



The Impact of Land Use Change on Migrant Birds in the Sahel

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The Impact of Land Use Change on Migrant Birds in the Sahel

Abstract

Drought and environmental degradation in the drylands of the West Africa are widely cited as a possible cause of population decline in migrant birds that winter or stage in the Sahel. Low rainfall was an important factor in declines of long-distance migrants in the 1960s and 1970s, but longer-term declines are likely to be complex in causation, affected by factors operating on any or all of breeding grounds, migration routes or wintering grounds. Human activities have had profound effects on land use in the Sahel in the last four decades, as farmers, livestock keepers and other resource users have responded to drought and economic and social change. Localized ecological studies of habitat use by migrant birds in the Sahel have been undertaken, but a systematic understanding of the place of land use change in the decline of Afro-Palaearctic migrants is still lacking. This paper uses a systematic review of published scientific literature to assess the evidence base for the links between dryland environmental change in the Sahel and numbers of migrant birds that winter in this regions. It analyses the extent to which understanding is based on fieldwork in the Sahel itself and concludes that, despite the scientific consensus about the significance of human land use change on bird numbers, field evidence is greatly lacking. The two land use changes for which most evidence exist are loss of wetland and woodland habitats for which impacts on migrant bird species are largely, but not uniformly, negative. More direct research on the links between bird populations and dryland land use change in the Sahel is urgently needed.

Keywords: Sahel, migrant birds, Afro-Palaearctic, land use change, environmental degradation,

Introduction

A number of bird species that breed in Europe and migrate to Africa in the non breeding season (Afro-Palearctic migrants) are suffering population declines (Vickery et al. 2014). The causes of decline are likely to be complex because populations may be limited by factors operating on any or all of breeding grounds, migration routes or wintering grounds. However, a common explanation for population declines in Sahel migrant birds is environmental degradation caused by drought and associated land use change (e.g. Grimmett 1987; Jones et al. 1996; Vickery et al. 1999; Wilson and Cresswell 2006; Cresswell 2007; Zwarts et al. 2009).

Declines in species wintering in the arid savannas of the sub-Saharan Sahel zone during the non-breeding season have been associated with drought in these wintering areas since the 1970s (Winstanley et al. 1974). Rainfall in the Sahel is extremely variable, both inter-annually and over the longer term (Grist and Nicolson, 2001) but was generally above the long-term (100 year) average between 1920-1967 but below it between 1968-1985. In fact, the early 1970s were a period of rainfall failure and famine in the Sahel, and coincided with population declines in many of the migrant bird populations wintering in these drought-affected dryland habitats (Vickery et al. 2014). The annual survival of many migrant species that spend the northern winter in the Sahel has subsequently been linked to rainfall in that region (e.g. Peach et al. 1991; Zwarts et al. 2009; Norman and Peach 2013). However, whereas declines in migrants wintering in the Sahel in the 1960s and 1970s were linked to climatic variation, there is no obvious climatic link with the more recent declines. Annual rainfall has increased since 1986 and, in 2009 and 2010, rainfall levels once again, reached or exceeded the long term average.

The severity of the 1972-74 drought fuelled concerns that a process of 'desertification' was taking place in the Sahel. In 1935, Stebbing had argued that the Sahara was moving southwards, as open deciduous forest was progressively degraded by burning and shifting cultivation, grazing, browsing, and pollarding by pastoralists. The notion was revised, and widely repeated by scientists (e.g. Sinclair and Fryxell 1985), discussed at a United Nations conference in Nairobi in 1977, and became

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widely accepted as proven (Swift 1996). However, researchers soon began to highlight differences between very variable rainfall patterns and more persistent patterns land cover change (Warren 1993, 1996; Middleton and Thomas 1997). Analysis of long term, historical rainfall records demonstrated the high variability of rainfall between years: droughts are characteristic of the Sahel, disastrous when they come, but perfectly ‘normal’.

However, land use change has certainly taken place in the Sahel. The region is intensively managed for agriculture and pastoralism (Mortimore 1998; Raynaut 1998; Mortimore and Adams 1999) and human activities have had profound effects on land use in the Sahel in the last four decades. Change has resulted from the ways farmers, livestock keepers and other resource users have responded to drought as well as to economic and social change. As Sahelian countries have been integrated into the world economy, economic development has been rapid and agricultural intensification intense (Cour 2001).

This has brought changes in land cover over large areas, as land is brought into agricultural production, and fallow periods decline. Agriculture has both extended onto previously uncultivated land, and become more intensive, with shorter fallow periods, and increasing use of fertilisers, pesticides and irrigation. Livestock management has been transformed by changes in cattle ownership, in movements by pastoral people between ecological zones and across borders, and because of agricultural expansion. Areas of woodland have been more intensively cut for firewood, charcoal production and livestock browse, and forest and grazing reserves have been subject to more intensive use (both legal and illegal). The extent of Sahelian wetlands has been reduced by the construction of dams for hydro power and irrigation. The spatial patterns of land use change and the associated drivers are numerous and highly complex (Benjaminsen 2001; Tappan and McGahuey 2007; Brink and Eva 2008).

Localized ecological studies of habitat use by migrant birds in the Sahel have been undertaken, but systematic understanding of the place of land use change in the decline of Palaearctic migrants is still lacking. Whilst recognizing that similar habitats are occupied by some afro-palaearctic migrants elsewhere in Africa (e.g.

Salewski et al. 2002; Salewski and Jones 2006), we therefore undertook a systematic review of knowledge of the links between land use change and population decline in migrant birds that winter or stage in the Sahel. We seek to assess the extent to which scientists writing papers about Sahelian migrants believe land use change in West Africa is an important driver of change. We examine the extent to which the evidence they draw on, in making this assessment, is the result of fieldwork in the Sahel or based, for example, on measures of population change derived from the breeding grounds. We then use those studies that are based on fieldwork in the Sahel to assess the nature and importance of land use change on habitat suitability for migrant birds.

Methods

This paper uses systematic review, an established method in conservation science (Pullin and Stewart 2006; Stewart et al. 2007), to undertake a qualitative analysis (Graneheim and Lundman 2004) of the scientific evidence for the commonly held view of the importance of land use change in the Sahel in the decline of birds migrating to breed in Europe. Specifically, we investigated how many of the papers making reference to the significance of Sahelian land use change in migrant bird numbers, did so using field-based empirical data from the Sahel. We reasoned that a conclusion so widely accepted would be likely to be based on strong data from the region where the alleged effects were taking place.

Our review therefore asked this research question: *to what extent do scientific papers making reference to the significance of land use change in the Sahel for declines of Afro-Palaeartic migrant birds use field-based empirical data from the Sahel.* We identified two specific sub questions:

1. What proportion of scientific papers referring to links land use change and migrant bird populations use bird data from the Sahel?
2. What proportion of these report new quantitative data on land cover or land cover change?

The Afro-Palaeartic species used for the analysis consisted of 68 African-Eurasian identified by Atkinson et al. (2014). The categories of environmental change of concern were : desertification; degradation; climate change; land use; drought;

deforestation; greening; human population growth; over-grazing; fuelwood; rainfall.

We used both online bibliographic databases and Internet search engines (Table 1). We selected papers that met the following criteria (the selection criteria referred to in Figure 1, filter 2)

- 1) Paper discusses the status of Afro-Palaeartic migrant birds that winter in the Sahel or dryland West Africa and refers to one or more of the following: desertification; degradation; climate change; land use; drought; deforestation; greening; human population growth; over-grazing; fuelwood; rainfall.
- 2) Paper was published in an English language peer-reviewed journal

Table 1 here
Figure 1 here

This generated a list of 2792 papers. From this list, papers were selected for analysis, by applying four filters of increasing rigour (Figure 1). At all stages of the review process the numbers and identities of articles retrieved, accepted or rejected were recorded. We eliminated spurious hits by reading paper titles (filter 1, leaving 591 papers); determined relevance based on abstracts (filter 2, 155 papers), and checked the list with peer reviewers, who augmented the list with 3 additional papers (filter 3, leaving 159 papers). The final filter (4) left 20 papers containing new field based data on birds from the Sahel or more broadly from dryland West Africa, and quantitative data or direct qualitative or observations of land use change (Table 2).

Results

a) What proportion of scientific papers referring to land use change and migrant bird populations use bird data from the Sahel?

A total of 159 papers discussed the status of migrant birds in the context of land use change in the Sahel (following filter 3, Figure 1). Of these, only 60% (n=95) made reference to specific land use changes in the Sahel (as opposed to simply referring to change in general). Of these 95 papers, 75 (79%) were not based on fieldwork or data collected in the Sahel region, but discussed changes in bird numbers on Palearctic breeding grounds. For example, Peach et al. (1991) analyzed inter annual changes in

breeding numbers in relation to rainfall in the Sahel.

Our expectation was that, after the 4th filter, the majority of papers would be based on field research in the Sahel. However instead only a small proportion of papers relating to birds and land use change in the Sahel drew on in-region ornithological fieldwork. Only 20 papers discussed land use change in the Sahel using bird data actually collected in the Sahel (Table 2). Of these, 55% contained primary¹ data (n=11), 30% secondary² data (n=6), and 15% referred to either primary or secondary data regarding land use change.

b) What proportion of scientific papers referring to land use change and migrant bird populations use report new quantitative data on land cover or land cover change?

The 20 papers that used new data on birds the Sahel and referred to land use change were coded (c.f. Brooks et al. 2005) to classify the nature of the evidence used as the basis for discussion of the link between land use change and birds. Five categories were used (see Table 2). Assigning these 20 papers to one or more of five categories revealed that, as for the bird data, few actually contained new quantitative data on land use (category 1; n=6) or referred to published quantitative data on land use change (category 3; n=4) in the region of interest.

Table 2 here

The studies that did provide direct evidence of land use change impacting on wintering migrant birds identified two forms of land use change as of particular importance (c.f. Atkinson et al. 2013, Vickery et al. 2014). The first was the loss, through desiccation, of wetland habitats, usually linked to changes in water management (e.g. dams for irrigation and power generation) and variations in annual rainfall, and the second was the loss of trees in wooded savannahs linked to clearance for agriculture, wood fuel and grazing.

¹ Primary data was classed as either new formal survey data on vegetation or land cover or qualitative observations on vegetation or land cover in a specific area and over a specified period of time

² Secondary data was classed as either published paper (s) containing quantitative data on land cover change in the region or published paper(s) containing general remarks on land cover change in the region

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Discussion

Land use has been changing rapidly and extensively in Sahel for many decades. West Africa is a region of rapid social and economic change. Its population rose from 70 to 318 million from 1950 to 2010, and is projected to double by 2050. Urbanisation is rapid, and population and urban growth have important implications for food security, household incomes, regional markets and land use. Rural land management for agriculture and livestock has changed in response to drought and economic change (Mortimore 1998; Raynaut 1998; Mortimore and Adams 1999). As Sahelian countries have been integrated into the world economy economic development has been rapid and agricultural intensification intense (Cour, 2001).

Land use in the Sahel is broadly limited by rainfall (200-600mm, marginal for rainfed crops), short and variable rainy season, and isolation from markets. Even under traditional systems, farmers and herders carefully manage soil fertility (Mortimore and Harris, 2005), tree cover and biomass (Mortimore et al.1999, Gautier et al., 2005). Fertilisers, pesticides and irrigation are increasingly transforming production systems. Locally, land may be degraded as bird habitat as use intensifies. Thus in many regions of the Sahel, shrubland and woodland have been converted to farmland (Tappan et al. 2004; Tappan et al. 2000); Odihi 2003; Cresswell et al. 2007). However, studies also report the ‘greening’ of the region, as vegetation recovers from the dry decades of the late twentieth century (Olsson et al., 2005). Economic factors influencing land use decisions by farmers or livestock-keepers vary in both space (between counties, and between ecological regions within countries) and in time (as economic and other drivers change). As a result, patterns of land use change are complex and differ across regions, dependent on factors such as access to urban markets (Benjaminsen, 2001; Tappan and McGahuey, 2007; Brink and Eva, 2008).

It would be surprising if the extensive changes in land management and land cover taking place in the Sahel as the region develops did not have an effect on the wintering Afro-Palaeartic migrant birds. It is therefore not surprising that these

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3 impacts are widely assumed in the literature, with population declines of Afro
4 Palearctic migrant birds on their breeding grounds in Europe linked to land use
5 change in the Sahel, either as a result of drought or human activity or the interaction
6 of the two.
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11 However, our analysis shows a remarkable lack of direct evidence for such an
12 apparently widely accepted explanation in the scientific literature. We identified just
13 20 papers that related land use change in the Sahel to migrant bird declines using data
14 collected in the Sahel. Much of the other literature in this area relates to changes in
15 bird populations from breeding surveys in Europe, rather than on the wintering
16 grounds themselves, and much of the evidence of land use change is usually
17 qualitative observations or anecdotal. Only one study actually measured changes in
18 bird numbers over time (Cresswell et al. 2007) and none did so at anything above the
19 local scale.
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28 The studies that did provide direct evidence of land use change impacting on
29 wintering migrant birds identified two the loss of wetland and wooded savannahs
30 habitats as the two most important changes. The Sahel contains important seasonal
31 wetlands on major river systems (e.g. the Niger Inland delta, river floodplains), and
32 Lake Chad. The construction of dams for irrigation and hydro-electric power
33 generation have affected flooding patterns in all major Sahelian rivers (Adams 1992,
34 Zwarts et al. 2009). These anthropogenic impacts interact with (and are exacerbated
35 by) variations in annual rainfall, and the persistence of short and poor rainy seasons.
36 Changes in river flooding patterns are also associated with changed in wetland land
37 cover, for example the replacement of grassland, woodland and scrub with irrigated
38 fields. The impacts of the linked changes on birds are widely recognised (Zwarts et
39 al. 2009).
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49 The papers reviewed tend to focus on particular locations. However as the review by
50 Zwarts et al. 2009) notes, pressures differ across and between the major Sahelian
51 wetlands, such as Inner Niger Delta and Lake Chad basin, and therefore affect
52 different populations and species. The impact of wetland change also varies
53 considerably between species. For example ruff (*Philomachus pugnax*) and black-
54 tailed godwit *Limosa limosa* forage on rice fields and may benefit from conversion of
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floodplains to rice crops. Similarly some raptors may utilize rice fields for hunting and could benefit from the conversion of annually flooded land to agriculture (Cenin 2010). On the other hand, species that rely on wet grasslands, such as sedge warblers (*Acrocephalus schoenobaenus*) that rarely uses cultivated rice, irrigation impacts are detrimental. Many species of waterfowl and passerines utilise well-flooded perennial grasslands during winter (Zwarts et al. 2009), a habitat that is often lost after damming because vegetation shifts towards annual grasses. Indeed, small-scale rehabilitation of the Logone floodplain, Cameroon, to reverse this habitat change was accompanied by increases in waterfowl and passerines (Scholte et al. 2000), and reviewed papers report show high avian diversity associated with temporary wetlands and waterways (e.g. Nøhr and Jørgensen 1997). On the other hand, severe flooding and persistent standing water can be detrimental for species such as the yellow wagtail *Motacilla flava*, as it effectively destroys foraging habitat (Bell 2007)

The second significant form of land use change identified as impacting Afro/Palaearctic migrant birds was the loss of trees in wooded savannahs through, for example, clearance for agriculture, wood fuel and grazing may have a particularly detrimental impact on wintering migrant passerines such as common whitethroat (*Sylvia communis*), whose decline in the 1970s first alerted bird researchers to the significance of environmental conditions in the Sahel for breeding bird numbers in Europe (Winstanley et al. 1974). These ‘woodland’ species are more likely to occur in areas of high tree density or diversity and on farmland where large trees and hedgerows remain. On the other hand, this loss of trees may benefit some open country species such whinchat (*Saxicola rubetra*). The evidence for an impact of forest loss on ‘larger birds’ such as raptors is less convincing, reflecting the difficulty of relating the density of birds that range over vast distances to location specific habitat change. The extensive work of Thiollay in West Africa (e.g. 2006a, 2007) documents dramatic declines of resident and migrant raptors and vultures but does not identify any specific underlying cause.

Several studies provide evidence of a detrimental impact of loss of tree cover on wintering migrant birds, particularly passerines. (e.g. Jones 1985; Jones et al. 1996; Wilson & Cresswell 2006; Cresswell et al 2007). As for wetland change impacts differ between species and may not be entirely negative. Thus deforestation has been

shown to have a negative impact on common whitethroat *Sylvia communis* and subalpine warbler *Sylvia cantillans* but increases in western Bonelli's warbler *Phylloscopus bonelli*, yellow wagtail (Cresswell et al. 2007) northern wheatear *Oenanthe oenanthe* (Wilson and Cresswell 2010) and whinchat (Hulme and Cresswell 2012). Dry season farmland, which was derived largely from wooded savannahs, can often support good numbers of open country species such as wheatear and whinchat. One study revisited woodland sites over a number of years and been able to demonstrate loss of woodland species as a result of loss of woodland habitat and a concomitant increase in open country species (Cresswell et al 2007).

Less strong evidence of the impact of tree loss comes from habitat preference and selection studies that demonstrate, for a number of warbler species, higher density or higher likelihood of occurrence in areas of high tree density or diversity (Vickery et al. 1999; Jones et al. 1996). Although species like common whitethroat, lesser whitethroat *Sylvia curruca* and subalpine warbler can occur across a wide range of habitat types with varying tree density and species composition. Rather few studies have suggested specific tree species are important, although a diversity of species may be valuable (Vickery et al. 1999) with one exception – the shrub *Salvadora persica*. The fruits of this shrub have been suggested to be an important part of the pre migratory fattening diet for species such as common Whitethroat (Jones 1985; Stoate and Moreby 1995) making them potentially vulnerable to the disappearance of this shrub species

This lack of evidence reflects the weight of research on Afro-Palaeartic migrants that is confined to Europe. Reasons for this are easy to identify. First, there are more researchers in Europe, and greater financial and technical/scientific resources for research in Europe; second, field work in the Sub Saharan West Africa is more logistical challenging, more costly, seems more risky and in some cases is impossible due to political instability and insurgency in the region. It is therefore obvious why 'on the ground' information linking land use change in the Sahel to migrant bird declines is so scarce. However, the implications of this lack of an empirical basis for such a widely held view is surprising and significant.

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There appears to be a considerable knowledge gap between what is known from field evidence, and what is assumed in the literature. Filling this gap is an urgent priority. We suggest four dimensions of action needed. First, we agree with (Vickery et al. 2014), that detailed field study of migrant birds in sub-Saharan West Africa is a priority. Intensive field research is needed to identify the mechanistic links between the impact of changes in rainfall and land use in areas like the Sahel and population change of migrant birds (e.g. Maggini and Bairlein 2011; Arizaga et al. 2013). Extrapolating from localized ecological studies of habitat use by migrant birds in the Sahel to a systematic understanding of the place of land use change in the decline of Palaearctic migrants is an enormous challenge. However, the value of these localized studies can be greatly enhanced by capitalising on the use new emerging tracking technologies to identify key wintering and staging areas at which to undertake them (e.g. Bächler et al. 2010; Catry et al. 2011 Åkesson et al. 2012; Bairlein et al. 2012,).

Second, there is a need for research on actual patterns of land cover and land use change in sub-Saharan West Africa. There is potential to improve use of existing remote sensing earth observation data to analyse land cover change, both to improve understanding of how and where land cover is changing and how this relates to Afro-Palaearctic migrants. Future advances in technology towards higher high-resolution satellite imagery may allow differences in land cover relating to the habitats that affect migrant distribution to become resolvable.

Third, there is need for a new international commitment to field research capacity in West African countries. Both scientific understanding of the African-Palaearctic migration systems and conservation of the species concerned require a flyway approach that involves a significant transfer of scientific resources and expertise to Sub Saharan West Africa.

Finally, understanding and addressing the impacts of land use change demands an understanding of the drivers of change. Many migrant species occur at relatively low densities on land that is owned and managed by rural people living in great poverty. A classic conservation strategy based on the establishment of protected areas is unlikely to prove effective. These are birds of farm and grazing land, and their conservation in winter in the Sahel, as in summer in Eurasia, demands a landscape-

scale approach that incentivises landholders to manage their land in ways that support their survival. Research on habitat use by birds therefore needs to be closely linked to research on the ways land is managed for crops and grazing, and the economic drivers of changes that affect birds. The future health of Afro-Palaeartic migrant birds is inextricably linked to the future livelihood security of the people of Sahelian countries.

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Figure 1. Filters applied to 2792 papers mentioning land use in the Sahel and decline of Afro-Palaeartic migrant birds.

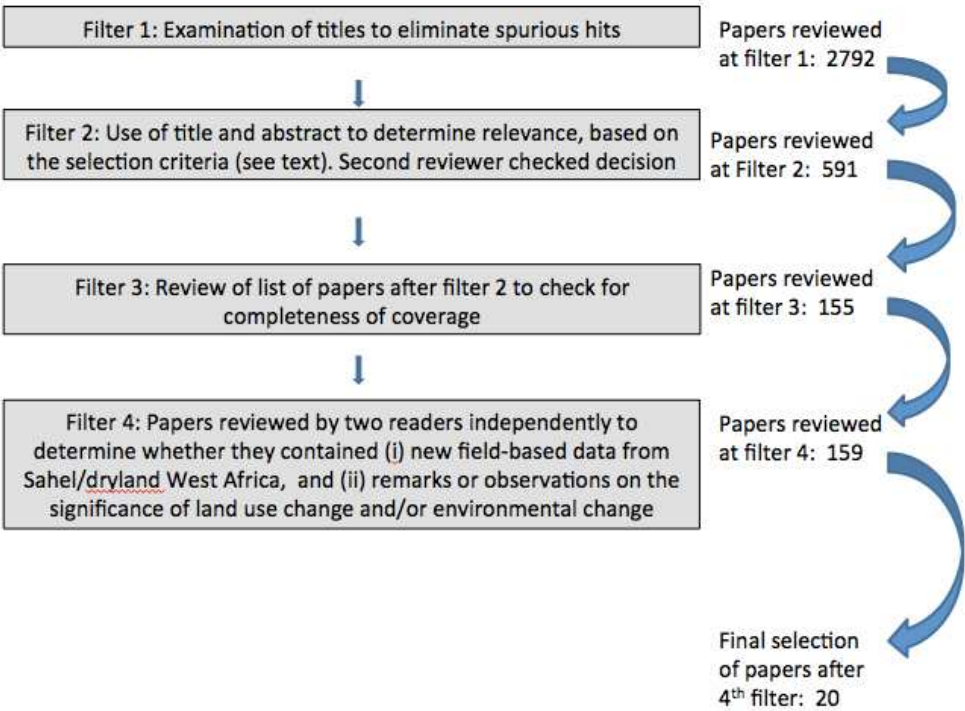


Table 1. Databases Searched for papers relating land use change in the Sahel for declines of Afro-Palaeartic migrant birds

Online Bibliographic Databases	<ul style="list-style-type: none"> • Scirus (URL http://www.scirus.com) • ISI Web of Knowledge (URL http://www.isiwebofknowledge.com/)rainfall • Copac (URL http://copac.ac.uk/) • JSTOR the Scholarly Journal Index to Theses Online (1970–2005; URL http://www.theses.com/)Archive (URL http://www.jstor.org/) 	<ul style="list-style-type: none"> • migrant bird* AND sahel* • migrant bird* AND sahel* AND environmental change* • migrant bird* AND sahel* AND desertification • migrant bird* AND sahel* AND degradation • migrant bird* AND sahel* AND climate change • migrant bird* AND sahel* AND land use • migrant bird* AND sahel* AND drought • migrant bird* AND sahel* AND deforestation • migrant bird* AND sahel* AND greening • migrant bird* AND sahel* AND population growth • migrant bird* AND sahel* AND over-grazing • migrant bird* AND sahel* AND fuelwood • migrant bird* AND sahel* AND (Boolean search * denotes wildcard)
Internet search engines	Google Scholar (English) (top 500 hits only) (http://scholar.google.co.uk/)	migrant bird* AND sahel*

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Table 1. Categories of land cover information used in papers on migrant birds in the Sahel

Author and Date	1. New formal survey data land cover	2. Qualitative observations on or land cover in specific area and period of time	3. Published quantitative data on land cover change in the region	4. Published general remarks on land cover change in the region	5. No specific citation to research on land cover change in the region
Bell 2007					
Catry et al. 2011					
Cresswell et al. 2007					
Cresswell et al. 2009					
Dami and Manu, 2008					
Hulme and Cresswell 2012					
Jones et al. 1996					
Nøhr and Jørgensen 1997					
Scholte et al. 2000					
Soderstrom et al. 2003					
Stevens et al. 2010					
Stoate 1998					
Thiollay 2006a					
Thiollay 2006b					
Thiollay 2006c					
Thiollay 2007					
Vickery et al. 1999					
Wilson and Cresswell 2006					
Wilson and Cresswell 2010a					
Wilson and Cresswell 2010b					

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Biographical Notes:

Bill Adams is Moran Professor of Conservation and Development in the department of Geography, University of Cambridge. He has worked on dryland agriculture and the impacts of dams and irrigation schemes in Africa, and now mostly works on social dimensions of conservation projects. He is currently studying the institutional politics of landscape scale conservation.

Rob Small works in the Africa Programme of Fauna & Flora International. He has previously undertaken research at the University of Cambridge (funded by the UK Darwin Initiative) on *Socio-economics of sustainable insect farming in Papua New Guinea*, and worked with Tenkile Conservation Alliance in the Torricelli Mountains of Papua New Guinea.

Juliet Vickery is Head of the International Research Section at the Royal Society for the Protection of Birds, undertaking research with international partner organisations to underpin the conservation of biological diversity at the species, site and habitat level. She has a particular interest in Palearctic migrants wintering in Africa in Nigeria, Ghana, Burkina Faso and Zimbabwe.

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