo over 2500 km^2, with the bulk of the population (80 per cent) located in Chiawa GMA (DNPW, 2016). Several other areas in the country host populations of a few hundred animals. East of the Kafue ecosystem, Kafue Flats wetlands (5600 km^2: Blue Lagoon and Lochinvar NPs Kafue Flats GMA) host about 900 head (Shanungu et al., 2015). West of the Luangwa Valley ecosystem, Bangweulu swamps host about 400 head (APN and DNPW, 2019). Finally, about 200 buffalo range in the Liuwa Plain NP and surrounding Upper West Zambezi GMA (APN and DNPW, 2020). To our knowledge, no recent information is available on the populations located between lakes Mweru and Tanganyika in the north of the country, but the total population appears to be constant.

Zimbabwe

Cape buffalo are now exclusively located in large protected area complexes in the northern (Northwest Matabeleland, Sebungwe region and Lower Zambezi Valley) and southern (South East Lowveld) sections of the country. During the period that covers the estimates of East (1998), the total number of buffalo was ~50,000. According to the most recent estimates, Zimbabwe currently hosts about 30,000–35,000 buffalo (Dunham et al., 2015a, 2015b, 2015c; Cumming, 2016; Dunham and van der Westhuizen, 2018). The populations in the northern part of the country (about 15,000) are free-ranging in State-protected areas and communal land under the CAMPFIRE programme, while most southern populations (about 18,000) are fenced-in within State and private land (commercial conservancies). The northern region faced a severe decline over the last 20 years (from about 42,000 in 2001 (Dunham et al., 2015a, 2015b, 2015c) to the present 15,000 head). In contrast, the numbers have been increasing in the southern section of the country. Three protected areas – Gonarezhou NP, Bubye Valley Conservancy

and Save Valley Conservancy – host two-thirds of the southern populations. There, buffalo recovered well from the devastating effects of the drought of 1992 (see East, 1998).

Trends in Abundance over the Last Decades

In this chapter, we have presented the most recent information available on the abundance and distribution of the African buffalo. We have also presented the trends observed where such information was available, usually at the local level. To do this, we drew on the published scientific literature, and collected and compiled a substantial amount of information from the grey literature (unpublished reports). We also contacted numerous organizations and field experts, to whom we express our sincere thanks (see below).

Although we believe that this synthesis is the most comprehensive to date, it is still not exhaustive. The puzzle remains especially incomplete in areas of ongoing or recent armed conflict, or in the large, often inaccessible areas of tropical forest where buffalo populations are small and diffuse. Consequently, the absence of buffalo sightings in a given area does not mean that buffalo are absent, but rather that no presence information was reported to us despite our investigations and many queries in our network (AFbIG members and others). Conversely, sightings of buffalo in previously unrecorded areas (e.g. Congo Basin) are simply the result of access to previously unavailable information.

Making temporal comparisons is also complex because few protected areas are monitored on a regular basis using robust and standardized approaches. Access to information is also a challenge. Although most often funded by public bodies and/or intended for public bodies, wildlife count reports are rarely published. Reports also rarely present disaggregated data, making temporal comparisons by area difficult (e.g. abundance inside versus outside protected areas).

Despite these limitations, a brief summary of the situation and regional trends is presented below.

Savanna Buffalo

The savanna buffalo population is estimated in 2022 at over 595,000 individuals, after deduction of the 75,000 buffalo under intensive private management in South Africa (q.v.; Table 4.1). Its abundance is roughly equivalent to that estimated 25 years ago (625,000) by East (1998). With

Table 4.1 *Abundance of the savanna subspecies of the African buffalo (three savanna subspecies:* brachyceros, aequinoctialis *and* caffer*) based on the most recent data available and comparison with earlier global assessments.*

	East (1998)	Cornélis et al. (2014)	Cornélis et al. (2023)
S. c. brachyceros	>20,000	>17,000	>20,500
Benin	>2000	4600	8200
Burkina Faso	1600	5000	5300
Cameroon	3200	4000	2500
Gambia	Ex	Ex	Ex
Ghana	C	700	1400
Guinea	V	X	X
Guinea-Bissau	X	U	U
Côte d'Ivoire	8300	900	1500
Mali	120	Ex	Ex
Niger	500	1200	1100
Nigeria	>200	>170	X
Senegal	>4000	460	500
Togo	U/R	X	X
S. c. aequinoctialis	>59,000	>23,000	>34,000
Central African Republic	19,000	4000	>4000
Chad	1000	8000	16,000
DRC	39,000	6000	9400
Eritrea	Ex	Ex	Ex
Ethiopia	X	4000	5000
South Sudan	>100	U	X
Sudan			X
S. c. caffer	>545,000	>447,000	>540,000
Angola	<500	X	X
Botswana	27,000	40,000	29,000
Burundi	500	Uk	X
DRC	No data	2000	600
Ethiopia	2300	3600	10,000
Kenya	>20,000	>17,000	42,000
Malawi	>3000	Uk	3000
Mozambique	10,000	23,000	45,000
Namibia	1000	6000	9000
Rwanda	1200	R	3500
Somalia	U	Uk	X
South Africa	28,500 (★)	52,000 (★★)	46,000 (★★★)
Eswatini	U	Uk	R
Tanzania	>342,000	>189,000	>240,000
Uganda	>20,000	23,000	38,000
Zambia	>40,000	>29,000	41,000

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

Table 4.1 (*cont.*)

	East (1998)	Cornélis et al. (2014)	Cornélis et al. (2023)
Zimbabwe	50,000	63,000	33,000
Total	>625, 000	>487,000	595,000

Legend: (C): Common; (Ex): Extinct; (R): rare; (U): uncommon; (Uk): unknown; (V): occurs only as a vagrant; (X): definitely present but abundance unknown; (*; **, ***): estimates excluding the 2500, 26,000 and 75,000 buffalo in game ranches/farms, respectively.

an estimated population of over 540,000 individuals, the Cape buffalo is by far the most abundant subspecies (91 per cent of the total), far ahead of the West (>20,000; 3 per cent) and Central (>34,000; 6 per cent) African savanna buffalo; for the forest buffalo, we do not dare to make a numerical assessment.

Tanzania is the country where the Cape buffalo is the most abundant, with an estimated population of over 240,000 individuals (44 per cent of the Cape buffalo subspecies), followed by South Africa (46,000), Mozambique (45,000), Kenya (42,000) and Zambia (41,000).

It is worth noting that four ecosystems contain more than 50,000 savanna buffalo. Three of these '5-star' ecosystems are in Tanzania: the Serengeti Ecosystem (~69,000; ~24,000 km^2), the Selous–Mikumi Ecosystem (~67,000; ~74,000 km^2) and the complex composed by the adjacent Katavi–Rukwa and Ruaha–Rungwa Ecosystems (~53,000; ~83,000 km^2). The other '5-star' ecosystem is the Kavango–Zambezi Transfrontier Conservation Area (KAZA, southern Africa; ~52,000; ~520,000 km^2).

Despite the apparent constancy of Cape buffalo abundance on a global scale, contrasts appear on a national scale (Table 4.1). A comparison with estimates made 25 years ago (East, 1998) suggests that some national buffalo stocks have increased significantly, such as those of Namibia (+800 per cent), Mozambique (+350 per cent), Ethiopia (+335 per cent), Rwanda (+190 per cent), South Africa (+60 per cent) and Uganda (+90 per cent). In contrast, some national buffalo stocks have declined substantially, such as in Tanzania (–30 per cent) and Zimbabwe (–34 per cent). However, these trends should be treated with great caution given the biases associated with these estimates. In Ethiopia, for example, part of the increase in numbers is due to the discovery of buffalo outside their previously established distribution range.

The same observation applies to the West African savanna buffalo. Despite a population apparently similar to that estimated 25 years ago, some countries have witnessed an increase in population (Benin: 310 per cent; Burkina Faso: 224 per cent; Niger: 127 per cent) and others a decrease (Senegal: –87 per cent; Côte d'Ivoire: –82 per cent). The largest buffalo population is located in WAP Regional Park (28,350 km^2), Benin, Burkina Faso, Niger. This complex comprises 3 National Parks ('W', Arly and Pendjari) and several neighbouring trophy hunting areas, with a buffalo population estimated at about 15,000 individuals (Bouché et al., 2015; Ouindeyama et al., 2021). Secondary strongholds are located in Cameroon (Bouba Ndjidda–Bénoué–Faro NP and neighbouring trophy hunting areas, ~2500), Ghana (Mole NP, ~1400), Côte d'Ivoire (Comoé NP, ~1200) and Senegal (Niokolo–Koba NP, ~500) (see country sections for details).

Finally, the most worrying situation is probably that of the Central African savanna buffalo, which has nearly halved in abundance over the last 25 years. The collapse of the population in the Central African Republic (–80 per cent) has only been partially offset by the increase (albeit spectacular: +1600 per cent) in Chad (Zakouma NP), and to a lesser but promising extent by the recent recovery of populations in DRC (Garamba NP). Today, half of the residual population of this subspecies is located in a single protected area (Zakouma NP).

Forest Buffalo

As pointed out above, estimating the abundance of forest buffalo is challenging, not to mention ascertaining a trend. Indeed, in dense tropical forest, populations are spatially dispersed, in small herds, in very dense habitats, and are distributed over a very large geographical area.

In the residual forest block of West Africa, we obtained very little information on the presence of the forest buffalo. The forest buffalo is restricted to limited and isolated patches of forest with small populations. In this circumstance, it is likely that forest buffalo in West Africa might be decreasing in much of its distribution range due to a combination of poaching for bushmeat trade, habitat loss and degradation.

In Central Africa, our investigations have shown that the forest buffalo is still well represented in areas with low human density, from the Atlantic coast to south-east Cameroon and up to the border of CAR and Republic of Congo, both in protected areas and adjoining logging and hunting concessions. Of the 235 locations of forest buffalo that we have collected in Central Africa during our review, 45 per cent are located

within the Greater TRIDOM-TNS, a vast contiguous block of mainly intact moist forest covering 250,000 km^2 (11 per cent of Central African forest block) and straddling four countries (Cameroon, Central African Republic, Gabon and Republic of Congo; European Commission, 2015). This vast area is thus probably the most strategic stronghold for the conservation of the forest buffalo in Central Africa.

Conservation Status, Challenges and Opportunities

The latest 10-year update of the conservation status of the African buffalo has led to its downgrading from 'Least concern' to 'Near threatened' (IUCN SSC Antelope Specialist Group, 2008, 2019). The African buffalo is therefore now placed at level 2 on a seven-step threat risk scale. As we have just seen, this global conservation status masks significant regional disparities that result from different combinations of environmental and human factors. In the following sections, we look at the main drivers of these contrasted trajectories. As both the West and Central Africa buffalo are globally confronted with similar factors (and are also very close from a genetic and phenotypic perspective, see Chapter 3), we have grouped them together in a single section called 'northern savanna buffalo'.

Northern African Savanna Buffalo (*S. c. brachyceros* and *S.c. aequinoctialis*)

The current distribution area of the northern African savanna buffalo is very fragmented and most populations are located within a few protected areas. This situation is the consequence of a strong anthropic pressure, in a context where poor soils limit biomass production (Chapter 5). The near extinction of the African buffalo in Nigeria, the most densely populated country in West Africa (Figure 4.11), is the culmination of similar processes taking place progressively throughout the region.

The protected areas in the savannas of West and Central Africa are particularly challenged by the increasing expansion of cash crops (e.g. cotton, groundnut) at their periphery, but also by the expansion of livestock husbandry. The massive movements of livestock in the immediate periphery and within protected areas has been a recurrent and growing problem in recent decades (Bouché et al., 2012; Aebischer et al., 2020). The increasing effective control of sleeping sickness (African trypanosomiasis) has facilitated the rising number of livestock (Gouteux et al., 1994; Cuisance, 1996; Reid et al., 2000; Courtin et al., 2010), the geographical

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

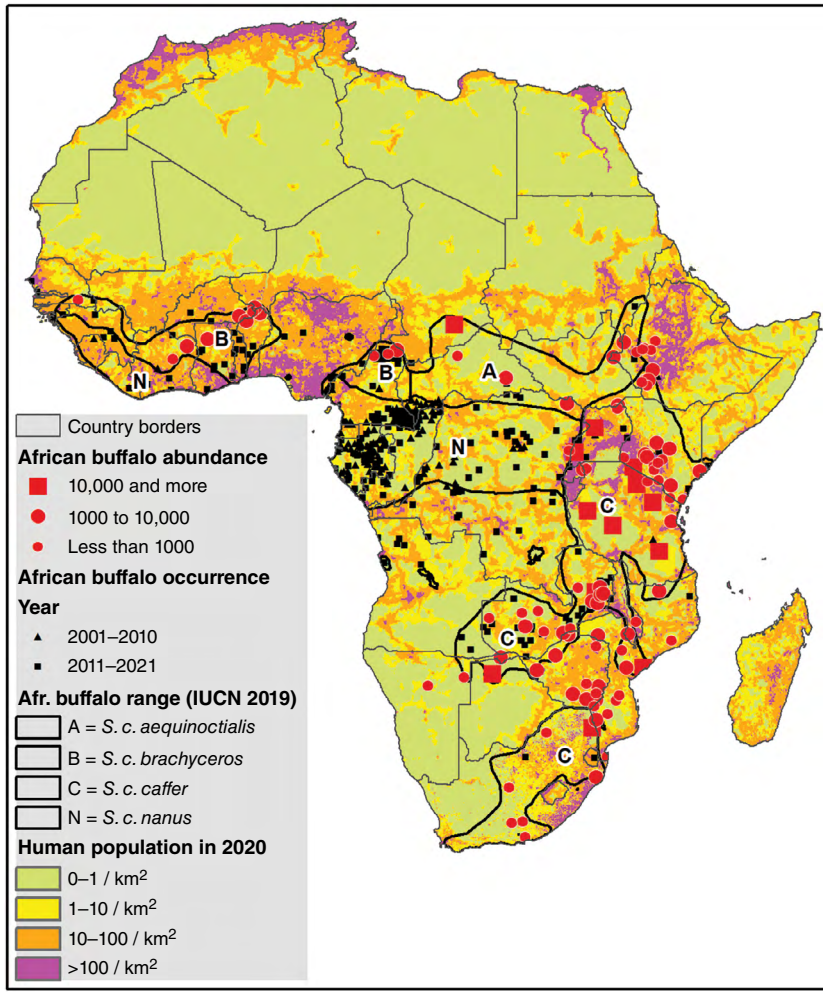

Figure 4.11 African buffalo distribution range in relation to human population density in 2020. Sources: Center for International Earth Science Information Network (2016) and IUCN SSC Antelope Specialist Group (2019).

range of which was previously greatly reduced to the benefit of trypanotolerant wild species such as the African buffalo (Chapter 9).

Against this backdrop, the conservation of wildlife in general and African buffalo in particular is highly dependent on effective governance and management systems. Unfortunately, in a global context of poverty, poor governance, insecurity, corruption and centralized management, most protected areas in West and Central Africa lack public and private investment (Scholte,

https://doi.org/10.1017/9781009006828.007 Published online by Cambridge University Press

2022). This situation is amplified by the fact that protected area networks are globally oversized in Central Africa, which holds the world record for the highest number of protected areas over 10,000 km². For example, the complex of protected areas in the north of Central African Republic (Manovo-Gounda St Floris, Bamingui Bangoran and adjacent gazetted Trophy Hunting Areas) covers 42,000 km², which represents half of the size of the region (80,000 km²). Such conservation overstretches, when combined with one of the highest poverty levels in the world, poorly developed infrastructure and massive and regular insecurity outbreaks, makes the conservation dilemma acute in Central Africa. In this context, it is estimated that West and Central African protected areas operate with 10 per cent of the resources needed for their sustainable management (Scholte, 2022).

Despite this bleak picture, targeted conservation efforts have managed to stabilize or even substantially increase buffalo populations in a few protected areas, today considered strongholds for biodiversity conservation in West and Central Africa. Over the last few decades, these protected areas have benefited from the support of public donors (such as the European Union or USAID). This support is now amplified by private investments in the form of public–private partnerships in the long term. The most striking example is the non-governmental organization (NGO) African Parks, which is successfully committed in long-term public–private conservation partnerships with governments in several countries such in Benin (Pendjari and W NPs), DRC (Garamba NP), Chad (Zakouma NP, Siniaka Minia Faunal Reserve and Aouk Aoukalé Faunal Reserve) and Central African Republic (Chinko Wildlife Refuge and Vovodo Hunting Area). It is also worth noting that protected areas organized in well-connected complexes with mixed management regimes (such as National Parks buffered and interconnected by functional trophy hunting areas) also tend to have stable buffalo populations (e.g. W–Arly–Pendjari complex or Bouba Ndjidda–Benoue–Faro complex).

So far, the strategy of focusing such conservation efforts over time on a few strongholds while waiting for better days is paying off. In this context, supporting sustainably a few more relevant strongholds (in Senegal, Cameroon, South Sudan, Central African Republic or Ethiopia) would help secure northern savanna buffalo populations, and in turn, a representative sample of ecosystems and species in this subregion. Once political stability is restored, regaining lost space around strongholds by diversifying conservation models (hopefully more participatory and inclusive) and restoring full sovereignty to national administrations seems the most realistic option to target (Scholte et al., 2022).

Forest Buffalo (*S. c. nanus*)

In West Africa, habitat loss and degradation are major threats to forest buffalo. The Guinean forests that run from Sierra Leone to Cameroon cover approximately 93,000 km² of natural vegetation, which represents only 15 per cent of its original cover (Mittermeier et al., 2005; Aleman et al., 2018).

The situation is less critical in Central Africa, which has historically been less disturbed, and where less than 9 per cent of the rainforest area has been lost since 2000 (Dalimier et al., 2022). However, since 2009, the annual rate of forest degradation has increased in all Central African countries. If the rate of forest degradation observed over the past 10 years continues, the Democratic Republic of Congo could lose 33 per cent of its undisturbed rainforest by 2050 (Vancutsem et al., 2020) as a result of agricultural expansion (Perrings and Halkos, 2015), infrastructure development and extractive industries (Malhi et al., 2013).

Hunting for wild meat or bushmeat is also a threat to forest buffalo in West and Central Africa, where many rural populations depend on wildlife for meat (van Vliet et al., 2016). Although poorly assessed, subsistence hunting and poaching are likely to have a strong impact on the forest buffalo insofar as the larger (and thus more profitable) species are generally the most sought after, especially when sold in big city markets. For example, buffalo meat was reported to be among the most expensive meat among ungulates in Bangui (Central African Republic; Fargeot et al., 2017) as well as in Kinshasa (DRC) and Brazzaville (Republic of the Congo; Gluszek et al., 2021).

Insecurity and the presence of armed groups are known to greatly amplify the pressure on forest buffalo, especially because military weapons are more suitable for hunting buffalo than traditional 12-gauge guns. For example, poaching by armed groups during the periods of rebellion in Yangambi landscape (DRC) led to the complete extirpation of buffalo (van Vliet et al., 2018).

In West Africa, our investigations show that the forest buffalo are clearly dependent on conservation efforts (protected areas and wildlife laws) to prevent extinction. The lack of effective conservation measures currently leaves forest buffalo critically endangered. In contrast, the conservation status of the forest buffalo is less of a concern in Central Africa as it benefits from better preserved habitats and less anthropogenic pressure, particularly West of the Congo basin. Several protected areas also benefit from long term public–private partnerships such as Nouabalé–Ndoki and Odzala NPs in the Republic of Congo, or Salonga NP in the Democratic Republic of Congo (Scholte, 2022).

Finally, although logging is often detrimental to wildlife because of easier access for poaching (Kleinschroth at al., 2019), it is likely that a moderate opening of the forest canopy allows the forest buffalo to access more profitable food resources, as shown for large primates (Bekhuis et al., 2008; Haurez et al., 2014). In this context, the developing forest certification in Central Africa opens up interesting conservation perspectives for wildlife in general and for forest buffalo populations in particular.

Cape Buffalo (*S. c. caffer*)

Our investigations show that the conservation status of the African buffalo remains satisfactory in most of the countries in its geographical range. However, with a few exceptions, the Cape buffalo is now mainly confined to protected areas. Despite increasing human pressure, the integrity of protected areas is better respected in Eastern and Southern Africa, where conflicts and insecurity are less prevalent than in Western and Central Africa. The Cape buffalo populations also globally benefit from better soils conditions, particularly in East Africa where volcanic soils provide more profitable forage (Chapter 5). However, eastern and southern Africa are subject to severe droughts that have repeatedly affected buffalo populations in recent decades (Prins and Sinclair, 2013; Cornélis et al., 2014). In a context where the frequency and amplitude of these events could increase in the near future due to climate change, buffalo populations – a water-dependent species – could be strongly and durably affected in Eastern and southern Africa and beyond (Sintayehu, 2018).

The good conservation status of the fauna in general and the buffalo in particular has made it possible for several countries to develop a thriving industry based on nature tourism (viewing and hunting; Chapter 16). In addition, the successful development of community-based natural resources management (CBNRM) programmes since about 25 years in several countries of the Cape buffalo range is to some extent responsible for the rather good conservation status of the subspecies in the two regions, for example the CAMPFIRE programme in Zimbabwe; Game Management Areas in Zambia; communal conservancies in Namibia; and Wildlife Management Areas in Tanzania. The role of Trophy Hunting Areas is often overlooked in the success of wildlife management, especially buffalo. The private ownership of buffalo in game ranches and the private management of buffalo in trophy hunting areas are powerful drivers of thriving buffalo populations (Chapter 16). Many National Parks of the Eastern and southern regions are embedded in networks of

Trophy Hunting Areas (another category of Protected Areas) functioning as buffer zones and socioecological corridors between National Parks. Such complexes make much stronger conservation tools than isolated National Parks. Within this context, mass translocation has become a common tool for wildlife management in southern Africa for either reintroduction of the species or reinforcement of small populations. A striking example is Mozambique, where large buffalo herds thriving in trophy hunting areas within the Marromeu complex and Niassa Special Reserve were translocated to Gilé and Zinave National Parks.

Acknowledgements

We are grateful to all the organizations and individuals who kindly contributed information and materials to this study. African Parks network (Jean-Marc Froment, Angela Gaylard, Joanne Dube, Jean Labuschagne and Thierry Aebischer) and Forest Resource Management (Nicolas Bayol and Alexandra Pasquier) kindly provided us with very useful information in their many areas of intervention. We also warmly thank the following individuals for their contributions: Joao Simoes Almeida, Félicien Amakpe, Catherine André, Dagmar Andres-Brümmer, Matt Becker, Emily Bennitt, Alain Billand, Robin Bouckaert, Susan Brown, Dave Bruce, David Brugière, Tim Caro, Nicola Carruthers, Simon Chamaille-Jammes, Mike Chase, Erwan Cherel, Marc Colyn, Alayne Cotterill, Ian Craig, Benoit Demarquez, Jean Pierre d'Huart, Louis and Karl Diakité, Kevin Dunham, Andy Dunn, Jef Dupain, David Elizalde, Samuel Ferreira, Eric Forni, Alessandro Fusari, Jamie Gaymer, Roland Goetz, Danny Govender, John Hart, Philipp Henschel, Naftali Honig, Howard Hunter, Richard Kock, David Kpelle, Nick La Grange, Alain and Kewin Lefol, Peter Lindsey, Dolmia Malachie, Roseline Mandisodza-Chikerema, Anthony Marx, Naomi Matthews, Menard Mbende, Rachel Mc Robb, Christophe Morio, Naomi Moss, Gilles Moyot, Victor Narat, Stuart Nixon, Nyambe Nyambe, Peter Oberem, Valentin Omasombo, Mike Peel, Carlos L. Pereira, Willie Prinsloo, Julie Price, Rafael Reyna-Hurtado, Lee-Anne Robertson, Holly Rosier, Hamish Rudland, Edward Sayer, Scott Schlossberg, Twakundine Simpamba, Raymond Snaps, Ian Stevenson, Grant Taylor, Dorian Tilbury, Girma Timer, Kenneth Uiseb, Jean-Claude Urvoy, Wouter van Hoven, Louis van Schalkwyk, David Wilkie, Fabrice Yapi, Kim Young-Overton and Craig Zytkow. A project like this is perhaps impossible without the help of e-mail and the Internet, and we exchanged more than 1500 messages. The mind boggles when one tries to imagine how Rod East undertook his

massive 1998 assessment not only for buffalo but for all African antelopes. It took us two years thanks to modern technology, whereas Rod needed 15. We dedicate this chapter to the memory of Rod, who was honoured with the Sir Peter Scott Award for Conservation Merit shortly before he died. More importantly, his work now allows us to assess in which countries conservation of buffalo works, and where it does not. Indeed, humans may need awards but buffalo need protection: thank you, Rod!

References

Aebischer, T., T. Ibrahim, R. Hickisch, et al. (2020). Apex predators decline after an influx of pastoralists in former Central African Republic hunting zones. *Biological Conservation* **241**: 108326.

Afriyie, J.O., M.O. Asare, E. Danquah, and H. Pavla (2021). Assessing the management effectiveness of three protected areas in Ghana. *Conservation and Society* **19**: 13–24.

Akinsorotan, O.A., V.A. Odelola, O.E. Olaniyi, and B.G. Oguntuase (2021). Human–wildlife conflicts and rural livelihood in Okomu national park, Edo state, Nigeria. *IOP Conference Series: Earth and Environmental Science* **655**(1): 012097.

Aleman, J.C., M.A. Jarzyna, and A.C. Staver (2018). Forest extent and deforestation in tropical Africa since 1900. *Nature Ecology & Evolution* **2**: 26–33.

Alistair, D.G. and N. Bereket (1996). Trends in large herbivore numbers of Omo and Mago national parks. Ministry of Agriculture, technical reports: 20.

Anstey, S. (1991). Large mammal distribution in Liberia: The findings of a preliminary national survey. WWF/FDA wildlife survey report. WWF International (Gland, Switzerland).

APN and DNPW (2019). Aerial survey report for Black Lechwe and other large herbivores in the Bangweulu Wetlands November 2019. African Parks Network and Department of National Parks and Wildlife.

APN and DNPW (2020). Aerial census report. October 2020 Liuwa Plain National Park. African Parks Network and Department of National Parks and Wildlife.

Astaras, C. (2009). *Ecology and Status of the Drill (Mandrillus leucophaeus) in Korup National Park, Southwest Cameroon: Implications for Conservation*. PhD thesis, Faculty of Mathematics and Natural Sciences, Georg-August-University of Göttingen.

Atsri, H., K. Adjossou, K. Tagbi, et al. (2013). *Inventaire faunique et forestier, études écologiques et cartographiques du Parc National de Fazao-Malfakassa*. Bern: Fondation Franz Weber.

Bassey, E. (2019). *Cross River National Park (Okwangwo Division) Annual Report: 2019*. WCS.

Baudenon, P. (1952). Notes sur les bovidés du Togo. *Mammalia* **16**: 49–61.

Bauer, H., A.A. Mohammed, A. El Faki, et al. (2018). Antelopes of the Dinder–Alatash transboundary Protected Area, Sudan and Ethiopia. *Gnusletter* **35**(1): 26–30.

Beja, P., P.V. Pinto, L. Veríssimo, et al. (2019). The mammals of Angola. In B. Huntley, V. Russo, F. Lages, and N. Ferrand (Eds.), *Biodiversity of Angola*. Cham: Springer, pp. 357–443.

Bekhuis, P.D.B.M., C.B. de Jong, and H.H.T. Prins (2008). Diet selection and density estimates of forest buffalo in Campo-Ma'an National Park, Cameroon. *African Journal of Ecology* **46**: 668–675.

Bessone, M., H.S. Kühl, and G. Hohmann (2020). Drawn out of the shadows: surveying secretive forest species with camera trap distance sampling. *Journal of Applied Ecology* **57**: 963–974.

Beudels-Jamar, R.C., R.-M. Lafontaine, H. Robert, et al. (2016). *Identification des zones de grande valeur de biodiversité à l'intérieur et dans la périphérie de l'Assiette de Coupe provisoire du*

permis 190 de la compagnie Sinfocam, limitrophe au Parc national de Dzanga-Sangha, APDS RCA. Belgium: WWF, ZSL.

Blake, S. (2002). Forest buffalo prefer clearings to closed canopy forest in the primary forest of northern Congo. *Oryx* **36**: 81–86.

Bolaños, N.C. (2012). Garamba National Park: aerial animal census 2012. African Parks.

Bouché, P. (2006). *Mole Wildlife Survey. Northern Savannah Biodiversity Conservation Project*. Gland: IUCN, p. 42.

Bouché, P. (2016). *Comptage aérien de la faune du Parc national de la Comoé et des deux zones de biodiversité*. Bonn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Bouché, P., C. Lungren, B. Hien, and P. Omondi (2003). Aerial total count of the "W"–Arli–Pendjari–Oti–Mandouri–Keran (WAPOK) ecosystem in West Africa. Mike-Paucof project.

Bouché, P., R. Nzapa Mbeti Mange, F. Tankalet, et al. (2012). Game over! Wildlife collapse in northern Central African Republic. *Environmental Monitoring and Assessment* **184**(11): 7001–7011.

Bouché, P., H. Frederick, and E. Kohi (2015). *Inventaire aérien de l'écosystème W-Arly-Pendjari Juin 2015*. Buffalo, NY: Vulcan, WCS: Elephants Without Borders.

Braga-Pereira, F., C.A. Peres, J.V. Campos-Silva, et al. (2020). Warfare-induced mammal population declines in Southwestern Africa are mediated by species life history, habitat type and hunter preferences. *Scientific Reports* **10**: 15428.

Brncic, T., B. Amarasekaran, A. McKenna, et al. (2015). Large mammal diversity and their conservation in the human-dominated land-use mosaic of Sierra Leone. *Biodiversity and Conservation* **24** (10): 2417–2438.

Bruce, T., R. Amin, T. Wacher, et al. (2018). Using camera trap data to characterise terrestrial larger-bodied mammal communities in different management sectors of the Dja Faunal Reserve, Cameroon. *African Journal of Ecology* **56**: 759–776.

Bruce, T., T. Wacher, H. Ndinga, et al. (2017). *Camera-trap Survey for Larger Terrestrial Wildlife in the Dja Biosphere Reserve, Cameroon*. London: Zoological Society of London (ZSL) and Yaoundé, Cameroon: Ministry of Forests and Fauna (MINFOF).

Butynski, T., C. Schaaf, and G. Hearn (1997). African buffalo *Syncerus caffer* extirpated on Bioko Island, Equatorial Guinea. *Journal of African Zoology* **111**: 57–61.

Buzzard, P.J. and A.J.A. Parker (2012). Surveys from the Subri River Forest Reserve, Ghana. *African Primates* **7**: 175–183.

Center for International Earth Science Information Network (2016). *Gridded population of the world, version 4 (GPWv4): Population count*. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC), Center for International Earth Science Information Network (CIESIN), Columbia University.

Chamberlan, C., C. Maurois, and C. Marechal (1995). Étude mammologique dans le Parc national d'Odzala. Programme ECOFAC (Congo).

Chardonnet, P., A. Fusari, J. Dias, et al. (2017). *Lessons Learned from the Reintroduction of Large Mammals in Gilé National Reserve, Mozambique*. Saint-Louis, Senegal: SSIG 17.

Chase, M. (2011). *Dry Season Fixed-Wing Aerial Survey of Elephants and Wildlife in Northern Botswana, September–November 2010*. Kasane, Botswana: Elephant Without Borders.

Chase, M., S. Schlossberg, R. Sutcliffe, and E. Seonyatseng (2018). *Dry Season Aerial Survey of Elephants and Wildlife In Northern Botswana*. Kasane, Botswana: Elephant Without Borders.

Christy, P., S. Lahm, O. Pauwels, and J.V. Weghe (2008). *Checklist of the Amphibians, Reptiles, Birds and Mammals of the National Parks of Gabon*. Tielt: Smithsonian Institution Lannoo SA.

Chuo, D.M. and T.E. Angwafo (2017). Status of large mammals: case study of gorilla (*Gorilla gorilla diehi*), chimpanzee (*Pan troglodytes ellioti*) and buffalo (*Syncerus caffer*), Menchum South, NW Cameroon. *International Journal of Environment, Agriculture and Biotechnology* **2**: 1523–1539.

Cockar, Z.S. (2022). A checklist of the mammals of Rwanda. *Journal of East African Natural History* **111** (1): 1–17.

Coppens, B. (2015). Report on the ornithological importance of the Boé region, Guinea-Bissau. Fieldwork from January to July 2015. Fondation Chimbo.

Cornélis, D., M. Melletti, L. Korte, et al. (2014). African buffalo (*Syncerus caffer* Sparrman, 1779. In M. Melletti and J. Burton (Eds.), *Ecology, Evolution and Behaviour of Wild Cattle: Implications for Conservation*. Cambridge: Cambridge University Press, pp. 326–372.

Cornélis, D.; Melletti, M.; Renaud, P.C.; Fonteyn, D.; Bonhotal, Hannah; Prins, H.; Chardonnet, P.; Caron, A., 2023, The African buffalo database, https://doi.org/10.18167/DVN1/AK1NQY, CIRAD Dataverse

Courtin, F., J.-B. Rayaissé, I. Tamboura, et al. (2010). Updating the northern tsetse limit in Burkina Faso (1949–2009): impact of global change. *International Journal of Environmental Research and Public Health* **7**(4): 1708–1719.

Craig, G.C. (2011a). Aerial Survey of Wildlife in the Niassa Reserve, Mozambique, October 2011. Sociedade para a Gestao e Desenvolvimento da Reserva do Niassa.

Craig, G.C. (2011b). Aerial survey of Quirimbas National Park and adjacent areas; annex 2 of the aerial survey of wildlife in the Niassa game reserve. WWF Mozambique.

Craig, G.C. and D.S. Gibson (2014). Aerial survey of elephants and other wildlife in the Zambezi Region September/October 2014. Ministry of Environment and Tourism (Namibia).

Craig, G.C. and D.S. Gibson (2015). Aerial survey of elephants and other wildlife in the Zambezi Region September/October 2015. Ministry of Environment and Tourism (Namibia).

Craig, G.C. and D.S. Gibson (2019). Aerial survey of elephants and other wildlife in the Zambezi Region September/October 2019. Ministry of Environment and Tourism (Namibia).

Cuisance, D. (1996). Réactualisation de la situation des tsé-tsé et des trypanosomoses africaines au Tchad. Rapport no. 96–024. CIRAD-EMVT, Montpellier.

Cumming, D. (2016). The buffalo–cattle interface in Zimbabwe: a preliminary review. AHEAD (Animal and Human Health for the Environment And Development) Program.

Dahourou, L.D. and U. Belemsobgo (2020). *Etude sur les chaînes de valeurs de la viande de brousse et des produits d'animaux sauvages au Burkina Faso (Version provisoire)*. Rome: FAO.

Dalimier, J., F. Achard, B. Delhez, et al. (2022). Répartition des types de forêts et évolution selon leur affectation. In R. Eba'a Atyi, F. Hiol Hiol, G. Lescuyer, et al. (Eds.), *Les forêts du bassin du Congo: état des forêts 2021*. Bogor, Indonesia: CIFOR.

Dandena, T. and T. Dinkisa (2014). *Report on Ecological and Socio-Economic Assessment in Tulu Lafto forests of Horo Guduru Wellega Zone: A Feasibility Study for Consideration to Designate a Protected Area*. Addis Ababa, Ethiopia: OFWE.

Danquah, E. and J.A. Owusu (2015). Distribution of buffalo in the Kogyae Strict Nature Reserve, Ghana. *Applied Research Journal* **1**: 20–26.

Da Silva, M.J.F., T. Minhos, R. Sa, et al. (2021). A qualitative assessment of Guinea-Bissau's hunting history and culture – and their implications for primate conservation. *African Primates* **15**: 1–18.

Devers, D. and J. Weghe (2006). Les forêts du Bassin du Congo: Etat des forêts 2006. Partenariat des forêts pour le Bassin du Congo. COMIFAC/EC/USAID/Coopération française, Kinshasa, République Démocratique du Congo.

DNPW (2019). Aerial survey of elephant and large terrestrial herbivores in the Kafue and Sioma Ngwezi Ecosystem. Department of National Parks & Wildlife.

DNPW (2016). The 2015 aerial census of elephants and other large mammals in Zambia: volume II. Population estimates for other large mammals and birds. Department of National Parks and Wildlife (Chilanga, Zambia).

Douglas-Hamilton, I., J.-M. Froment, G. Doungoube, and J. Root (1985). Recensement aérien de la faune dans la Zone Nord de la République Centrafricaine. ECOFAC.

Dunham, K.M. (1994). The effect of drought on the large mammal populations of Zambezi riverine woodlands. *Journal of Zoology* **234**: 489–526.

Dunham, K.M., C.S. Mackie, and G. Nyaguse (2015). Aerial survey of elephants and other large herbivores in the Zambezi Valley (Zimbabwe): 2014. Parks and Wildlife Management Authority. Zimbabwe and Great Elephant Survey, Paul G. Allen Project (Harare).

Dunham, K.M., C.S. Mackie, G. Nyaguse, and C. Zhuwau (2015a). Aerial survey of elephants and other large herbivores in north-west Matabeleland (Zimbabwe). Zimbabwe and GreatElephant Survey, Paul G. Allen Project (Harare).

Dunham, K.M., C.S. Mackie, G. Nyaguse, and C. Zhuwau (2015b). Aerial survey of elephants and other large herbivores in the Sebungwe (Zimbabwe). Zimbabwe and Great Elephant Survey, Paul G. Allen Project (Harare).

Dunham, K.M. and H.F. Westhuizen (2018). Aerial survey of elephants and other Large herbivores in Gonarezhou National Park (Zimbabwe) and some adjacent areas: 2018. Gonarezhou Conservation Trust, Gonarezhou National Park (Chiredzi, Zimbabwe).

Dupuy, A.R. (1971). *Le Niokolo-Koba: premier grand parc national de la République du Sénégal*. Dakar: GIA.

East, R. (1998). *African Antelope Database*. Edited by IUCN/SSC. Vol. *Antelope Specialist Group*. Gland, Switzerland and Cambridge, UK: IUCN.

Eban, J. (2020). *Mbe Mountains Annual Report: January–December 2019*. New York: Wildlife Conservation Society.

Elizalde, S., D. Elizalde, E. Lutondo, et al. (2019). Luando Natural Integral Reserve, Angola – a large and medium sized mammal survey. Instituto Nacional de Biodiversidade e Areas de Conservação (INBAC)/The Range Wide Conservation Programme for Cheetah and African Wild Dogs (RWCP).

Elkan, P., R. Fotso, C. Hamley, et al. (2015). Aerial surveys of wildlife and human activity across the Bouba N'djidda–Sena Oura–Benoué–Faro Landscape Northern Cameroon and Southwestern Chad 2015. Government of Cameroon, Great Elephant Census – Paul G. Allen Foundation and Wildlife Conservation Society.

Elkan, P., C. Hamley, S. Mendiguetti, et al. (2013a). Aerial recce surveys of wildlife and human activity in key areas of Sudd 2013. Government of South Sudan, USAID, and Wildlife Conservation Society.

Elkan, P., C. Hamley, S. Mendiguetti, et al. (2016). Aerial surveys of wildlife and human activity in key areas of South Sudan Boma, Badingilo, Nimule, Southern and Shambe National Parks, and Loelle Proposed Protected Area 2015–2016. Government of South Sudan, USAID, Great Elephant Census – Paul G. Allen Foundation and Wildlife Conservation Society.

Elkan, P., R. Mwinyihali, S. Mendiguetti, et al. (2013b). Aerial reconnaissance survey of wildlife, human activity and habitat across the Bili–Uéré Protected Area Complex, Democratic Republic of Congo (April 2013). Institut Congolais pour la Conservation de la Nature and Wildlife Conservation Society.

Elkan, P., H. Vanleeuwe, O. Eldar, et al. (2017). Sondage aérien de la faune, des habitats et des activités humaines dans les zones clefs du Nord Centrafrique. WCS & Agreco/Ecofaune.

Eniang, E., C. Ebin, A. Nchor, et al. (2017). Distribution and status of the African forest buffalo *Syncerus caffer nanus* in south-eastern Nigeria. *Oryx* **51**(3): 538–541.

Erena, M., A.A.D. Bekele and H.J. Debella (2019). Diet composition of forest inhabiting Cape buffalo (*Syncerus caffer caffer*) in western Ethiopia. *International Journal of Ecology and Environmental Sciences* **45**(2): 165–178.

European Commission (2015). *Larger than Elephants. Inputs for the Design of an EU Strategic Approach to Wildlife Conservation in Africa: Synthesis*. Luxembourg: Publications Office of the European Union.

Fagotto, F. (1980). The caffer buffalo and its habitat in Somalia. *Atti della Societa Toscana Scienze Naturali Memorie B* **87**: 161–79.

Fargeot, C., N. Drouet-Hoguet, and S. Le Bel, (2017). The role of bushmeat in urban household consumption: insights from Bangui, the capital city of the Central African Republic. *Bois et Forêts Des Tropiques* **332**, 31–42.

Fay, M., P. Elkan, M. Marjan, and F. Grossmann (2007). Aerial surveys of wildlife, livestock, and human activity in Southern Sudan. USFWS and GoSS.

Ferreira, S., C. Greaver, C. Bissett, J. Hayes, J.M. Herbst, and N. Mzileni (2021). Large vertebrate abundances in SanParks in 2020/20121. Scientific Services. South African National Parks. Summary Report.

Fick, S.E. and R.J. Hijmans (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology* **37**(12): 4302–4315.

Fonteyn, D., C. Vermeulen, N. Deflandre, et al. (2021). Wildlife trail or systematic? Camera trap placement has little effect on estimates of mammal diversity in a tropical forest in Gabon. *Remote Sensing in Ecology and Conservation* **7**: 321–336.

Fraticelli, C., O. Ourde, J. Arnulphy, et al. (2021). Dry Season Aerial Total Count of Zakouma National Park, Chad, 2021. African Parks Network (Johannesburg).

Funston, P., P. Henschel, L. Petracca, et al. (2017). The distribution and status of lions and other large carnivores in Luengue–Luiana and Mavinga National Parks, Angola. KAZA TFCA Secretariat.

Fusari, A., C. Lopes Pereira, J. Dias, et al. (2017). Reintroduction of large game species to Gilé National Reserve, Mozambique. In IUGB 33rd Congress, Montpellier, 22–25 August 2017.

Gautier, A. (1988). "L'exploitation saisonnière des ressources animales pendant le paléolithique supérieur dans la vallée du Nil égyptien." L'animal dans l'alimentation humaine: Les critères des choix. Actes du colloque international de Liège, 26–29 novembre 1986 (*Anthropozoologica* Numéro Spécial).

Gedow, A.O., J. Leeuw, and G. Koech (2017). Assessment of the biodiversity in terrestrial and marine landscapes of the proposed Lag Badana National Park and surrounding areas, Jubaland, Somalia. ICRAF working paper No. 251.

Gessner, G., R. Buchwald, and G. Wittemyer (2013). Assessing species occurrence and species-specific use patterns of bais (forest clearings) in Central Africa with camera traps. *African Journal of Ecology* **52**: 59–68.

GIZ (2017). *Plan d'aménagement et de gestion 2016–2025 du complexe d'aires protégées de Togodo. Réserve de Biosphère Transfrontalière du Delta du Mono*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Gluszek, S., J. Viollaz, and M.L. Gore (2021). Using conservation criminology to understand the role of restaurants in the urban wild meat trade. *Conservation Science and Practice*, **3**(5): e368.

Gonfa, G., T. Gadisa, and T. Habitamu (2015). The diversity, abundance and habitat association of medium- and large-sized mammals of Dati Wolel National Park, Western Ethiopia. *International Journal of Biodiversity and Conservation* **7**(2): 112–118.

Gouteux J.P., F. Blanc, E. Pounekrozou, et al. (1994). Tsé-tsé et élevage en République Centrafricaine : le recul de *Glossina morsitans submorsitans* (Diptera, Glossinidae). *Bulletin de la Société de Pathologie Exotique* **87**: 52–56.

Groom, R., D. Elizalde, S. Elizalde, et al. (2018). Quiçama National Park, Angola. A large and medium sized mammals survey. INBAC/RWCP (Luanda, Angola).

Grossmann, F., H. Fopa Kueteyem, A. Vailia Nguertou, et al. (2018). *Aerial Survey of Wildlife and Human Activity in the BSB Yamoussa Landscape, Cameroon, Dry Season 2018*. New York: Wildlife Conservation Society.

Grossmann, F., C. Lopes Pereira, D. Chambal, et al. (2014a). *Aerial Survey of Elephant, Other Wildlife and Human Activity in the Niassa National Reserve and Adjacent Areas*. New York: Wildlife Conservation Society.

Grossmann, F., C. Lopes Pereira, D. Chambal, et al. (2014b). *Aerial Survey of Elephant, Other Wildlife and Human Activity in Quirimbas National Park and the Western Corridor*. New York: Wildlife Conservation Society.

Grossmann, F., C. Lopes Pereira, D. Chambal, et al. (2014c). *Aerial Survey of Elephant, Other Wildlife and Human Activity in the Tete Province Areas South and North of Lake Cahora Bassa and Magoe National Park*. New York: Wildlife Conservation Society.

Haurez, B., C.-A. Petre, C. Vermeulen, et al. (2014). Western lowland gorilla density and nesting behavior in a Gabonese forest logged for 25 years: implications for gorilla conservation. *Biodiversity and Conservation* **23**(11): 2669–2687.

Hauptfleisch, M. and C. Brown (2019). Wildlife Census for Mole National Park 16–18 September 2019. Namibia University of Science and Technology.

Hedwig, D., I. Kienast, M. Bonnet, et al. (2018). A camera trap assessment of the forest mammal community within the transitional savannah-forest mosaic of the Batéké Plateau National Park, Gabon. *African Journal of Ecology* **56**(4): 777–790.

Hickey, J.R., A.C. Granjon, L. Vigilant, et al. (2019). Virunga 2015–2016 surveys: monitoring mountain gorillas, other select mammals, and illegal activities. Kigali, Rwanda.

Hoeven, C.A., W.F. Boer, and H.H.T. Prins (2004). Pooling local expert opinions for estimating mammal densities in tropical rainforests. *Journal for Nature Conservation* **12**: 193–204.

Holubová, Z. (2019). *Assessment of Selected Methods for Monitoring of Large African Ungulates*. Master's thesis, Czech University of Life Sciences, Faculty of Tropical AgriSciences.

Hongo, S., Z.S.C. Dzefack, L.N. Vernyuy, et al. (2020). Use of multi-layer camera trapping to inventory mammals in rainforests in southeast Cameroon. *African Study Monographs* **60**: 21–37.

Hoppe-Dominik, B., H.S. Kühl, G. Radl, and F. Fischer (2011). Long-term monitoring of large rainforest mammals in the biosphere reserve of Taï National Park, Côte d'Ivoire. *African Journal of Ecology* **49**: 450–458.

Houngbégnon, F.G.A. (2015). *Gestion de la faune sauvage et du secteur de la viande de brousse en Afrique-Centrale. Étude diagnostique de durabilité. Village de Ngokoéla (Ovan), Gabon*. Master GAED (Mondialisation, Dynamiques Spatiales et Développement Durable dans les pays du Sud), La Sorbonne.

ICCN and WWF (2015a). Evaluation du massif forestier du Nord Ubangi. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2015b). Évaluation du domaine et réserve de chasse de Swa-Kibula. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2015c). Évaluation des aires protégées de Mangaï et Gungu. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2016a). Revue des stratégies de conservation des valeurs naturelles de l'espace Tumba–Lediima. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2016b). Statut de la grande faune de la réserve naturelle d'Itombwe. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2016c). Evaluation des aires protégées de Bushimaie. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2016d). Evaluation du refuge à éléphants de Kaniama. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2017a). Évaluation des zones prioritaires de Pangi et Kasongo. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2017b). Evaluation des aires protégées de Luama–Kivu. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

ICCN and WWF (2017c). Evaluation des aires protégées de Bombo–Lumene. Programme d'appui au Réseau des Aires Protégées. Institut Congolais de la Conservation de la Nature and World Wildlife Fund.

Imbey, M.O., J.Y.N. Mbezele, Y.A. Ahanda, et al. (2019). Suivi écologique de la dynamique des grands et moyens mammifères dans les clairières du parc national de Boumba Bek: cas du complexe de clairières de Pondo. *Journal of Applied Biosciences* **144**: 14755–14763.

IUCN SSC Antelope Specialist Group (2008). *Syncerus caffer*. The IUCN Red List of Threatened Species 2008.

IUCN SSC Antelope Specialist Group (2019). *Syncerus caffer*. The IUCN Red List of Threatened Species 2019.

Jallow, A., O. Touray, and M. Jallow (2004). An update of the status of antelopes in The Gambia. In B. Chardonnet and P. Chardonnet (Eds.), *Antelope Survey Update*. Paris, France, pp. 18–20. IUCN/SSC Antelope Specialist Group Report.

Jebessa, H.D. (2015). New range of the African buffalo (*Syncerus caffer sparrman*, 1772) in the upper Blue Nile valley, Western Ethiopia – a preliminary study. *SINET, Ethiopian Journal of Science* **38**(1): 61–66.

Kebede, A., T. Timer and A. Gebre-Michael (2011). *Report on Wildlife Census in Weleshet–Sala Controlled Hunting Area. South Nations Nationalities and People's Regional State*. Addis Ababa, Ethiopia: Ethiopian Wildlife Conservation Authority.

Kebede, A. and B. Tsegaye (2012). *Wildlife Census Report in the Haro Aba Diko Controlled Hunting Area in Illubabor zone of the Oromia Regional State of Ethiopia*. Addis Ababa, Ethiopia: EWCA and OFWE.

Kebede, A., E. Wendim, Z. Abdulwahid, et al. (2013). *Wildlife Census in Beroye Proposed Controlled Hunting Area (Oromia Regional State)*. Addis Ababa, Ethiopia: Ethiopian Wildlife Conservation Authority.

Kisame, F., F. Wanyama, E. Buhanga and A. Rwetsiba (2018a). *Ground Counts for Medium to Large Mammals in Lake Mburo Conservation Area*. Kampala: Uganda Wildlife Authority.

Kisame, F.E., F. Wanyama, E. Buhanga and A. Rwetsiba (2018b). *Ground Counts for Medium to Large Mammals in Pian Upe Wildlife Reserve, Karamoja, Uganda*. Kampala: Uganda Wildlife Authority.

Klein, R.G. (1988). The archaeological significance of animal bones from Acheulean sites in southern Africa. *African Archaeological Review* **6**: 3–25.

Klein, R.G. (1994). The long-horned African buffalo (*Pelorovisantiquus*) is an extinct species. *Journal of Archaeological Science* **21**: 725–733.

Kleinschroth, F., N. Laporte, W.F. Laurance, et al. (2019). Road expansion and persistence in forests of the Congo Basin. *Nature Sustainability* **2**(7): 628–634.

Korte, L. (2008a). Habitat selection at two spatial scales and diurnal activity patterns of adult female forest buffalo. *Journal of Mammalogy* **89**: 115–125.

Korte, L. (2008b). Variation of group size among African buffalo herds in a forest–savanna mosaic landscape. *Journal of Zoology* **275**: 229–236.

Lamprey, R., D. Ochanda, R. Brett, et al. (2020). Cameras replace human observers in multi-species aerial counts in Murchison Falls, Uganda. *Remote Sensing in Ecology and Conservation* **6**: 529–545.

Macandza, V.A., C.M. Bento, R.M. Roberto, et al. (2017). *Relatório da contagem aérea de fauna bravia na reserva nacional do Gilé*. Maputo, Mozambique: Centro De Estudos De

Agricultura E Gestão De Recursos Naturais (CEAGRE), Faculdade De Agronomia E Engenharia Florestal (FAEF), Universidade Eduardo Mondlane (UEM), Administração Nacional Das Áreas De Conservação (ANAC).

Macandza, V.A., C.P. Ntumi, F.P.S. Mamugy, et al. (2020). *Marromeu Complex Wildlife Census Report*. Mozbio, Republic of Mozambique: Ministry of Land and Environment, ANAC, FNDS.

Macpherson, D. (2019). *Aerial Wildlife Census of Akagera National Park, Rwanda – August 2019*. Namitete, Malawi: Cluny Wildlife Management Services.

Madidi, J., F. Maisels, F. Kahindo, et al. (2019). *Inventaires des Grands Mammifères et de l'Impact Humaine, Réserve de Faune à Okapis, 2018*. Rapport technique No.: 01/BION/RFO/2019. Kinshasa, DRC: WCS DRC.

Malhi, Y., S. Adu-Bredu, R.A. Asare, et al. (2013). African rainforests: past, present and future. *Philosophical Transactions of the Royal Society B: Biological Sciences* **368**(1625): 20120312.

Malonga, R. and I. Nganga (2008). *Potentialités naturelles de la Foret de Ntokou–Pikounda. Synthèse des résultats des études de faisabilité du projet de création d'une aire protégée*. Kinshasa, DRC: WCS-Congo and CNIAF-MEF.

Martin, M. (2002). *Species Management Plan for Southern Savanna Buffalo (Syncerus caffer caffer)*. Windhoek, Namibia: Ministry of Environment and Tourism.

Martin, R. (2008). *Transboundary Species Project: Southern Savanna Buffalo. Species Report for Southern Savanna Buffalo in Support of The Transboundary Mammal Project of the Ministry of Environment and Tourism*. Windhoek, Namibia: Namibia Nature Foundation and the World Wildlife Fund's Living in a Finite Environment (LIFE) Programme.

Mathot, L., F. Ikoli and B.R. Missilou (2006). *Rapport annuel de monitoring de la faune du Projet Lésio–Louna*. Port Lympne: The John Aspinall Foundation.

Matuštíková, M. (2021). *Mapping of Water Sources Available for wildlife*. Master's thesis. Faculty of Tropical AgriSciences, Czech University of Life Sciences, Prague.

Megaze, A., M. Balakrishnan, and G. Belay (2018). Current population estimate and distribution of the African buffalo in Chebera Churchura National Park, Ethiopia. *African Journal of Ecology* **56** (1): 12–19.

Melletti, M., V. Penteriani, and L. Boitani (2007). Habitat preferences of the secretive forest buffalo (*Syncerus caffer nanus*) in Central Africa. *Journal of Zoology* **271**: 178–186.

Melletti, M., V. Penteriani, M. Mirabile, and L. Boitani (2008). Effects of habitat and season on the grouping of forest buffalo resting places. *African Journal of Ecology* **47**: 121–124.

MERF (2013). *Evaluation de l'efficacité de la gestion d'Oti–Kéran et Oti–Mandouri (Togo). Projet PNUD/FEM: 'Renforcement du rôle de conservation du système national d'aires protégées du Togo'*. Lomé, Togo: Ministère de l'environnement et des ressources forestières.

MERF (2014). *Cinquième rapport national sur la diversité biologique du Togo (2009–2014)*. Lomé, Togo: Ministère de l'environnement et des ressources forestières (MERF).

MERF (2016). *Plan d'aménagement et de gestion de l'aire protégée de Amou–Mono*. Lomé, Togo: Ministère de l'environnement et des ressources forestières (MERF).

MERF (2017). *Plan d'aménagement et de gestion de l'aire protégée d'Abdoulaye (réserve de faune)*. Lomé, Togo: Ministère de l'environnement et des ressources forestières (MERF).

Mills, M., H. Biggs, and I. Whyte (1995). The relationship between rainfall, lion predation and population trends in African herbivores. *Wildlife Research* **22**: 75–87.

Mittermeier, R., P. Gil, M. Hoffmann, et al. (2005). *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions: Conservation International*. Sierra Madre: Cemex, p. 315.

MNRT (2021). United Republic of Tanzania: Ministry of Natural Resources and Tourism. Accessed August, 29 2022. www.maliasili.go.tz/about/category/ministry-overview.

Morgan, B.J. (2007). Group size, density and biomass of large mammals in the Réserve de Faune du Petit Loango, Gabon. *African Journal of Ecology* **45**: 508–518.

Musika, N.V., J.V. Wakibara, P.A. Ndakidemi, and A.C. Treydte (2021). Spatio-temporal patterns of increasing illegal livestock grazing over three decades at Moyowosi Kigosi Game Reserve, Tanzania. *Land* **10**(12): 1325.

Musika, N.V., J.V. Wakibara, P.A. Ndakidemi, and A.C. Treydte (2022). Using trophy hunting to save wildlife foraging resources: a case study from Moyowosi–Kigosi Game Reserves, Tanzania. *Sustainability* 14(3): 1288.

N'Goran, K.P., N.R. Maho, Y.C. Kouakou, et al. (2010). *Etat des ressources naturelles du Parc National de la Comoé et de sa zone périphérique. Rapport de l'inventaire faunique par survol aérien; mars 2010*. Abidjan, Côte d'Ivoire: Wild Chimpanzee Foundation, GTZ & OIPR.

Naidoo, R., P. Preez, G. Stuart-Hill, and P. Beytell (2014). Movements of African buffalo (*Syncerus caffer*) in the Kavango–Zambezi Transfrontier Conservation Area. *African Journal of Ecology* **52**(4): 581–584.

Nakashima, Y. (2015). Inventorying medium- and large-sized mammals in the African lowland rainforest using camera trapping. *Tropics* **23**(4): 151–164.

Natta, A., S. Nago and P. Keke (2014). Structure et traits ethnozoologiques du buffle de forêt (*Syncerus caffer nanus*) dans la forêt classée d'Agua (Centre Bénin). *Sciences Naturelles et Agronomie*, **4**(1): 39–52.

Nebesse, C. (2016). Caractérisation de la viande de brousse prélevée du village Basukwambula (PK 92) au village Baego (PK147) sur l'axe Kisangani–Ituri. MSc thesis, Faculté des Sciences, Université de Kisangani.

Nefzi, T. (2020). *Etude des potentialités touristiques des aires protégées de la Guinée*. Guinée: Ministère de l'Environnement des Eaux et Forêts.

Ngaba, M.Y. and M. Tchamba (2019). Etude de faisabilité de la mise en place d'un site écotouristique dans le parc national de Boumba-Bek: cas des clairières forestières de Pondo. *International Journal of Biological and Chemical Sciences* **13**(7): 3177–3192.

Ngoma, A., A. Diodio, K.L. Dieudonné, et al. (2021). *An assessment of intermediate and large mammal population sizes across the Garamba National Park and adjacent protected areas*. Kinshasa, Democratic Republic of Congo: Institut Congolais pour la Conservation de la Nature, African Parks, USAID.

Nunez, C.L., G. Froese, A.C. Meier, et al. (2019). Stronger together: comparing and integrating camera trap, visual, and dung survey data in tropical forest communities. *Ecosphere* **10** (12).

Nzigidahera, B., D. Mbarushimana, B. Habonimana, and F. Habiyaremye (2020). *Habitats du Parc National de la Ruvubu au Burundi. Guide sur la flore pour le suivi de la dynamique des habitats du PNR*. Bruxelles: Institut royal des Sciences naturelles de Belgique.

OIPR (2019). *Inventaire aérien de la grande faune du parc national de la Comoé et des sites de Warigue et mont Tingui*. Abidjan: Office Ivoirien des Parcs et des Réserves (OIPR) and Coopération Allemande.

Omondi, P., E.K. Bitok, M.R.M. Tchamba, and B.B. Lambert (2008). *The Total Aerial Count of Elephants and Other Wildlife Species in Faro, Benoué and Bouba Ndjida National Parks and Adjacent Hunting Blocks in Northern Cameroon*. Yaounde, Cameroon: WWF and Cameroon Ministry of Forestry and Wildlife.

ONFI (2021). *Inventaire forestier et faunique national (Côte d'Ivoire). Rapport final de l'inventaire faunique – Livrable no. 55 Janvier 2019–Juin 2021*. Nogent-sur-Marne: ONF International.

Orban, B., G. Kabafouako, R. Morley, et al. (2018). Common mammal species inventory utilizing camera trapping in the forests of Kouilou Département, Republic of Congo. *African Journal of Ecology* **56**(4): 750–754.

Ouindeyama, A., J. Chevillot, J.D. Akpona, et al. (2021). Inventaire Aérien des grands mammifères et du bétail du complexe W–Arly–Pendjari, Benin–Burkina Faso. African Parks Network, Johannesburg, South Africa.

Owiunji, I., D. Nkuutu, D. Kujirakwinja, et al. (2005). The Biodiversity of the Virunga Volcanoes. Unpublished report. New York: Wildlife Conservation Society.

PAPFCA (2007). *Plan d'Aménagement Participatif de la Forêt Classée d'Agoua. Projet d'aménagement des massifs forestiers d'Agoua, des Monts Kouffé et de Wari-Maro*. Cotonou, Bénin: MEPN/DGFRN.

PAPSA (2018). Rapport d'évaluation des tendances évolutives des espèces fauniques sur la période de 2010 à 2017, dans la forêt classée et ranch de gibier de Nazinga. projet PAPSA. Ministère de l'Environnement, de l'Economie Verte et du Changement Climatique, Ouagadougou, Burkina Faso.

Perrings, C. and G. Halkos (2015). Agriculture and the threat to biodiversity in sub-Saharan Africa. *Environmental Research Letters* **10**(9): 095015.

Petracca, L., P. Funston, P. Henschel, et al. (2020). Modeling community occupancy from line transect data: a case study with large mammals in post-war Angola. *Animal Conservation* **23**: 420–433.

Plumptre, A., D. Kujirakwinja, D. Moyer, et al. (2010). *Virunga Landscape Large Mammal Surveys, 2010*. New York: US Fish and Wildlife Service WCS, UWA, CITES/MIKE.

Prins, H.H.T. (1992). The pastoral road to extinction: competition between wildlife and traditional pastoralism in East Africa. *Environmental Conservation* **19**: 117–123.

Prins, H.H.T. (1996). *Ecology and Behaviour of the African Buffalo*. London: Chapman & Hall.

Prins, H.H.T. and J.F. De Jong (2022). The ecohistory of Tanzania's northern Rift Valley – can one establish an objective baseline as endpoint for ecosystem restoration? In C. Kiffner, M.L. Bond, and D.E. Lee (Eds.), *Tarangire: Human–Wildlife Coexistence in a Fragmented Landscape*. Cham: Springer Nature, pp. 129–161.

Prins, H.H. and I. Douglas-Hamilton (1990). Stability in a multi-species assemblage of large herbivores in East Africa. *Oecologia* **83**(3): 392–400.

Prins, H.H.T. and H.P. Jeugd (1993). Herbivore population crashes and woodland structure in East Africa. *Journal of Ecology* **81**: 305–314.

Prins, H.H.T. and J.M. Reitsma (1989). Mammalian biomass in an African equatorial forest. *Journal of Animal Ecology* **58**: 851–861.

Prins, H.H.T. and A. Sinclair (2013). The African buffalo: species profile. In M.H. Knight, J. Kingdon, and M. Hoffmann (Eds.), *Mammals of Africa. Pigs, Hippopotamuses, Chevrotain, Giraffes, Deer and Bovids*. London: Bloomsbury, pp. 125–136.

Prins, H.H.T., Y. Wato, L. Kenana and R. Chepkwony (in review). Is the collapse of large mammal populations in Sibiloi National Park and the Chalbi Desert (Kenya) caused by local people or climate change? *African Journal of Ecology*.

Rabeil, T., P. Hejcmanová, M. Gueye, et al. (2018). *Inventaire combiné terrestre et aérien Parc National du Niokolo-Koba, Sénégal*. Dakar: Direction des Parcs Nationaux, Randgold resources.

Reid, R.S., R.L. Kruska, U. Deichmann, et al. (2000). Human population growth and the extinction of the tsetse fly. *Agriculture, Ecosystems & Environment* **77**(3): 227–236.

Renaud, P.C. (2007). *Omo National Park Report for the Wet Season Aerial Survey*. Gembloux, Belgium: Ethiopia African Parks Foundation, Nature+ et Université de Gembloux.

Renaud, P.-C., M.B. Gueye, P. Hejcmanová, et al. (2006). *Inventaire aérien et terrestre de la faune et relevé des pressions au Parc National du Niokolo Koba*. Johannesburg: African Parks.

Renaud, P.C., M. Fay, A. Abdoulaye, et al. (2005). *Recensement aérien de la faune dans les préfectures de la région Nord de la République Centrafricaine*. Bruxelles, Belgium: AGRECO/UE.

Rolkier, G.G., K. Yehestial, and R. Prasse (2015). Habitats map of distributions of key wild animal species of Gambella National Park. *International Journal of Innovative Research and Development* **4**(4): 240–259.

Roulet, P.A. (2006). Plan d'aménagement de la Zone Cynégétique Villageoise (ZCV) de Mourou-Fadama, Sud-Est RCA. Projet PILED/RICAGIRN-FB/Fonds Français pour l'Environment Mondial, Paris, France.

Rwetsiba, E. and A. Nuwamanya (2010). Aerial surveys of Murchison Falls Protected Area, Uganda, March 2010. *Pachyderm* **47**: 118–123.

Scholte, P. (2005). *Floodplain Rehabilitation and the Future of Conservation & Development. Adaptive Management of Success in Waza-Logone, Cameroon*. Tropical Resource Management Papers 67. Wageningen, The Netherlands: Wageningen University and Research Centre.

Scholte, P. (2022). Fifteen years of delegated protected area management in West and Central Africa: five recommendations to guide maturity. *Oryx* **56**: 1–9.

Scholte, P., O. Pays, S. Adam, et al. (2022). Conservation overstretch and long-term decline of wildlife and tourism in the Central African savannas. *Conservation Biology* **36**(2): e13860.

Shanungu, G.K., C. Kaumba, and R. Beilfuss (2015). *Current Population Status and Distribution of Large Herbivores and Floodplain Birds of the Kafue Flats Wetlands, Zambia: Results of the 2015 Wet Season Aerial Survey*. Chilanga, Zambia: Zambia Wildlife Authority.

Shortridge, G.C. (1934). *The Mammals of South West Africa: A Biological Account of the Forms Occurring in That Region*. London: W. Heinemann.

Sidney, J. (1965). *The Past and Present Distribution of Some African Ungulates*. London: Zoological Society.

Sievert, O. and J. Adenorff (2020). *Majete Wildlife Reserve, Malawi, Aerial Census 2020*. Johannesburg, South Africa: Lilongwe Wildlife Trust and African Parks Network.

Sinclair, A.R.E. (1977). *The African Buffalo. A Study of Resource Limitation of Populations*. Chicago: University of Chicago Press.

Sinsin, B., D. Kampmann, A. Thiombiano,and S. Konaté (2010). *Atlas de la Biodiversité de l'Afrique de l'Ouest. Tome I: Benin*. Cotonou & Frankfurt/Main: BIOTA.

Sintayehu, D.W. (2018). Impact of climate change on biodiversity and associated key ecosystem services in Africa: a systematic review. *Ecosystem Health and Sustainability* **4**(9): 225–239.

Spira, C., G. Mitamba, A. Kirkby, et al. (2018). *Inventaire de la biodiversité dans le parc national de Kahuzi–Biega République Démocratique du Congo*. New York: Wildlife Conservation Society.

Stalmans, M. and M. Peel (2020). *Aerial Wildlife Count of the Gorongosa National Park*. Mozambique: Afrecology & USAID Mozambique.

Tambling, C., J. Venter, J. Toit, and M. Child (2016). A conservation assessment of *Syncerus caffer caffer*. In M.F. Child, L. Roxburgh, E. Do Linh San, D. Raimondo, and H.T. Davies-Mostert (Eds.), *The Red List of Mammals of South Africa, Swaziland and Lesotho*. South Africa: South African National Biodiversity Institute and Endangered Wildlife Trust, pp. 1–7.

Taylor, R.D. and R.B. Martin (1987). Effects of veterinary fences on wildlife conservation in Zimbabwe. *Environmental Management* **11**: 327–334.

TAWIRI (2019a). *Aerial Survey of Large Animals in the Mkomazi National Park, Wet Season, 2019. TAWIRI Aerial Survey Report*. Arusha, Tanzania: Tanzania Wildlife Research Institute.

TAWIRI (2019b). *Aerial Wildlife Survey of Large Animals and Human Activities in the Selous–Mikumi Ecosystem, Dry Season 2018. TAWIRI Aerial Survey Report*. Arusha, Tanzania: Tanzania Wildlife Research Institute.

TAWIRI (2020). *Aerial Wildlife Census in the Tarangire–Manyara Ecosystem, Wet Season, 2019. TAWIRI Aerial Survey Report*. Arusha, Tanzania: Tanzania Wildlife Research Institute.

TAWIRI (2021a). *Aerial Elephant, Buffalo and Giraffe Total Count Census in the Serengeti Ecosystem, Wet Season, 2020. TAWIRI Aerial Survey Report*. Arusha, Tanzania: Tanzania Wildlife Research Institute.

TAWIRI (2021b). *Aerial Survey in The West-Kilimanjaro–Natron Landscape, Wet Season, 2021. Tawiri Aerial Survey Report*. Arusha, Tanzania: Tanzania Wildlife Research Institute.

TAWIRI (2022). *Aerial Survey of Large Animals and Human Activities in the Ruaha–Rungwa and Katavi–Rukwa Ecosystems, Tanzania. Dry Season, 2021.* Arusha, Tanzania: Tanzania Wildlife Research Institute.

TFCI (2010). *Aerial Survey Report: Gambella Reconnaissance 2009 & Census 2010.* TransFrontier Conservation Initiative. Addis Ababa: Ethiopian Wildlife Conservation Authority.

Tiedoue Manouhin, R., A. Diarrassouba, and A. Tondossama (2020). *Etat de conservation du Parc national de Taï: Résultats du suivi écologique, Phase 14.* Soubré, Côte d'Ivoire: Office Ivoirien des Parcs et Réserves/Direction de Zone Sud-ouest.

Tiedoue Manouhin, R., S. Kone Sanga, A. Diarrassouba, and A. Tondossama (2019). *Etat de conservation du Parc national de Taï: Résultats du suivi écologique, Phase 13.* Soubré, Côte d'Ivoire: Office Ivoirien des Parcs et Réserves/Direction de Zone Sud-ouest.

Tola, A. (2020). *Species Diversity, Population Size and Density of Medium and Large Mammals of Mago National Park, South West Ethiopia.* MSc thesis, Hawassa University Wondo Genet College of Forestry and Natural Resource, Wondo-Genet.

Tsegaye, E. (2020). *Species Diversity, Population Size and Density of Medium and Large Mammals of Omo National Park, South West Ethiopia.* MSc thesis, Hawassa University Wondo Genet College of Forestry and Natural Resource, Wondo-Genet.

UNEP-WCMC and IUCN (2022). *Protected Planet: The World Database on Protected Areas (WDPA)* [On-line]. Cambridge: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.

Vancutsem, C., F. Achard, J.-F. Pekel, et al. (2020). Long-term (1990–2019) monitoring of tropical moist forests dynamics. *bioRxiv* 2020.09.17.295774.

Vanleeuwe, H., P. Henschel, C. Pélissier, et al. (2009). *Recensement des grands mammifères et des impacts humains. Parcs nationaux de l'Upemba et des Kundelungu République Démocratique du Congo.* Kampala, Uganda: Wildlife Conservation Society.

Vanthomme, H., J. Kolowski, L. Korte, and A. Alonso (2013). Distribution of a community of mammals in relation to roads and other human disturbances in Gabon, Central Africa. *Conservation Biology* **27**: 281–291.

Van Vliet, N., D. Cornélis, H. Beck, et al. (2016). Meat from the wild: extractive uses of wildlife and alternatives for sustainability. In R. Mateo, B. Arroyo, and J.T. Garcia (Eds.), *Current Trends in Wildlife Research, Wildlife Research Monographs, Volume 1.* Cham: Springer, pp. 225–265.

Van Vliet, N., J. Muhindo, J. Kambale Nyumu, et al. (2018). Mammal depletion processes as evidenced from spatially explicit and temporal local ecological knowledge. *Tropical Conservation Science* **11**: 1940082918799494.

Van Vliet, N., C. Nebesse, S. Gambalemoke, et al. (2012). The bushmeat market in Kisangani, Democratic Republic of Congo: implications for conservation and food security. *Oryx* **46**: 196–203.

Wanyama, F., E. Balole, P. Elkan, et al. (2014). *Aerial Surveys of the Greater Virunga Landscape.* New York, NY: WCS, UCCN & UWA.

Wanyama, F., E.F. Kisame and D. Owor (2019). *Aerial Surveys of Medium–Large Mammals in Kidepo Valley National Park and Karenga Community Wildlife Area.* Kampala: Uganda Wildlife Authority.

Waweru, J., P. Omondi, S. Ngene, et al. (2021). *National Wildlife Census 2021 Report.* Nairobi: The Wildlife Research and Training Institute (WRTI) and Kenya Wildlife Service (KWS).

WCS Flight Programme (2008). *Aerial Surveys of Kidepo National Park, Lipan Controlled Hunting Area & Madi Corridor, March–April 2008.* Kampala, Uganda: Wildlife Conservation Society.

Wendim, E. (2015). *Maokomo Nature Conservation Area 2015.* Addis Ababa: Ethiopian Wildlife Conservation Authority.

Wendim, E. (2018). *Assessment of Wildlife and Socioeconomic in Didessa (Bijimiz) National Park*. Addis Ababa: Ethiopian Wildlife Conservation Authority.

White, J.T.L. (1994). Biomass of rain forest mammals in the Lopé Reserve, Gabon. *Journal of Animal Ecology* **63**: 499–512.

Wild Chimpanzee Foundation (2021). La faune du Parc National du Moyen-Bafing, Guinée. La faune du Parc National du Moyen-Bafing, Guinée – Fauna of the Moyen-Bafing National Park, Guinea. www.youtube.com/watch?v=Ui-S6krni_o

Winterbach, H.E.K. (1998). Research review: the status and distribution of Cape buffalo (*Syncerus caffer caffer*) in southern Africa. *South African Journal of Wildlife Research* **28**(3): 82–88.

WRI (2013). Aménagement forestier au Gabon. Situation en juillet 2013. http://data.wri.org/forest_atlas/gab/poster/gab_poster_2013_fr.pdf.