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Raptors in changing West African savannas : the impact of anthropogenic land transformation on populations of Palearctic and Afrotropical raptors in northern Cameroon

Buij, R.

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Author: Buij, Ralph

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Chapter 1

General introduction

Ralph Buij



1.1 Introduction

Over the past 40 years unprecedented land cover and land use changes have occurred in sub-Saharan Africa, which is mainly driven by overexploitation of the land, notably for the expansion of croplands (Brink & Eva 2009). Agricultural expansion has increased sharply with human populations, which were reported to have tripled between 1970 and 2010 from just under 250 million to over 850 million (World Bank 2012). The resulting loss of native habitats has contributed to significant wildlife declines in Africa's savannas, which are widely represented outside protected area network but under immense pressure from human populations (e.g. Ottichilo *et al.* 2000, Homewood *et al.* 2001, Serneels & Lambin 2001, Sinclair *et al.* 2002, Darkoh 2003, Blaum *et al.* 2007, Biggs *et al.* 2008, Craigie *et al.* 2010). Compared to the rest of the continent, West Africa's biodiversity stands out for being most severely threatened (Clerici *et al.* 2006, Newmark 2008, Fa & Brown 2009, Craigie *et al.* 2010). This was attributed to human population densities and rates of habitat conversion, which were higher in West Africa's sub-Saharan savannas than elsewhere on the continent (Brink & Eva 2009), because dry forests are easy to clear for agriculture and have often fertile soils with suitable climate for livestock husbandry (Murphy & Lugo 1986). Protected areas in West Africa are widely scattered and few cover the range of habitats necessary to maintain the diverse assemblage of species adapted to different vegetation types and structure (Thiollay & Clobert 1990), or support migratory populations with almost constantly shifting populations along latitudinal gradients (Thiollay 1978a). West Africa's protected areas do have a crucial role in safeguarding fragmented wildlife populations in the face of growing human pressure, but their limited size, coverage and increased isolation are likely to severely compromise their effectiveness in doing so (Chape *et al.* 2005, Clerici *et al.* 2006, Brashares *et al.* 2001). As human populations, markets, and infrastructure continue to drive conversion of forested and pastoral lands to other land uses around protected areas (Clerici *et al.* 2006, Newmark 2008), predominantly agriculture (Odihi 2003, Tappan *et al.* 2004, Paré *et al.* 2008, Ouedraogo *et al.* 2010), little is known about the processes that sustain wildlife populations within increasingly human-transformed savanna landscapes.

1.2 West African raptor decline

Birds of prey, or raptors (in this thesis treated as diurnal raptors belonging to the order Falconiformes, i.e. excluding owls), like other top predators, are among the most vulnerable taxa to environmental disturbance (Newton 1979). Consequently, their presence has been often cited as indicative for the biological diversity of the ecosystems on which they depend, since top predators select such sites, promote ecosystem diversity by top-down predation, or provide essential resources, such as carrion for scavengers (reviewed in Sergio *et al.* 2006, 2008). As raptors are relatively easily observed top predators, they are among the most useful higher taxa to evaluate the state of the environment over wide areas in open to semi-open areas, including savannas. To date, a range of studies have inferred from spatial variation in raptor populations, that habitat transformation through human interference is having an huge impact on ecosystem functioning and species diversity (e.g.

Herremans & Herremans-Tonnoeyr 2000, Sánchez-Zapata *et al.* 2003, Machange *et al.* 2005, Carrete *et al.* 2009). The largest among the raptors, which require the largest areas to support breeding efforts, are ideal “umbrella species”, meaning that areas large enough to support these species automatically provide adequate resources for populations of smaller, less demanding species. Also, raptors may be “flagship species”, driving public interest and support for conservation programs through their charismatic appearance and behavior, which may have aided the recovery of several species in temperate regions after decades of persecution and environmental contamination (Newton 1979, 1998, Zuberogitia & Martínez 2011).

In Africa, raptors population declines have been documented since the 1970s, throughout the continent (e.g. Brandl *et al.* 1985, Sorley & Anderson 1994, Herremans & Herremans-Tonnoeyr 2000, Thiollay 2000, 2001, 2006a, 2007a, Anadón *et al.* 2010, Ogada & Keesing 2010, Ogada & Buij 2011, Virani *et al.* 2011). The particularly dire state of raptors in the West Africa’s Sudan and Sahel savannas was illustrated by repeated counts of raptors along road transects in four West African countries (Cameroon, Niger, Burkina Faso, Mali) by Jean-Marc Thiollay, between 1969-1973 and again between 2000-2004. Despite regional variation in the severity of the declines, the overriding population trend was negative, especially outside protected reserves (Thiollay 2001, 2006a,b,c, 2007a,b). Given their indicator role, the raptor decline implied a general “ecological collapse” according to Thiollay (2006a), reflecting similar trends for medium-sized to large vertebrates and gamebirds in the region (Thiollay 2006b). Large Afrotropical raptors, which sit at the apex of food pyramids, were disproportionably hard hit, illustrated among others by the 98% decline of large vulture populations outside protected areas, and 86-93% decrease of populations of four large eagles (Thiollay 2006a). Many formerly widespread large raptors now survive only in a few pockets of intact habitat, mostly inside protected areas, while populations of some are on the brink of regional extinction, or have already disappeared (Thiollay 2006a).

The widespread, dramatic impoverishment of almost the entire West African raptor assemblage in less than four decades is unprecedented in Africa. It is, in fact, the most devastating decline reported for avian taxa at this scale in Africa, and it affects an area of global importance to raptor conservation, with 69 regularly occurring raptor species (excluding vagrants; Borrow & Demey 2004), representing 22% of the world’s raptors. Of these, 13 are considered threatened (“Near Threatened”, “Vulnerable”, or “Endangered”; IUCN Red List 2012), including three out of 23 regularly recorded Palearctic raptors, which breed in the Palearctic and winter in sub-Saharan Africa. This suggests that factors which affect raptors here might also have repercussions for endangered populations in Eurasia. Overall, the reported raptor declines coincide with and reflect the relatively high anthropogenic pressure on dwindling resources in this part of Africa, and as such, they offer a glimpse into the future for most of the continent, and how raptors cope with the changing conditions.

1.3 Palearctic and Afrotropical raptors

The raptor population trends in West African savannas were alarming for their scope, both in terms of numbers and the scale at which they were detected. However, not all species declined as strongly, and few apparently remained stable locally (Thiollay 2001, 2006a), pointing to variation in species-specific response to environmental alteration and degree of development (e.g. Rodríguez-Estrella *et al.* 1998, Sergio & Bogliani 2000, Anderson 2001, Thiollay 2007a, Carrete *et al.* 2009, Cardador *et al.* 2011). Such differences in sensitivity to habitat transformation depends on life-history traits such as body mass (Owens & Bennett 2000, Gehring & Swihart 2003), relative brain size (Sol *et al.* 2005, 2010), dispersal (Pereira *et al.* 2004) and niche breadth (Swihart *et al.* 2006). Interspecific differences in body mass, energy needs, and diet (Schipper 1973, Jaksic & Braker 1983, Marti *et al.* 1993, Garcia & Arroyo 2005), may render large birds more vulnerable to change (Gaston & Blackburn 1996, Gillespie 2001), and this also seems to hold for raptors (e.g. Thiollay 2006a,b, 2007a). Similarly, sexually dimorphic raptors may exhibit distinct sex-related spacing patterns based on differences in diets and energy requirements (Marquis & Newton 1982, Smallwood 1988), allowing the possibility of intraspecific variation in vulnerability to land use change.

Recent studies further suggest that sedentary birds, i.e. those that depend on year-round territories, have morphological and behavioral traits that allow them to cope relatively well with changing environments (Sol *et al.* 2005, 2010), whereas migratory species tend to be less flexible. This was related to differences in brain size, relative to the size of the body; the relatively smaller brains of migrants may limit their capacity to produce flexible responses to challenging feeding conditions (Lefebvre *et al.* 1997), for example as a result of habitat destruction. On the other hand, Palearctic birds have been attributed with strong flexibility in habitat use on their winter grounds, occupying a wider range of habitat types and employing a higher diversity of foraging techniques, even profiting from anthropogenic habitat alteration (Moreau 1972, Morel & Morel 1992, Jones *et al.* 1996, Wilson & Cresswell 2002). Evidence suggests that, like other migrants, Palearctic raptors wintering in Africa also readily occupy man-modified habitats (Herremans & Herremans-Tonnoeyr 2000, Anadón *et al.* 2010, Limiñana *et al.* 2012), which might imply that they are rather flexible in adjusting to changing conditions on their winter grounds. Still, populations of Palearctic migratory birds wintering in Africa have suffered sustained and often severe declines over the past few decades, which were not apparent for non-migratory species (residents and short-distance migrants) breeding in the same habitats in Europe (Sanderson *et al.* 2006). Although declines may have been due partly to effects outside the African winter grounds, e.g. hunting at migration points (Zalles & Bildstein 2000), or deterioration of staging areas and increased flight distances over the Sahara (Doswald *et al.* 2009), ample evidence suggests that deteriorating conditions on West African wintering grounds influence survival and population numbers of Palearctic birds (e.g. Peach *et al.* 1991, Szép 1995, Eraud *et al.* 2009), including raptors (Clarke 2002, Grande *et al.* 2009, Zwarts *et al.* 2009, Mihoub *et al.* 2010).

Sensitivity to habitat change may increase, or have more significant consequences at population level during the reproductive season (Newton 1979). Afrotropical raptors, defined here as the array of (partially) nomadic, sedentary, and migratory raptors breeding in sub-Saharan Africa (Thiollay 1977a, 1989), depend on the region for secure nest sites and (seasonally) productive territories, and consequently, are likely to be more vulnerable to land use change than Palearctic migrants (Herremans & Herremans-Tonnoeyr 2000, Anadón *et al.* 2010). Similar to Palearctic migrants, some Afrotropical raptors respond to marked seasonal fluctuations in food supply by adopting a migratory lifestyle, displaying regular north-south population movements along a latitudinal gradient of declining rainfall (Thiollay 1978a). The timing and extent of seasonal movements varies between species, some are only partially migratory or nomadic, while population displacements for Afrotropical migrants, or intra-African migrants, occur between West Africa's forests and wet Guinea savannas and the arid Sahel (Thiollay 1977a, 1978a), while at least one species visits from southern Africa (Wahlberg's Eagle *A. wahlbergi*; Meyburg *et al.* 1995). Several Afrotropical migrants are among the most common raptors in West Africa, suggesting that they are coping fairly well with changing conditions, similar to some migratory raptors on European breeding grounds (Sergio & Bogliani 2000, Suárez *et al.* 2000, Cardador *et al.* 2011). On the other hand, persecution and disturbance by humans might depress reproductive output in West African agro-ecosystems and have been shown to limit the potential nest distribution of raptors (Bisson *et al.* 2002, Bamford *et al.* 2009). Furthermore, breeding densities are limited by saturation effects even in patches of optimal habitat, while effects of suboptimal food conditions, which are more likely in degraded habitats, may constrain nestling development and reproductive output of raptors breeding in rural landscapes.

Their high site fidelity suggests that Afrotropical sedentary raptors might be more vulnerable to habitat deterioration than Afrotropical migrants, since sedentary raptors depend on productive ranges to sustain them year-round. Despite a potentially greater foraging flexibility which may allow them to cope with seasonal environments (Schultz *et al.* 2005, Sol *et al.* 2005), increasingly rapid processes of urbanization and agricultural intensification in developing countries may negate the adaptive response of raptors to changing habitats (Carrete & Donazar 2005). For populations of sedentary raptors in agro-ecosystems, declining food resources (Herremans & Herremans-Tonnoeyr 2000) or shifts in prey abundance and selection (Ogada & Kibuthu 2009) may particularly worsen foraging conditions, potentially hampering long-term population persistence.

1.4 Research aims

As described in the preceding sections, land use can have various effects on the life cycle of raptors and depend upon species-specific adaptability to changing conditions. Studies of raptors in Africa have merely begun to scratch the surface of the myriad of effects that may influence population persistence, and clues to the mechanisms and causal drivers behind population declines remain little studied. Moreover, it is unclear how changing conditions differently affect the diverse assemblage of Afrotropical and Palearctic raptors, and how vulnerability, or adaptability to changing environments, relates to life-history traits such as

sex, age, body mass, and diet. This thesis aims to shed light on such mechanisms by quantifying the effects of land transformation on foraging, diet, and reproductive output. More specifically, it addresses the following questions:

- I How do intraspecific traits, i.e. sex and age, and interspecific body mass and diet differentiation influence foraging habitat selection by Palearctic raptors on African wintering grounds?
- II What is the effect of habitat transformation on nestling diet and growth, and on nest density and reproductive output, in Afrotropical migratory raptors?
- III What is the impact of habitat transformation on diet and foraging, in terms of effort and energy intake, in a sedentary Afrotropical raptor?
- IV How does sensitivity to habitat modification differ between Palearctic and Afrotropical raptors, Afrotropical migratory and sedentary raptors, and between Afrotropical raptors of different size?
- V How do protected area coverage and land use influence biogeographical patterns of abundance, richness, and diversity of raptors in West African savannas?

1.5 Study area

In order to answer these question, a field study was carried out in northern Cameroon from 2007-2010. Research was mostly conducted in the Far North and North Regions of Cameroon, but extended into the Adamawa Region, thus incorporating the three northernmost provinces of the country (7°6'N-12°2'N and 13°°E-15°3'E; Figure 1).

The climate is semi-arid, with rains occurring between April into October, peaking between June-September in the north and between May-October in the south. A cold dry season (Nov-Jan) precedes a hot season (Feb-May) during which the first rains occur (several weeks earlier and ending later in the southern part of the study area). Mean annual temperature is 24 °C-28 °C and peaks in March-May when temperatures of 47 °C are reached in the Lake Chad Inundation zone.

Species-specific examinations were performed in the Lake Chad Inundation zone and its fringing woodlands, located in the transition zone of the Sudan and Sahelian savanna belts (rainfall: 450-700 mm/annum). The region supports edaphic grassland mosaics with communities of *Acacia* and broad-leaved trees (White 1983). The 8000 km² Waza-Logone floodplains are part of a much larger floodplain area shared with Chad. These flooded grasslands are fringed by open *Sclerocarya birrea* woodland with *Anogeissus leiocarpus*, *Balanites aegyptiaca*, and *Acacia seyal*. Agriculture in the area includes mainly dry-season sorghum, millet, and rice. Human population density is low (10-25 people/km²) but has increased following partial floodplain rehabilitation (Scholte 2003). Although West Africa's floodplains are of regional importance to migratory raptors (Zwarts *et al.* 2009), the Waza-Logone floodplains and other floodplains associated with the greater Lake Chad Basin were labelled as the "centre of overwintering" for Palearctic migratory raptors, in reference to various Palearctic raptors which are rare further west (Thiollay 1978b). Thiollay (2001) suggested that a major reason for the recent raptor decline in the region was

the construction of a dam which caused the desiccation of 1,500 km² of the floodplains to create agricultural schemes. Re-flooding of part of the desiccated floodplains by the breaching of the Logone river embankment in 1994 raised flooding levels in an area of 600 km² and rehabilitated 180 km², with positive effects on vegetation dynamics, waterbird and antelope population recovery (Scholte 2005). The 1700-km² Waza National Park protects part of the floodplains and small populations of herbivores, notably Elephants *Loxodonta africana*, Buffon's Kob *Kobus kob* and Topi *Damaliscus korrigum*, but large wildlife has been virtually exterminated in the 45-km² Kalamaloué N.P. (Scholte 2003) and also threatens Waza N.P. (De Iongh *et al.* 2009).

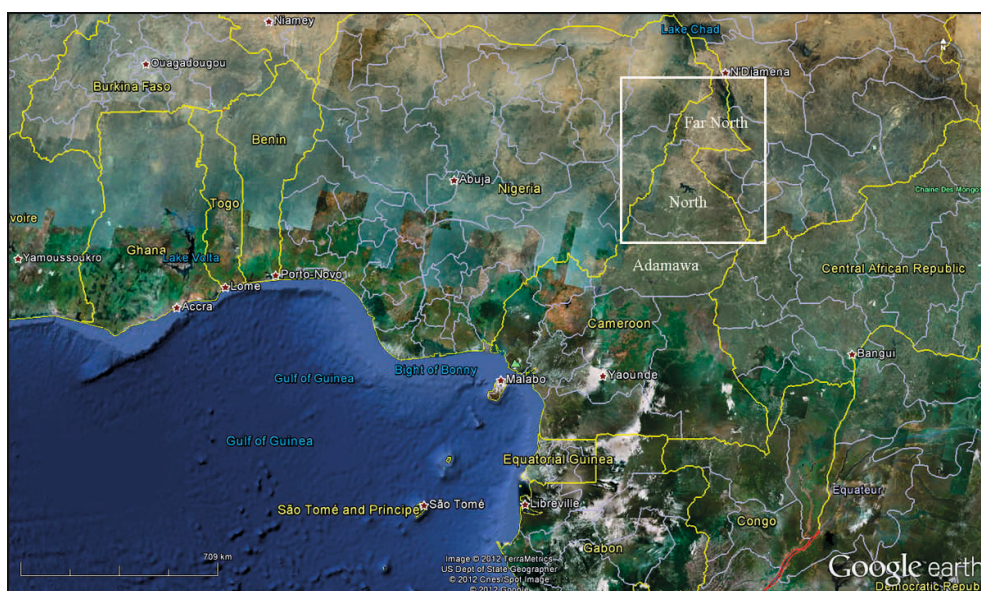


Figure 1. Location of the study area in the north of Cameroon. Country borders are yellow and provincial or state borders are blue. Satellite image © Google Earth.

To the south, the Sudan savanna belt (rainfall: 700-1100 mm/annum) with undifferentiated Sudanian woodlands (White 1983) is characterized by hilly terrain which rises to the Mandara Mountains in the west at 500-1000 m a.s.l. with isolated peaks up to 1442 m. The entire area is densely populated (averagely *c.* 50 people/km², but > 100-150 people/km² in many areas, locally up to 350 people/km²) and deforestation has been significant during the past 20 years (Fotsing 2009). Sorghum, millet, maize, beans, and groundnut are the most important food crops and cotton is cultivated throughout the zone as the main cash crop. Few patches of natural habitat remain in scattered, small (< 40 km²) and heavily exploited forest reserves with *Isoperlinia doka*, *Balanites aegyptiaca*, *Piliostigma reticulatum* and *Combretum erythrophyllum*.

The Guinea savanna belt south of the Sudan savanna (rainfall: 1100-1600 mm/annum) is on undulating terrain with some scattered rocky outcrops. The Bénoué Valley encompasses a

large river system and three National Parks (Bénoué, Boubandjidda, Faro) covering an area of approximately 7600 km². Twenty-eight sport-hunting zones cover an additional 16,000 km² and are managed as protected areas but with hunting quota for larger mammals and gamefowl (Mayaka 2002). The region has a low human population density (on average 13 people/km²), which is rapidly increasing (growth rate is c. 5%; Mayaka 2002). Cultivation covers c. 20% of the zone, particularly traditional crops such as millet but increasingly cotton. Herbaceous layer cover during the study period varied between 17% (mean minimum) to 81% (mean maximum).

1.6 Thesis outline

The thesis is organized into sections dealing with the effect of land use on selected species groups or species within the Palearctic migratory, Afrotropical migratory, and sedentary raptor assemblages, and a section dealing with habitat associations of the entire assemblage, at different spatial scales. This section introduces the West African raptor assemblage, the research questions, and the study area, quantifying aspects of land transformation during the past 40 years, which corresponds with a period of extensive land transformation and impoverishment of the raptor assemblage in Cameroon (Thiollay 2001).¹ The second section is divided into seven chapters, and discusses the impact of land transformation on Palearctic, sedentary and Afrotropical migratory raptors. The third section encompasses three chapters and combines lessons learnt from species-specific investigations to evaluate habitat associations of Palearctic migrants, African migrants and sedentary raptors. The fourth section concludes with a synthesis of the thesis results. Specifically, the chapters address the following:

Chapter 1 includes a description of the raptor assemblage and the study area in northern Cameroon, with delineation of the research themes and outline of the study. Chapter 2 assesses the foraging distribution of sex and age groups within three sexually dimorphic Palearctic harriers, to examine the role of body mass, sex and age groups, on habitat use and vulnerability to land transformation. The foraging patterns of the harriers are investigated in northern Cameroon, using point counts in five habitat types along a gradient of transformation on the Waza-Logone floodplain. Pellet analyses provide details of harrier diet, which are used to explain the observed foraging patterns. Box A analyzes in more detail the bird hunting success by Pallid Harriers *Circus macrourus*, with a discussion of habitat elements that facilitate hunting.

Chapters 3-5 examine the relationship between land use, food availability, nest success, productivity, and growth in an Afrotropical migrant, the Grasshopper Buzzard *Butastur rufipennis*, a species threatened by extensive land transformation in its Sudano-Sahelian breeding range. Chapter 3 provides the first detailed information of the breeding biology

¹ The study area in northern Cameroon is situated on the transition boundary between West and Central Africa, which is commonly placed on a line running from Mt. Cameroon in the south to Lake Chad in the north of Cameroon. Because of the greater ecological similarity with the West African savannas compared to the wet savannas and forests that dominate Central Africa, northern Cameroon is often included as part of the West African savanna region (cf. Tchamba 1996, Thiollay 2001) and this classification is adopted here.

and nestling development of the Grasshopper Buzzard. Using the information from Chapter 3, Chapter 4 examines the importance of land use and rainfall on Grasshopper Buzzard nesting growth parameters, to understand how changing environmental conditions within its breeding range impact nestling growth and condition at fledging. This includes an investigation of diet composition and energetic content of food brought to the nests, and how these may explain the observed growth patterns. Chapter 5 examines the relationship between environmental conditions, nest density and reproductive parameters in the Grasshopper Buzzard, based on an assessment of reproductive output at nests in transformed and natural habitat. Chapter 6 reports on the breeding biology of another Afrotropical migrant, the African Swallow-tailed Kite *Chelictinia riocourii*, in Cameroon and Senegal, including a diet comparison of kites during breeding and non-breeding seasons, to evaluate how diet shifts between seasons may influence vulnerability to land transformation. The chapter also discusses how nest dispersion related to land use may influence breeding performance.

Chapter 7 attempts to evaluate the impact of habitat transformation on foraging in sedentary Dark Chanting Goshawks *Melierax metabates*, by examining differences of microhabitat selection, foraging effort and energy intake in natural and transformed habitats. To determine microhabitat selection by hunting goshawks, six male goshawks are radio-tracked in both habitat types and vegetation structure at patches used by hunting goshawks compared with nearby unused patches. This method also permits for an assessment of hunting effort and energy intake through estimation of prey energy content.

Chapter 8 investigates environmental factors underlying habitat-scale patterns of raptor community richness in northern Cameroon, to provide insights into the raptor decline and identify elements of habitat transformation that most threaten raptors in the region. Year-round patterns of raptor richness and abundance were documented along road transects in the Lake Chad Inundation zone, Sudan savanna and Guinea savanna of Cameroon, covering four years and dry and wet seasons, and related to vegetation structure, human population size, and land use along the transects. To assess their presumed differences in sensitivity, I separately analyzed habitat associations of Afrotropical raptors to Palearctic raptors, sedentary raptors to Afrotropical migratory raptors, and large raptors (eagles and vultures) to smaller raptors. Chapter 9 documents habitat associations of raptors on the Waza-Logone floodplains, which represent a highly localized but threatened habitat of great importance to raptors, to provide insight into the effect of Sahelian floodplain transformation on Palearctic and Afrotropical raptors. Chapter 10 assesses the role of biogeographical zonation, protected area coverage, and land use at broad, landscape-scale patterns of abundance, richness, and diversity of raptors in northern Cameroon. Further, the conservation value for raptors of Cameroon's northern savannas, and those elsewhere in West Africa, is examined on a continental and global scale, to ascertain their value to global raptor conservation. Box B finally describes the first observation in Cameroon of globally endangered Sooty Falcon *Falco concolor*, indicative for the scarcely documented raptor richness of the region and a potential migration route through this part of Africa.

Chapter 11 represents the concluding section, which discusses the main findings and puts them into the wider perspective of raptor conservation. The chapter includes recommendations for conservation projects.

