Survey of Chimpanzees (*Pan troglodytes verus*) Outside Protected Areas in Southeastern Senegal

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Survey of chimpanzees (*Pan troglodytes verus*) outside protected areas in southeastern Senegal

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While West African chimpanzees (*Pan troglodytes verus*) were elevated to Critically Endangered status by the IUCN in 2016 as a result of significant population declines in recent decades, little is known about the population in Senegal. We surveyed the West African chimpanzees outside protected areas in the Kedougou region of southeastern Senegal between November 2014 and July 2015 using recce walks (*n* = 57, totalling 300 km of pedestrian survey distance) in potential chimpanzee habitats. We recorded direct observations of chimpanzees or indices of chimpanzee activity, such as sleeping nests, footprints and faeces. We accumulated 21 direct contacts with chimpanzees and recorded 3489 chimpanzee nests. We mapped the distribution of chimpanzee sleeping sites and indicators of anthropogenic activity by regional administrative units to facilitate species management and conservation planning in the immediate future. In addition, we identified the habitats and tree species used by chimpanzees to construct their nests in order to explore nesting tree preferences. Chimpanzees used almost 40 tree species in the Kedougou region but 84% of nests were associated with eight tree species, namely *Pterocarpus erinaceus*, *Diospyros mespiliformis*, *Anogeissus leiocarpus*, *Hexalobus monopetalus*, *Cola cordifolia*, *Lannea* sp., *Parkia biglobosa* and *Piliostigma thonningii*. Among these eight nesting tree species, 60% of the corresponding nests were located in three species: *P. erinaceus*, *D. mespiliformis* and *A. leiocarpus*. Chimpanzees nested more often in woodland habitat than in gallery forests, although the latter accounts for only a small percentage of available habitat. This study is the most geographically extensive survey of chimpanzees in Senegal to date, broadening our knowledge of the species' northwestern-most distribution in West Africa.

Keywords: West African chimpanzee, *Pan troglodytes verus*, nest, distribution, gold mining impacts.

INTRODUCTION

Chimpanzees (*Pan troglodytes*) are endangered across their geographic range. The conservation status of the West African chimpanzee (*P. t. verus*) was elevated to Critically Endangered by the IUCN in 2016 as a result of significant population declines in recent decades. They are either rare or close to extinction in four West African countries: Burkina-Faso, Ghana, Guinea-Bissau and Senegal (Kormos, Boesch, Bakarr & Butynski, 2003).

Most field studies of chimpanzees are conducted in protected areas (McGrew, 2017). In Senegal, however, the majority of chimpanzees are found in hot, dry and open savanna-woodland ecosystems, which are not formally protected. The northwestern boundary of the West African chimpanzee range is located in the Kedougou and Tambacounda regions of southeastern Senegal (Fig. 1). Prior to the 21st century, most of the studies on Senegalese chimpanzees were conducted by the Stirling African Primate Project (SAPP) and

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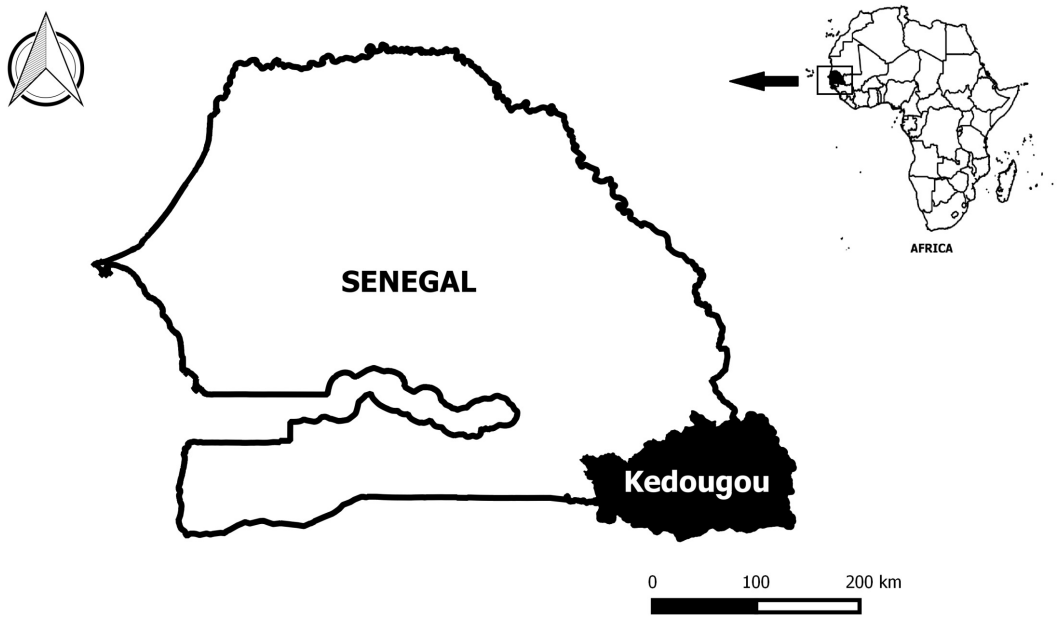

Fig. 1. The unprotected area of Senegal where West African chimpanzees (*Pan troglodytes verus*) range, namely the Kedougou region.

were focused on the Mount Assirik chimpanzees of Niokolo Koba National Park (McGrew, Baldwin & Tutin, 1981). Studies outside this protected area started in 1998 with the IPMO project (Perturbation et grande faune sauvage) de l'Institut de Recherche pour le Développement (IRD) and were followed soon after by the Miami Assirik Pan Project (MAPP, 2000), the Fongoli Savanna Chimpanzee Project (2001–present), and the Salemata and environs project directed by J. Carter. These early projects increased our knowledge of chimpanzees in Senegal outside Niokolo Koba National Park (Ndiaye, 1999; Galat-Luong, Galat, Ndiaye & Keita, 2000; Pruetz, Marchant, Arno & McGrew, 2002; Ndiaye, Galat, Galat-Luong & Nizinski, 2013a; Ndiaye, Galat-Luong, Galat & Nizinski, 2013b; Lindshield, 2014; Boyer-Ontl & Pruetz, 2014). However, the precise distribution of chimpanzees in unprotected areas and their total numbers have so far been unclear.

The previous surveys of chimpanzees in the whole of Senegal were used to estimate a total population size of 300 to 500 individuals (Galat-Luong *et al.*, 2000; Carter, Ndiaye, Pruetz & McGrew, 2003). Carter *et al.* (2003) conducted the last extensive survey of chimpanzees in Senegal. During the past decade, several chimpanzee study sites were developed or newly established (*i.e.* Faleme [K. Boyer-Ontl], Kayan [Pan African Programme], and Dindefelo [Jane Goodall Institute–Spain]). More recently, in anticipation of gold mining, research has been initiated in the Mako area involving S. Ndiaye (National Parks, Senegal), P.I. Ndiaye (University of Cheikh Anta Diop, Dakar, Senegal) and J. Pruetz (Fongoli Savanna Chimpanzee Project & Iowa State University). Altogether, we possess extensive knowledge of chimpanzees in Senegal at a limited number of sites (n = 5–6, including Niokolo Koba National Park and the Réserve Naturelle Communautaire de Dindefelo), have more detailed evidence on ranging patterns *via* nesting surveys at a larger number of sites (n = 9–10), but we lack sufficient information in approximately 70% of the chimpanzee range in Senegal, mainly outside the protected areas.

Thus, it is crucial to collect sufficient data on chimpanzees inhabiting the unprotected areas of Kedougou, particularly in light of the rapid growth in artisanal and corporate mining in the region, which can impact chimpanzees and their habitats (Grep, 2012). Moreover, information on the potential for dispersal through biological corridors is urgently needed (Niane, 2014; Niane *et al.*, 2014, 2015; Boyer-Ontl & Pruetz, 2014; Ndiaye, 2015). We think that the availability of data about the sleeping sites, the trees bearing nests and impacts of anthropogenic activities can be very useful for the

natural resources management plans in line with the conservation of chimpanzees in this hot and dry habitat.

METHODS

Study area

Kedougou is situated in southeastern Senegal (Fig. 1) at the edge of chimpanzees' range. This region is characterized by a Sudano–Guinean climate and pronounced rainfall seasonality. The short rainy season typically lasts four months (June–September), and the dry season occurs from October to May. Between 2004 and 2014, mean annual rainfall was about 1200 mm and the mean annual temperature was 28.5°C (Agence Nationale d'Aviation Civile et de la Météorologie). The vegetation consists mainly of woodlands on hills and plateau edges, grasslands on plateaus, and gallery forests along the Gambia River and its tributaries (Ba *et al.*, 1997; Galat *et al.*, 1994; Gray, 2010). During the longer dry season, almost all plants lose their leaves except those evergreen species located in gallery forests. Many of the deciduous tree species flush with young leaves before the first rains (Ba *et al.*, 1997), such as *Pterocarpus erinaceus*, *Anogeissus leiocarpus*, *Adansonia digitata* and *Parkia biglobosa* (P.I. Ndiaye, pers. obs. 2015). In accordance with the development of gold mining in recent decades, the human population of Kedougou has increased exponentially. The migratory flow toward Kedougou is increasing. Thus, we are observing a high level of human pressures (deforestation, agriculture, hunting, gold mining, grazing, amongst others) on natural resources, particularly a degradation of chimpanzee habitats in this region.

Surveys

Data were collected during 57 recce walks on 45 days between November 2014 and July 2015 by several teams, each consisting of three observers. Researchers were members of Fongoli Savanna Chimpanzee Project, Jane Goodall Institute, Faleme Chimpanzee Conservation Project, Cheikh Anta Diop University of Dakar, and local field guides. Surveys were conducted simultaneously at different sites on the same dates. During this period, we principally used recce walks to search for signs of chimpanzees, including direct (individuals) and indirect (vocalizations, nests, footprints, faeces) evidence to denote presence or absence of apes at a site, covering a total pedestrian survey distance of 300 km. In this case, a recce walk is a survey on foot in a predetermined direction along a path of least resistance, which can deviate by any degree, through the survey area (see Kühl, Maisels, Ancrenaz & Williamson, 2008; Ross & Reeve, 2011). Survey sites were identified by the authors and local stakeholders as areas where chimpanzees were predicted to occur but whose presence had not been verified through previous surveys (Fig. 2).

Recce transects were conducted within these sites in habitats (gallery forests, woodlands) typically known to provide key food, water, shade and sleeping site resources (Fig. 3). Each survey day, our team walked these transects, which averaged 5 km in length. Each transect was monitored once. We used handheld smartphones equipped with GPS receivers (Runbo X6) and Cybertracker software to record the locations of recce sites and observations. In addition to direct or indirect indicators of chimpanzee presence, we recorded evidence of anthropogenic pressures, including gold mining, deforestation, charcoal production, agriculture, livestock grazing and hunting. We recorded the geographic coordinates, date and time for each observation. For chimpanzee nests, we recorded the tree species supporting each nest, the age of the nests, the habitat type, and the number of nests in each supporting tree. Nest age was classified as fresh, recent, old, and rotten, following Tutin & Fernandez (1984). Fresh nests consist entirely of green, fresh leaves – unless the nest has been reused – and fresh faeces and urine may be present. Recent nests have leaves that are changing in colour from green to brown, and the green leaves are wilted. Old nests consist of brown leaves, although wilted green leaves may still be found. Rotting nests consist entirely of brown leaves and are disintegrating. In this study, we did not control for the influence of nesting group size on nesting tree species proportions but such relationships should be considered in future research.

Distribution maps were created in QGIS or ArcGIS (ESRI, Redlands, California, U.S.A.). Shapefiles of administrative districts were downloaded from DIVA-GIS (http://www.diva-gis.org). Survey efforts (*i.e.* number of survey days) among the administrative districts in this study (Bandafassi, Fongolimbi, Salemata, Saraya) were unequal, and thus frequencies were weighted by survey effort in order to compare chimpanzee and anthropogenic indices across administrative districts.

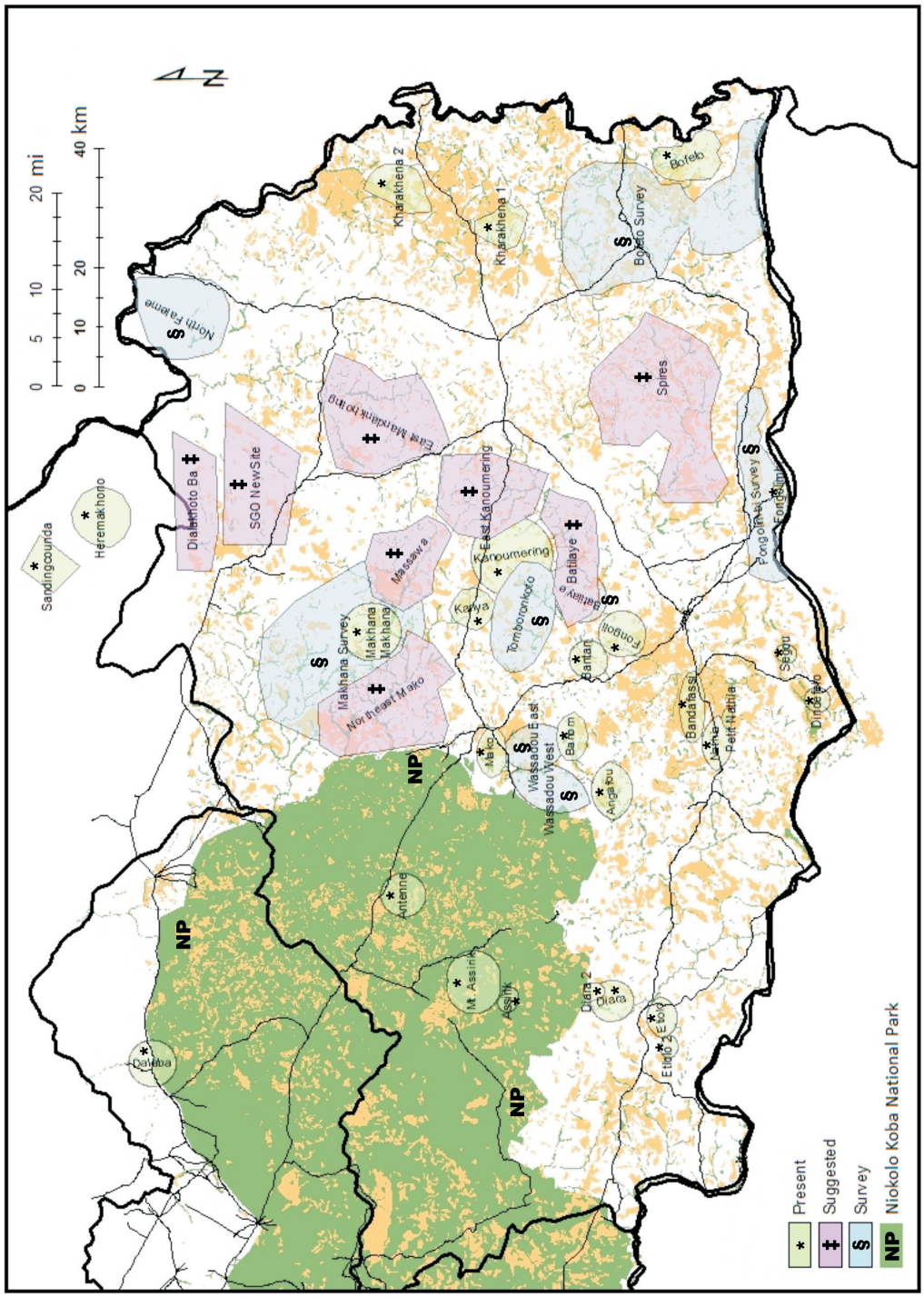

Fig. 2. Map of southeastern Senegal and proposed chimpanzee survey sites.

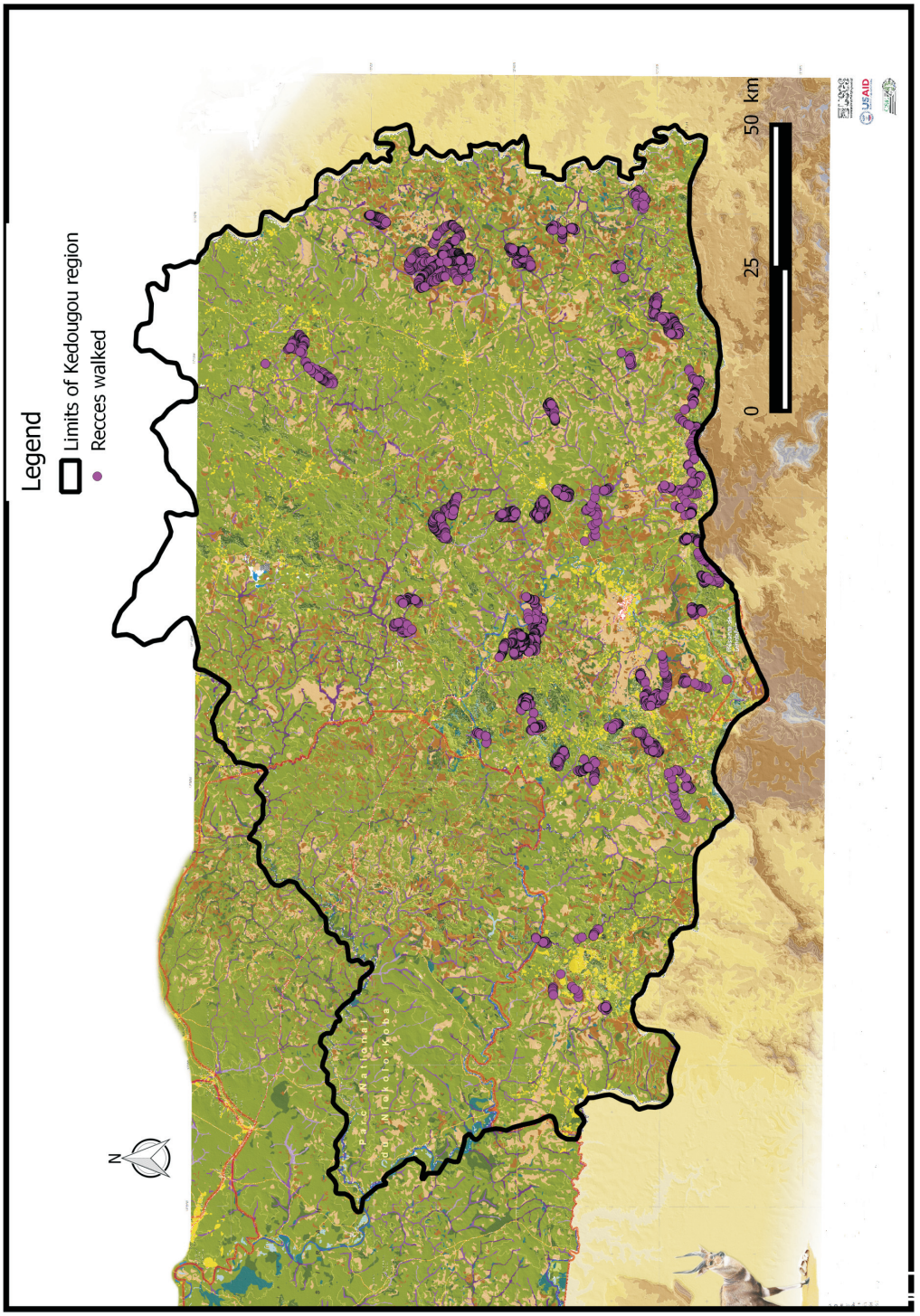

Fig. 3. Map of recce locations.

Over-represented areas were weighted less, and under-represented areas were weighted more in these comparisons. Woodland and forest habitat covers were estimated in ArcGIS with the USGS land cover map of Kedougou (Tappan, 2010) and the ArcMap area calculation tool.

RESULTS

Survey effort varied by administrative district. The most extensively surveyed district was Bandafassi (40% of survey days, n = 23, weight = 0.35), followed by Fongolimbi and Saraya (each 26%, n =15, weight = 0.54), and lastly Salemata (7% or n = 4 survey days, weight = 2.03). We recorded 21 direct observations of chimpanzees (Fig. 4) and identified a total of 3489 chimpanzee nests, including 78 fresh (2%), 485 recent (14%), 1877 old (54%), and 1049 rotten nests (30%). Locations of these nests is indicated in Fig. 5. Ground nests were not encountered during our study.

Chimpanzees were in close geographic proximity to major rivers, particularly along the Diarha, Gambia, and the tributaries of the Falémé. In addition, they often occupied the hills separating Senegal from Guinea Conakry. Chimpanzees were more frequently located in Bandafassi and Fongolimbi after adjusting for survey effort per administrative district (Fig. 6).

Evidence of agriculture, artisanal mining and timber extraction were located throughout the survey area (Fig. 7). Mining was most prevalent in Saraya, followed by Bandafassi, Fongolimbi and Salemata (Fig. 8a). Fig. 8 shows the weighted frequencies of these non-mutually exclusive human impacts, including agriculture, charcoal production, deforestation, grazing, artisanal mining and hunting, by administrative district. Mining is a major conservation concern due to its complex environmental impacts (Figs 8 & 9), such as the numerous deep excavation pits within chimpanzee community home ranges (Fig. 9).

Although chimpanzees used at least 40 plant species to construct sleeping nests (Fig. 10), 84% of nests (2608 of a total of 3088) were associated with only eight tree species: *Pterocarpus erinaceus* (37.6%), *Diospyros mespiliformis* (11.7%), *Anogeissus leiocarpus* (10.6%), *Hexalobus monopetalus* (5.8%), *Cola cordifolia* (5.5%), *Lannea* sp. (5.5%), *Parkia biglobosa* (4%) and *Piliostigma thonningii* (3.3%). Within this subset, 60% of nests were found in three species only: *P. erinaceus, D. mespiliformis* and *A. leiocarpus.*

Fig. 4. An adult male chimpanzee observed in Bagnomba (786221W, 1407110N). Photographed by P. I. Ndiaye.

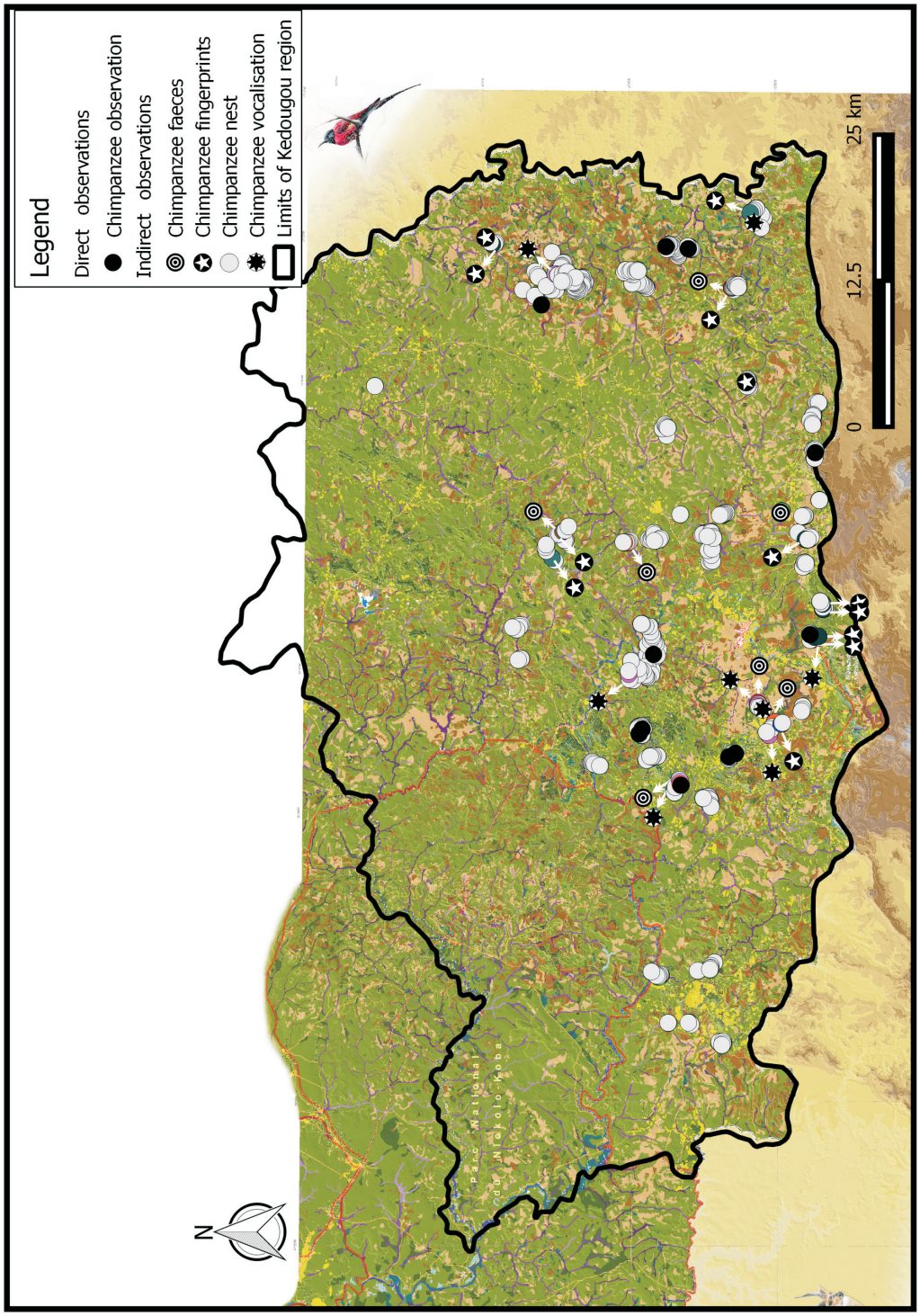

Fig. 5. Locations of chimpanzee observations. (Projection: WGS 84 Zone 28N; Data source: USGS.)

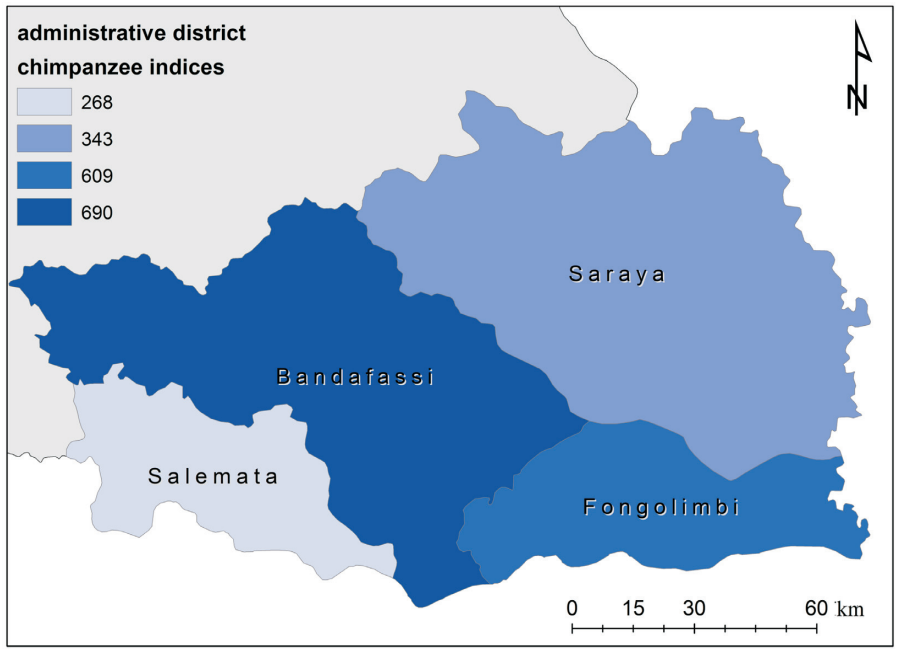

Fig. 6. Distribution of chimpanzee observations (weighted *n*) by administrative district. (Projection. WGS 84 Zone 28N, Data source: USGS.)

The remaining 16% of nests were constructed within 32 additional tree species.

Land cover across all survey sites combined consisted of woodland (61.3%), grassland (26.9%), forest (7.5%), cropland (3.9%), and other (0.4%: settlements, water bodies, gravel quarries/bare soil). While chimpanzees can potentially nest in grassland and cropland, nests were only located in forest (49.0%) and woodland (51.0%) habitats. Assuming that real nesting habitat only includes woodland and forest, the former dominates (89%) and the latter comprises 11% of nesting habitat cover.

DISCUSSION

Chimpanzee nests usually disappear or decompose after the rainy season in the Kedougou region (P.I. Ndiaye unpubl. data). Thus, the majority of recent and old nests (68%) were constructed by chimpanzees no more than 12 months prior to our surveys. The low number of fresh nests recorded during the study (2%) is probably related to the fact that the surveys were not made simultaneously across all habitats. However, if we sum the total number of fresh ($n = 78$) and recent nests ($n = 485$), this total approaches the number of at least 500 individuals estimated by Galat-Luong *et al.* (2000), which was also at the high end of the range given by Carter *et al.* (2003). Most surveys have been carried out using nest counts to estimate population densities of chimpanzees (Hashimoto, 1995; Fleury-Brugière & Brugière, 2010; Kühl *et al.,* 2008). However, more research is essential for accurately determining the total population size of chimpanzees in Senegal.

Chimpanzees were widely distributed throughout unprotected areas of Kedougou. They often occupied the gallery forests networks and woodlands near the Gambia and Falémé Rivers, and in the forests lining the edges of hills. A similar distribution was described by Ndiaye *et al.* (2013b) in the same region. Thus, we argue that conserving these gallery forest systems is critical to the long-term survival of West African chimpanzees in Senegal.

Agriculture and timber extraction were most often encountered within the survey area. However, it should be noted that the intensification of traditional and industrial gold mining in Senegal is an emerging threat to the survival of chimpanzees, as is the case elsewhere (Maldonado *et al.*, 2012; Estrada *et al.*, 2017). Mining is a major concern because of its entanglement with numerous anthropogenic impacts. In addition to habitat loss, air and water pollution from toxic substances such as mercury and cyanide is problematic (Niane,

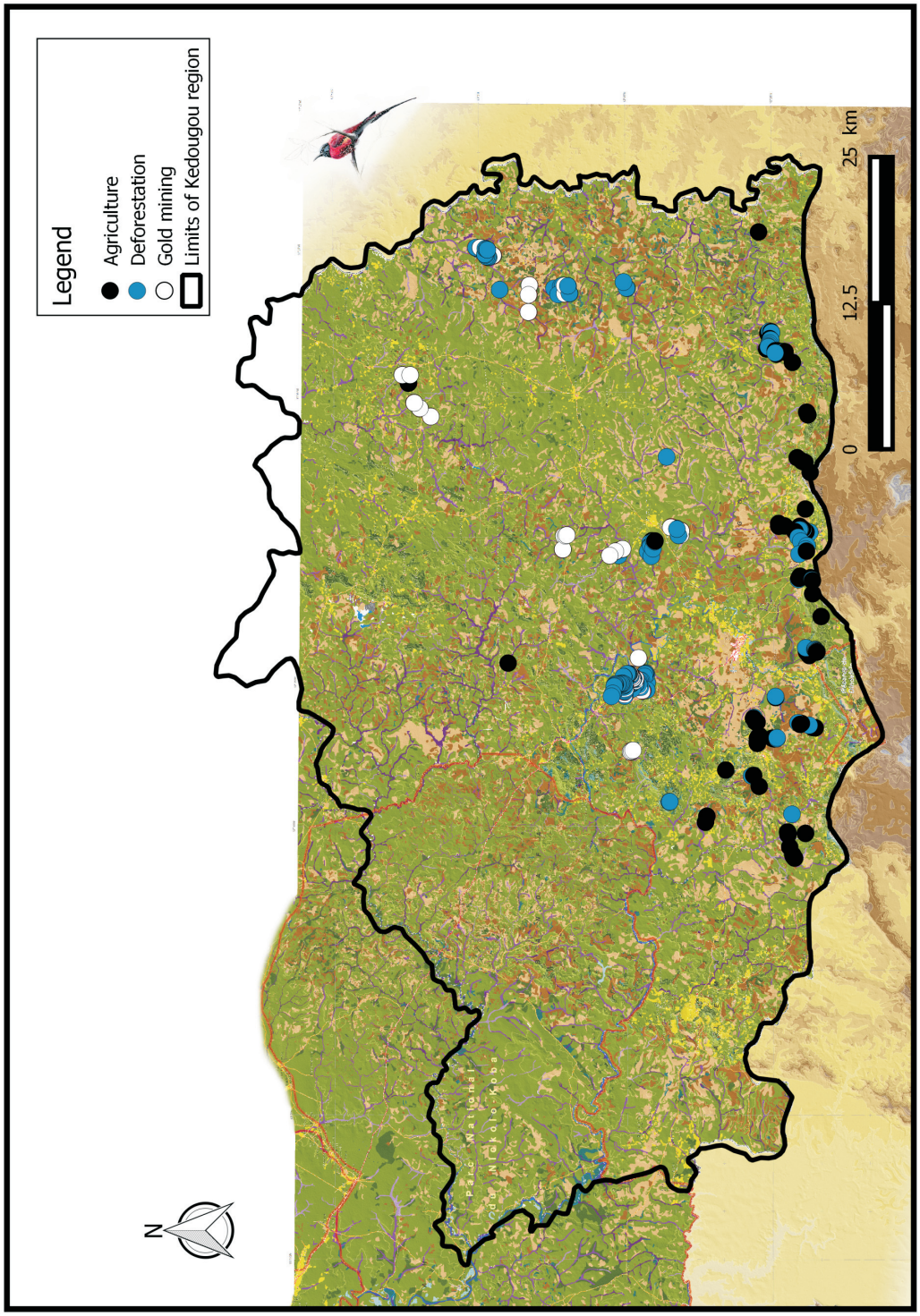

Fig. 7. Map of key anthropogenic pressures in the unprotected zones of Senegal.

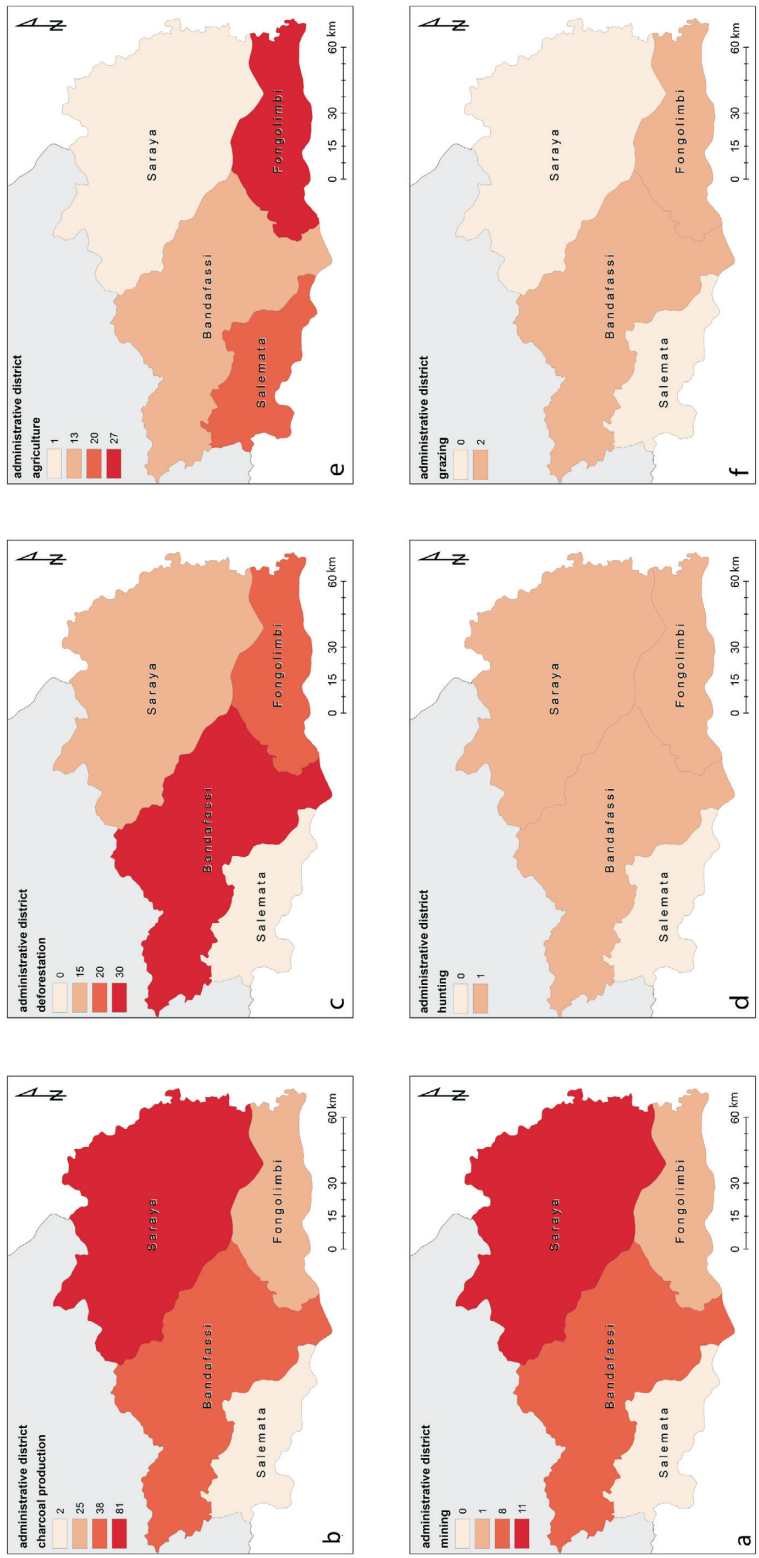

Fig. 8. Anthropogenic impacts by district, given as weighted frequencies, including (**a**) mining (**b**) charcoal production, (**c**) deforestation, (**d**) hunting, (**e**) agriculture, and (**f**) livestock grazing. (Projection: WGS 84 Zone 28N; Data source: USGS.)

Fig. 9. Clearing of gallery forest habitat in the Kedougou region by artisanal miners. Photograph by P. I. Ndiaye.

2014; Niane *et al.*, 2014, 2015; Ndiaye, 2015). Moreover, the threat of poaching for bushmeat may increase as migrant workers who do not observe local taboos against eating apes flow into Senegal from neighbouring countries (Wilkie *et al.*, 2016).

Chimpanzees in this study nested in forest and woodland, but more so in forested areas considering that this habitat is relatively rare (Tappan, 2010). These results are consistent with a study by Pruetz *et al.* (2002) for chimpanzees living outside the Niokolo Koba National Park. According to these authors, chimpanzees outside the Niokolo Koba National Park in southeastern Senegal nested in woodland areas half of the time, while Niokolo Koba National Park chimpanzees used this habitat for nesting 30% of the time. Gallery forest was the next most frequently used habitat by chimpanzees outside the Niokolo Koba National Park, but was the most frequently used nesting habitat for Niokolo Koba National Park chimpanzees. Our data support interpretations by Pruetz *et al.* (2002), who suggested that the discrepancies in nesting behaviour between chimpanzees within and outside the Niokolo Koba National Park may be due to the influence of humans on chimpanzees' habitat use. However, we also suggest that another reason is the presence of water in the valleys during a large portion of the year (Galat-Luong & Galat, 2000; Galat-Luong, Galat & Nizinski, 2009). These results conform to those of Koops, McGrew, De Vries & Matsuzawa. (2012) at Seringbara, Nimba Mountains in Guinea, West Africa. However, in the case of Senegal, we think that more research is needed in order to determine the proximate causes of habitat use.

Chimpanzees appear to prefer certain tree species for the construction of nocturnal nests (Brownlow, Plumptre, Reynolds & Ward, 2001; Stanford & O'Malley, 2008; Ndiaye *et al.*, 2013b), although we do not have tree availability data for the areas we surveyed to test this hypothesis. Such a preference could explain the high percentage of the night nests (60%) attributed to only three plant species, *Pterocarpus erinaceus*, *Diospyros mespiliformis* and *Anogeissus leiocarpus*. Stanford & O'Malley (2008) obtained similar results by studying the nesting behaviour of chimpanzees living in Bwindi National Park in southwestern Uganda. According to these authors, Bwindi chimpanzees use 38 of 163 available tree species to build their nests, and four of these 38 species accounted for about 72% of all nests. The predominance of *P. erinaceus* as a nesting species in the Kedougou region was also described by Ndiaye *et al.* (2013b) in a study

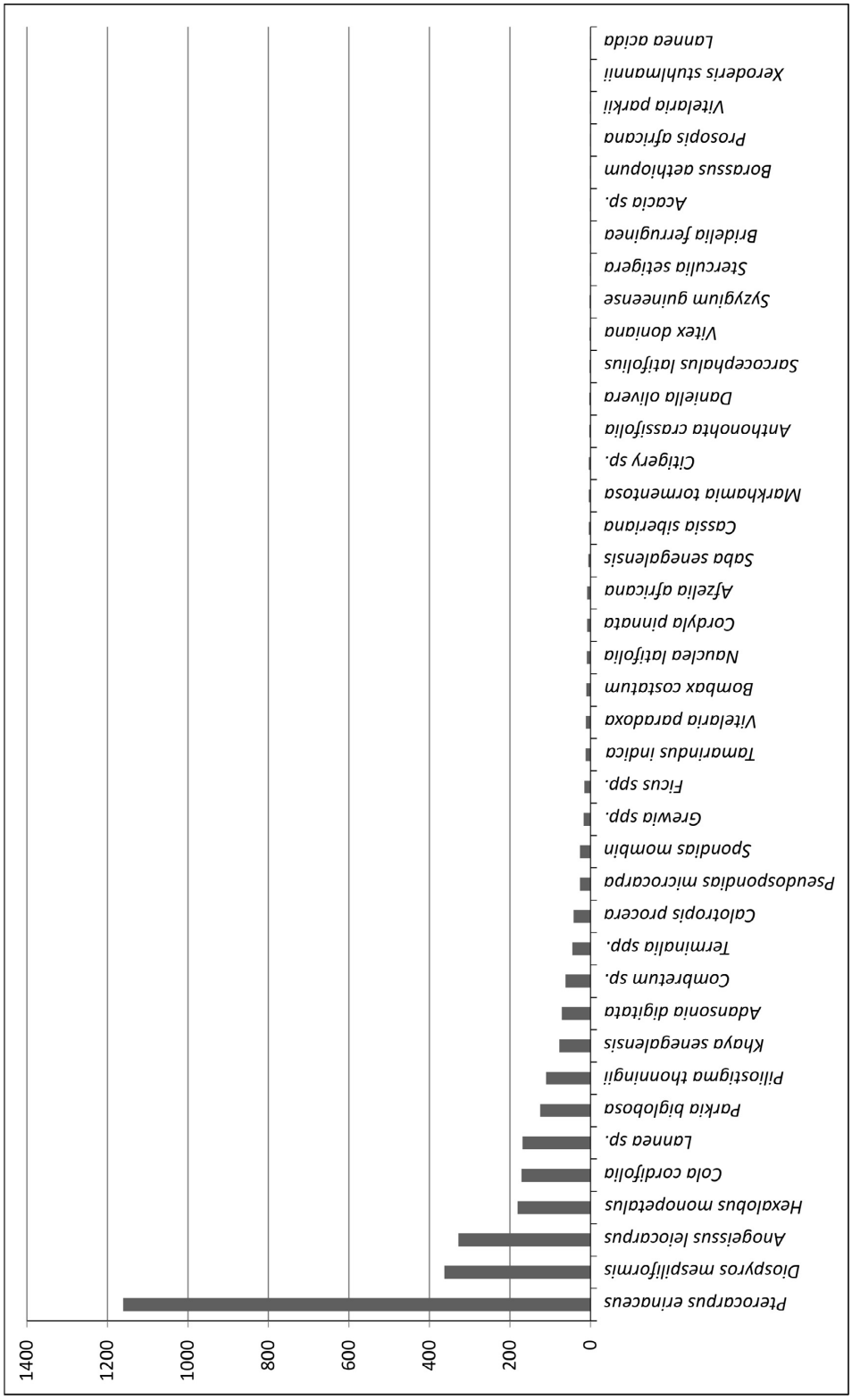

Fig. 10. Absolute frequency of tree species used by chimpanzees to build their nests (n = 3088).

between 1998 and 2000, where it was noted that chimpanzees may prefer *P. erinaceus* for its hardwood properties. Because chimpanzees exhibit a preference for specific trees to use as nesting sites, chimpanzee conservation efforts need to ensure the proper conservation of these plant species. Adequate conservation measures should be taken by management authorities, as we found that *P. erinaceus* was heavily exploited by artisanal gold miners for shoring up mining pits. Conservation and management of these habitats requires special attention because habitat destruction often causes species to migrate to areas more favourable to survival, and chimpanzees cannot survive in areas with extensive deforestation (Bernstein *et al*., 1976).

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