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

Buij, R.

Chapter 11

Synthesis

Ralph Buij

11.1 Introduction

Increasing evidence suggests that raptor species respond differently to alteration of their native habitats, some even increasing in numbers along gradients of transformation or remain apparently unaffected, while other species decline (Jullien & Thiollay 1996, Rodríguez-Estrella *et al.* 1998, Sánchez-Zapata & Calvo 1999, Sergio & Bogliani 2000, Anderson 2001, Palomino & Carrascal 2007, Cardador *et al.* 2011). Research in temperate and (sub-)tropical environments have revealed that moderate habitat alteration may positively influence raptor diversity and abundance if it coincides with increased foraging and nesting availability (Rodríguez-Estrella *et al.* 1998, Sánchez-Zapata & Calvo 1999, Anderson 2001), particularly favoring species with high levels of behavioral and ecological flexibility to changing conditions (Suárez *et al.* 2000, Cardador *et al.* 2011). Conversely, specialist raptors of dense tropical forests may decrease even after slight modification of their habitat (Jullien & Thiollay 1996). Such results imply that raptor conservation aimed at specific species, or their use as umbrella species for conservation management, requires detailed knowledge of species-specific ecological requirements. Such knowledge is scarce for the tropical West African savannas between Senegal and Cameroon, even by African standards (Virani & Watson 1998). This region, roughly six times the size of France, is of great importance to a rich assemblage of Afrotropical sedentary and migratory raptors, as well as a wintering ground for Palearctic migratory raptors from western Europe (Zwarts *et al.* 2009) east to central Asia (Terraube *et al.* 2011), and south to southern Africa (Meyburg *et al.* 1995).

The effects of land use change on the sedentary and migratory raptors are described in more detail in this thesis, focusing on changes in prey availability and diet in response to transformation, and in-depth analyses of habitat use, breeding ecology and food intake of representatives within the Palearctic, Afrotropical migratory and sedentary raptor assemblage. Based on existing literature, I hypothesized that the largest impact of land use change would be on sedentary Afrotropical raptors, because their low mobility may limit their ability to cope with increasingly rapid and significant declines in habitat and prey availability (Carrete & Donázar 2005). Similar to some migratory raptors on European breeding grounds (Sergio & Bogliani 2000, Suárez *et al.* 2000, Cardador *et al.* 2011), I expected that Afrotropical migrants may cope better with changes in land use than sedentary species, while Palearctic migrants were expected to be most flexible and generally adapt best to changes in land use (Jones *et al.* 1996, Wilson & Cresswell 2002). I further expected that intraspecific and interspecific traits, such as sex, age, and body mass influenced vulnerability to land use change in Afrotropical and Palearctic raptors. This chapter concludes with a synthesis and an integrative discussion of the main results of the research and ends with a set of recommendations.

Response of raptors to land transformation

Foraging habitat selection by Palearctic raptors and the role of sex, age, and body mass differentiation

Dspite their hypothesized flexibility to changes in land use, I expected that interspecific (Schipper 1973, Jaksic & Braker 1983, Marti *et al.* 1993, Garcia & Arroyo 2005) or intraspecific differences (Marquis & Newton 1982, Smallwood 1988) in body mass, energy needs, and diet render large Palearctic raptors, or the larger sex of sexually-dimorphic raptors, more vulnerable to land use change than smaller raptors, or the smaller sex (Thiollay 2006a,b, 2007a). Results of the study presented in Chapter 2 confirmed my hypothesis that the vulnerability to land use change of Palearctic raptors may be influenced by gender-specific patterns of habitat selection. In addition, I found evidence for age-specific patterns of habitat selection. Intraspecific differences in foraging distribution was particularly evident in relationship to rice fields for Montagu's *Circus pygargus* and Pallid Harriers *C. macrourus*, as females of both species selected rice fields over the original, naturally flooded grassland habitat, whereas males seemed to avoid rice fields. As a result, sexual dimorphism may result in smaller males of these species being negatively affected by floodplain conversion for rice cultivation, whereas females may profit from an increase in food supply. Contrary to expectations, I recorded limited evidence for interspecific foraging segregation, although the mean prey mass differed significantly between harriers, mainly because heavier species took heavier prey items with greater frequencies, which was related to interspecific differences in body mass which determine food requirements (Nagi 1987, 2005). The interspecific food niche segregation associated with increased landscape and food resource heterogeneity suggests that floodplain development may facilitate co-existence of large numbers of harriers, supporting the general assumption that land use change may be profitable for Palearctic raptors due to increased food supply. Importantly, however, floodplain embankment and subsequent large-scale desiccation of formerly productive, inundated grasslands reduced the foraging habitat quality for harriers over an extensive area, counteracting the positive effect of increased food supply in cultivated fields.

The effect of habitat transformation on nestling diet, growth, nest density and reproductive output in Afrotropical migratory raptors

Although nestling growth in raptors was shown to be affected by productivity and land use in a temperate zone (Newton *et al.* 1979), few data are available for the tropics. As shown in Chapter 4, differences in prey availability with anthropogenic habitat transformation caused a dietary shift in a migratory Afrotropical raptor, the Grasshopper Buzzard *Butastur rufipennis*, during the breeding season. Possibly as a consequence of differences in diet quality and composition, nestling growth parameters, including asymptotic weight, were significantly affected by land use, leading to a superior condition of fledglings in natural habitat compared to those in transformed habitat. This may increase the potential for survival and recruitment of fledglings in natural habitat (Arroyo 2002, McDonald *et al.* 2005). This finding suggests that changes in food supply with habitat alteration might have rather subtle effects, with potentially important consequences for population persistence (Rodríguez *et al*. 2006). Despite the evidence for better food conditions in natural habitats, I

found no significant effect of land use on productivity and nest success in Grasshopper Buzzards (Chapter 5). This was primarily related to the opposing effects of generally more favourable food conditions in natural habitat versus lower losses due to natural predation and longer inter-nest distances in transformed habitat, the latter possibly reducing intraspecific interference and competition (Newton 1979). Thus, transformed habitats may offer particular advantages to breeding Afrotropical migratory raptors in terms of reduced natural predation pressure, which exerted a heavy toll on reproductive output of Grasshopper Buzzards and African Swallow-tailed Kites *Chelictinia riocourii* (Chapters 5, 6).

Chapters 4 and 5 also demonstrated some of the complex trade-offs between food supply and predation risk, through their impact on nestling condition and productivity, for breeding raptors in changing landscapes. Firstly, dietary analyses (Chapter 4) revealed that rodents comprised a larger proportion of the diet of Grasshopper Buzzards in natural than transformed habitat (Chapter 4). This reflected greater rodent availability in natural habitat, which contributed to denser nest spacing, suggesting rodents were an important determinant of habitat quality for Grasshopper Buzzards (Newton 1979). Although I did not find conclusive evidence, differences in rodent supply might also have contributed to the superior nestling condition at fledging in natural compared to transformed habitat (Chapter 4), which is supported by the positive association of rodent availability around nests with nestling survival (Chapter 5). On the other hand, rodent availability around nests was negatively associated with clutch survival (Chapter 5), presumably because high rodent densities attracted predators which also targeted clutches. Overall, no effect of rodent supply around nests on nest success and productivity was recorded. The combined evidence suggests that high rodent abundance in natural habitat enabled higher breeding densities and improved nestling survival compared to transformed habitat, but these advantages appeared to be countered by the greater loss of clutches.

Chapters 5 and 6 further revealed evidence for the impact of habitat transformation, through expanding cultivation and woodcutting, on nest dispersion and reproductive success of Grasshopper Buzzards and African Swallow-tailed Kites. I found that Grasshopper Buzzard nests were more widely spaced in the transformed habitat compared to protected areas, which was associated with the lower food supply and larger area under cultivation in transformed habitat. At the larger inter-nest distances, breeding raptors may experience lower intraspecific interference, or competition (Newton 1979), as suggested by the positive effect of inter-nest distance on nest success (Chapter 5). In Chapter 6, I describe the process of woodland cover loss in the Saloum River delta in Senegal, as a potential driver behind the largest breeding aggregation of African Swallow-tailed Kites known to date. Although further investigations are needed, frequent intraspecific interactions might have contributed considerably to the extremely low breeding output at this site. These results suggest that anthropogenic land transformation may have divergent effects on reproductive output by influencing nest dispersion of Afrotropical migratory raptors, by driving breeding aggregations into restricted habitats, or by lowering breeding densities and thereby the negative effects of intraspecific interactions.

The results of Chapter 4 also demonstrated a positive association between rainfall during the nestling phase, and nestling growth rate, suggesting that seasonal rains provide a crucially important food stimulus (e.g. insects, amphibians; Thiollay 1978a, Njiforti 1997) which enhanced nestling growth. In line with these results, I found a positive relationship between rainfall and Grasshopper Buzzard nest success and productivity (Chapter 5). These results add to existing evidence of the positive role of rainfall on raptor productivity in arid African savannas (Hustler & Howells 1990, Wichmann *et al.* 2003). It is interesting, in this regard, that Thiollay's transect counts were conducted at the start (1969-1973) and following (2000-2004) an exceptionally severe drought in the Sahel region, between 1968–1997, one of the most severe of the 20th century (Hulme *et al.* 2001). Although the extent of the decline caused by suboptimal rainfall is unknown, it is evident that this circumstance must have impacted the results of his surveys. My results suggest that climate change and ecological change of the wintering grounds may have acted synergistically to decrease resource availability for raptors, notably those Afrotropical migrants breeding in the Sudano-Sahelian savannas.

The impact of habitat transformation on diet and foraging in a sedentary Afrotropical raptor

Chapter 7 provides insight into the impact of habitat transformation on foraging in sedentary Dark Chanting Goshawks *Melierax metabates*. Contrary to expectations based on our studies of Grasshopper Buzzards (Chapter 4), and other raptors (e.g. James & Smith 1987, Pande *et al*. 2007, Ogada & Kibuthu 2009), habitat alteration did not prompt a dietary shift in male Dark Chanting Goshawks. Instead, habitat modification increased prey accessibility while lowering prey quality; I found that goshawks in transformed habitat compensated for smaller, less profitable prey items by higher prey capture rates compared to natural habitat. Herbaceous layer height and tree density at the range-level negatively impacted capture rates by goshawks, suggesting that anthropogenic changes to the vegetation (e.g., from livestock grazing, fires, herbicide use, wood cutting) improved prey accessibility, thus compensating for lower prey energy content in man-altered habitat. However, patch-level selection for tall trees and high tree density, shrub cover, and dense herbaceous cover by hunting goshawks appeared to be primarily related to optimization of prey biomass, suggesting that vegetation clearance negatively impacted important microhabitats for lizard and rodent prey populations (Cooper & Whiting 2000, Meik *et al.* 2002). Thus, to a certain degree, grazing and woodcutting favor Dark Chanting Goshawk foraging, but heavy and extensive wood cutting, tree pruning and grazing pressure may suppress the abundance or quality of prey resources; at a certain point, degraded landscapes may become too impoverished to sustain breeding pairs of sedentary raptors.

Sensitivity to habitat modification: the role of Afrotropical or Palearctic breeding distribution, body size and migratory behaviour

Studies of Palearctic raptors wintering in Africa have shown that winter populations can be abundant in, or even particularly attracted to, man-modified habitats (Herremans & Herremans-Tonnoeyr 2000, Anadón *et al.* 2010, Limiñana *et al.* 2012). My results (Chapters 2, 8, 9) add to various other studies which tend to support high adaptability to man-modified landscapes by some Palearctic migrants (Moreau 1972, Morel & Morel

1992, Jones *et al.* 1996, Wilson & Cresswell 2002). Conversion of floodplains, for example, may create habitat mosaics with abundant and varied food resources for Palearctic raptors, enabling the co-existence of large multi-species assemblages (Chapters 2, 9). The flexibility of Palearctic raptors to cope with changing conditions is further apparent by their shifting distributions in response to changes in prey availability (Chapter 9, Figure 3).

Despite the general indifference of Palearctic raptor community richness to land use at a 5-km scale (Chapter 8), my results illustrated that some species may profit from anthropogenic land use change, at least locally, whereas others appear mostly negatively affected. Monthly surveys on the Waza-Logone floodplains indicated that Eurasian Marsh Harrier *Circus aeruginosus* and Booted Eagle *Hieraaetus pennatus* preferably foraged over rice crops compared to other habitats (Chapter 9), Booted Eagle also responding positively to cultivation at a larger spatial scale (Chapter 8). On the other hand, the large-scale deterioration of grasslands, through heavy grazing and as a by-product of embankment for irrigated rice schemes (Chapter 2), may depress habitat quality for Palearctic raptors dependent on food resources in such grasslands. Depleted insect prey resources might particularly impact smaller, predominantly insectivorous Palearctic raptors, which appear to profit little from abundant rodent populations in cultivation (Chapters 2, 8, 9), while their high site fidelity and dependence on restricted, seasonally productive habitat, such as floodplains, increases their vulnerability to conversion of such habitats (Thiollay 1989, Limiñana *et al.* 2012, Trierweiler *et al*. in press). Increasing droughts and locust control operations add to such threats by further reducing insect prey populations (Sánchez-Zapata *et al.* 2007, Mihoub *et al.* 2010).

As hypothesized, the richness of the Afrotropical raptor assemblage was negatively associated with man-modified habitat, including croplands (Chapters 8, 9), suggesting Afrotropical raptors were generally more sensitive to habitat conversion than Palearctic raptors. This might be explained partly by their morphological adaptations, which constrain exploitation of abundant food sources in open, seasonally productive habitats (Thiollay & Clobert 1990) or as a result of human disturbance and persecution associated with cultivation (Chapter 5). However, model results did reveal that small to moderate loss of original habitat in largely untouched, dense Guinea woodlands, was positively associated with Afrotropical raptor richness, possibly because it allowed exploitation of rich prey resources to generalist raptors adapted to more open habitats (Rodríguez-Estrella *et al.* 1998, Anderson 2001). As hypothesized, I found evidence that the sensitivity of raptors to land use appeared to depend on body size, with corresponding food needs and area requirements (Newton 1979, Machange *et al.* 2005), at least in the Guinea savannas. The finding that large raptor richness decreasing with distance from protected areas supported previous results of the particular importance of the region's protected areas for sustaining populations of large eagles and vultures (Thiollay 2006a, 2007a).

The results of the habitat association models indicated that the Afrotropical migrant assemblage profited locally from moderate anthropogenic disturbance (Chapter 8), which may favor their hunting strategies (Thiollay & Clobert 1990), whereas the sedentary raptor assemblage responded negatively to anthropogenic land use across biogeographical zones.

However, the vulnerability to land modification by Afrotropical migrants varied with breeding status or landscape context, or a combination of both. For example, Afrotropical migratory Grasshopper Buzzards were positively associated with agriculture in Guinea savannas (Chapter 8), where populations spend the non-breeding season (Thiollay 1978a) and they might have profited from increased prey availability and accessibility resulting from agricultural activities. In contrast, nest density and presence was positively related to habitat preservation in the Inundation zone, where they breed (Chapters 5, 8). These results suggest that sensitivity to land use change varies seasonally and between biogeographical zones, according to the timing and location of breeding, which may confound assessments of vulnerability to habitat change if such factors are not taken into consideration.

The role of protected area coverage and land use on biogeographical patterns of abundance, richness, and diversity of raptors in West African savannas
As hypothesized, I detected clear patterns of raptor abundance, richness and diversity between Cameroon's biogeographical zones, which vary in their extent of habitat preservation (Chapter 10). My results suggest that human-induced habitat modification influenced raptor communities at the landscape scale in Cameroon, leading to greater abundance within potentially suboptimal habitat at the periphery of distribution ranges. This contrast general patterns of species abundance, which tends to decline in peripheral areas of distribution ranges (Brown *et al*. 1995) where conditions are less favorable (Pulliam 2000, García & Arroyo 2001) and sensitivity to habitat alteration higher (Swihart *et al.* 2003). I conclude that extensive habitat modification resulting from anthropogenic land use and the absence of protected areas may override the dominant role of biogeographical zonation in shaping community patterns of West African raptors.

Together, the rich assemblage of Palearctic winter and passage migrants and Afrotropical raptors highlight the importance of West African savannas as a focal point for raptor conservation, especially given the immense pressure from human populations. Protected areas have an important role in shaping landscape-scale patterns (Chapter 8, 10), and might act as source areas for raptor populations, thus ensuring preservation of the integrity of the raptor assemblage at the landscape-scale. However, the current protected area network in West Africa may not adequately cover the range of habitats necessary to maintain the diverse assemblage of species, including migratory populations with almost constantly shifting populations, and further studies are urgently needed to identify causes for the decline of Afrotropical raptors inside the region's protected areas.

11.2 Recommendations

Management recommendations emanating from this thesis would be to conserve trees or, preferably, patches of woodland, shrubland and pasture among crop fields, as they supply nest sites, foraging perches, and vital resources for prey populations exploited by raptors in agro-ecosystems. The commitment to develop more intensive agricultural strategies in Africa could limit the land converted to agriculture compared to the current low-input extensification of African agriculture (World Bank 2009), and may be seem as a favorable development. However, the introduction of new crops and changes in farm size for

commercial farm development are likely to further reduce natural vegetation cover in croplands, with detrimental consequences particularly for Afrotropical raptors. Implementations of intensive agriculture (e.g. cotton; Chapter 8) may carry additional costs for raptors exposed to heavy pesticide use, through secondary poisoning (Mullié *et al*. 1991, Keith & Bruggers 1998). Applications of pesticides toxic to birds may be particularly detrimental in areas with high raptor abundance: around National Parks and on floodplains, where Afrotropical and Palearctic raptor abundance peaks (Chapter 10), and in rice fields, with large concentrations of Palearctic raptors (Chapter 9). Although predation by raptors was shown to have little effect on the population dynamics of *Mastomys natalensis*, a major rodent pest in tropical Africa (Vibe-Petersen *et al*. 2006), raptors could be promoted as valuable predators aiding the control of grasshoppers and locusts (Fowler *et al*. 1991, Mullié 2009), and assisted through supplementation of perches (Sheffield *et al*. 2001).

Since implementation of some of the above-mentioned measures in a vast region is extremely challenging, conservation efforts for Afrotropical raptor populations should best focus on maintaining the functions of those areas which are key to their preservation at wider landscape scales: the protected areas and their peripheral zones (Chapter 5, 8, 10). Improved protection of the National Parks, with restrictions on incursions by shepherds and poachers into National Parks, is a necessity to prevent disappearance of endangered raptors from such key areas for their conservation. This would reduce disturbance at nest sites and often unsustainable harvesting of vertebrate prey resources inside protected areas (Brashares *et al.* 2001). To further accomplish this, co-management regulations pertaining to exploitative utilization of resources (e.g. wood, fish) inside protected areas, some ill-devised and little regulated (Scholte 2003), also need to be revised where appropriate, as some directly or indirectly affect raptor food availability and nest security.

Since large raptors are vulnerable to factors operating beyond protected areas, such as direct persecution (Herholdt & Kemp 1997, Ogada & Keesing 2010), a major objective should be to increase the extent of strict protected areas, although this may pose challenging given the low per-capita gross domestic product in the region (Musters *et al.* 1999, McDonald & Boucher 2011). Given such constraints, the protection of reserves needs to be integrated with compensating mechanisms that promote the economic value of the ecosystems inside and around parks for local communities (Kramer *et al.* 1997, Clerici *et al.* 2006). Hereto, buffer zone management around many protected areas may need to be re-evaluated, which includes strategies to resolve growing human-wildlife conflict (Weladji & Tchamba 2003), a more equitable distribution of wildlife revenues generated from tourism or hunting (Mayaka *et al.* 2005), and a limit to human immigration flow into buffer zones (Newmark 2008). Such measures, together with appropriate silvicultural practices encouraged, enforced, and implemented by state and traditional authorities, with limitations on agricultural expansion, might ensure continued persistence of intact raptor communities in a large part of the West African savanna region.