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The Ndiael, a former floodplain at the brink of change from dry to wet.

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Cover photo
P. Robinson. Yowre mare under wet conditions (Jan. 2014)

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Contents

The Grande Mare of the Ndiael, the actual Ramsar site in September 2011, with B. Diagne posing next to the signpost.

Abstract

A strongly degraded natural reserve in the lower Senegal delta, the Ndiael, has been subject of multiple attempts for ecological restoration. Being cut off from the natural flood in the 1960's its potential for fisheries, livestock-grazing and as a wintering or breeding site for birds has been hampered greatly for more than forty years. It has long been recognised that artificial inundation would be the key to create change in the Ndiael, as in the nearby Diawling National Park (Mauritania). In 2010 and thereafter local efforts contributed to in a small increase in inundated area. Subsequent joint actions with the newly installed regional water body led to a well defined, and financed, plan to structurally organize the hydrological system, which will allow for such inundations on a yearly basis at larger scale. The reserve authorities have supported local communities to organise themselves and participate in the management of the reserve. A local team has mapped the baseline situation in terms of habitats and birds and formulated elements for the future management plan. In spite of the lack of water, the reserve harbours considerable diversity, but there are clear threats. The most important of these are the illegal cutting of wood, and the tensions between a recently installed agro-business, small holders and the development of natural values.

Résumé

Une réserve naturelle fortement dégradée dans le bas delta du fleuve Sénégal, le Ndiael, a fait l'objet de plusieurs tentatives de restauration écologique. Etant coupé de l'inondation naturelle depuis les années 1960, son potentiel pour la pêche, l'élevage et le pâturage et son statut de site d'hivernage et de reproduction pour les oiseaux a été grandement entravé depuis plus de quarante ans. Il a été reconnu depuis longtemps que l'inondation artificielle serait la clé pour créer un changement dans le Ndiael, comme c'est le cas dans le Parc National du Diawling voisin (Mauritanie). Ainsi, à partir de 2010 les efforts entrepris au niveau local ont contribué à une légère augmentation de la zone inondée. Des actions communes ultérieures comme l'organisation de la gestion de l'eau (nouvellement installée) a conduit à un projet bien défini et financé, prévoient d'organiser structurellement le système hydrologique. Celui-ci permettra d'aboutir à ces inondations sur une base annuelle à plus grande échelle. Les autorités de la réserve ont soutenu les communautés locales à s'organiser et à participer à la gestion de la réserve. Une équipe locale a cartographié la situation de référence en termes d'habitats et oiseaux et éléments formulés pour le futur plan de gestion. En dépit du manque d'eau, la réserve abrite une biodiversité considérable, mais il y a des menaces claires. Le plus important d'entre eux est la coupe illégale de bois, et les tensions entre une agro-entreprise récemment installée, petits propriétaires et le développement de valeurs naturelles.

1 Introduction

Within the lower Senegal valley there are large tracts of land that used to be subject of a dynamic flooding regime, but that are now cut off from the water (Triplet & Yésou, 2000; Zwarts *et al.* 2009). This paper focuses on one of these areas, the Ndiael (Réserve Spéciale d'Avifaune du Ndiael (RSAN) 16◦10-16◦18 N and 16◦00-16◦07W), a bird reserve in the delta of the Senegal River. The Ndiael is formally declared a Ramsar site, but is presently on the red list of the Montreux register, because of its current strongly degraded state (Faye 2015). The Ndiael is part of the UNESCO Man and Biosphere reserve “Réserve de Biosphère Transfrontière du Delta du Sénégal” (RBTDS), commonly declared by the two bordering countries, Senegal and Mauritania, and recognised by the United Nations since 27 June 2005. The concepts and ideas behind the RBTDS are further explained in Borrini-Feyerabend & Hamerlynck (2011).

Within the RBTDS there are three National Parks (NP), Djoudj NP, Diawling NP and PN de Langue de Barbarie. Especially relevant for this study are the Djoudj NP and the Diawling NP and to a certain extent also the hunting area Trois Marigots (three elongated and parallel situated basins between Ndiael and Saint Louis). These are the remaining wetland areas with seasonal dynamics in flooding regime in the lower delta, and extremely important for wintering migrant and colony breeding birds (Triplet *et al.* 2014; Zwarts *et al*, 2009). They are a spatial reference for the Ndiael under restored conditions and serve as examples for the type of water management required.

The cause of the degraded state for the Ndiael is a lack of water according to many sources (e.g. de Naurois 1965; Humbert *et al.* 1995; Kane *et al.* 1999). In 1995, Humbert *et al.* published (in this journal) on the relevant options for its restoration. As of 2015, major hydrological investments are being made in the region, which is reason to review the historical developments and document the baseline situation.

The aim of this paper is to provide an overview over 1) the efforts that have been taken to restore the wetlands in the Ndiael, 2) the baseline ecological situation, now that fundamental hydrological changes are being implemented and 3) the threats and tensions that need to be tackled, when implementing the scheme of water management desired. This study provides information to feed the public debate on how the scarce water resources in this part of the Sahel region should be used in an optimal way, and what balance should be found in dividing land and water between different options of land use, i.e. intensive agriculture, pastoralism and natural development.

2 Historical developments and attempts for restoration

Until the years 1950, the Ndiael never dried out with an area of open water varying from 10-30.000 ha (De Naurois in Mietton & Humbert 1992). The three sources of water that used to feed the Ndiael (see fig 1) have been cut over time for different reasons. The Yéti Yone from the north became cut-off in 1956 (Kotschoube 2000, Zwarts *et al.* 2009) by the construction of a dike around Lac de Guiers. The acces from the North-West became blocked when the national highway was constructed in the years 1950-59 and the link to the Trois Marigots in the south became regulated by a series of dams which reduced spill-overs and by 1965 the Ndiael had dried out as a result of this (de Naurois 1965). At the beginning of the 1990's a drain was created underneath the national highway (see fig 1), that supplies excess drainage water from Kassack (2250 ha) and Grande digue (3000 ha) rice fields in the north-west, flooding some 100 ha according to Kane *et al.* (1999). A small channel in the north, the canal Idrissa, supplied a trickle of water to the village at the north boundary of the reserve. As of that time the majority of water reaching the Ndiael was rainfall, supplemented with some river input from the drain and the Trois Marigots.

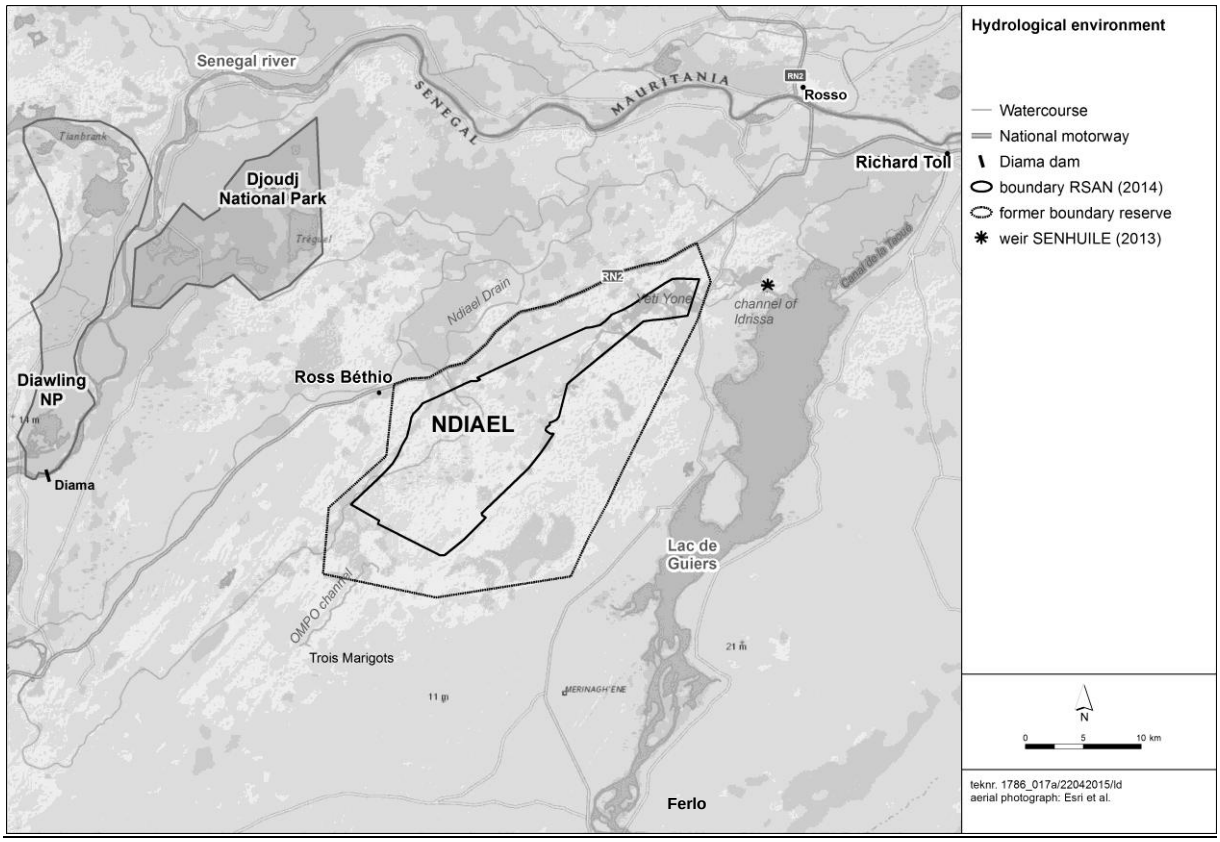


Fig 1. Map of reserve boundaries and hydrological system in the lower Senegal valley. The reserve boundary in 2014 is an approximation based on an image by SAED in 2014.

By 1961 the first studies were done to estimate the costs of rewetting the Ndiael by the Mission d'Amenagement du Senegal (M.A.S., de Naurois 1965). Such studies were repeatedly put forward in later years, for example by Mietton *et al.* (1991), Kane *et al.* (1999), Kotschoubey (2000), Tecsult (2006), and AIV (2008). In 1994 the OMPO took practical action, and supported the digging of a small channel in the south, reconnecting the Trois Marigots to the Ndiael (Kane *et al.* 1999). Water actually reached the cuvette in 1996/97 when the flood was strong. As of 1998 a new weir between the Djeuss and the Trois Marigots subsystem allows quick filling up of the Trois Marigots and a significant flow towards the Ndiael when the flood is strong in the Senegal river (Kane *et al.* 1999). In 2010 the local

population, together with the reserve authorities, reduced some of the blockades (sanddunes and the invasive plant Cattail *Typha domingensis*) in the Yéti Yone which coincided with heavy rains and contributed to a serious flood (6200 hectares in October 2010) after six years of drought (see fig 2).

The government of Senegal is very aware of the strategic and economic importance of the water management in the hydrological system of the Lac de Guiers and the Ndiael-Yéti Yone sub-system (PDMAS/SAED, 2009). It has installed a water authority (Office du Lac de Guiers, OLAG) in the end of the year 2010, that should ensure sustainable water management and restauration of ecosystems. This authority has acquired funding for an integrative project to do so and for this project the ecological restoration of the Ndiael is one of the most important objectives (Kitane *et al.* 2013). In 2012 a large agro-business company was installed in the area, after a de-classification of 26.000 ha of the reserve for that purpose (décret de déclassement numéro 2012-822). However, the reserve boundaries are not clear. There are several maps circulating from 2012, 2013 and 2014 (source: SAED), but we did not find an official document presenting the defenitive boundary. We have taken the boundaries as shown on an image by SAED in 2014 as the best approximation (shown in figure 1 and 3).

Pont Alain Daniel in Oct. 2012, was constructed with the help the local outfitter Alain Daniel to support the AIV and to allow for water in the Ndiael.

Pont Alain Daniel is a nice and diverse place, when there is water (left picture, e.g. Oct. 2012), and a logical stop during excursions in the Ndiael (middle). It is being removed in February 2015 (right picture) to allow for the passage of larger volumes of water in the near future by PREFELAG. The Yéti Yone is dammed during these works.

Rainfall and inundated area.

Rainfall in the Sahel is low, and very erratic. The long term average rainfall in St Louis over the years 1984-2014 was 281mm (119 st. dev., see Annex 3). For Ross-Béthio, the rainfall station nearest to the Ndiael, the long term average is a little lower (262 mm for the years when data are available). The correlation between rainfall in Ross Béthio with that from St Louis is positive but the strength is poor (n = 18, R^2 = 0.13). However, because we have no uninterrupted series for Ross Béthio we present the yearly deviation from the average sum of rainfall in St Louis in figure 2A. The rainfall is highly constricted to the rainy season between June and October and the majority of rain usually falls in September (Fall 2015). Evaporation varies between 1400-1900mm /yr between 1983 and 2012 in St Louis (Fall 2015).

We acquired Landsat TM images for several moments in the months of October-January from 1984-2015 and estimated the surface of inundated area in the Ndiael using the algorithms provided by Feyisa *et al.* (2013). We used the 'no shade' algorithm for all images until and including 2013 and the 'shade' algorithm thereafter, because of a change in data provided by Landsat TM8 images in comparison to the previous types. The selection of images was made such that it allowed us to arrive at the best possible estimate for maximal inundated surface in each of the years studied. Assuming that maximum inundation would occur in October, we concentrated on images for October and November. If the inundated area was higher than 1000 ha in any of these months we also estimated the inundation in January. We only selected images with cloud cover < 10 % and visually inspected those with for presence of clouds in the study area. For many years in the late eighties and early nineties we did not succeed in obtaining images that met our criteria, mainly due to malfunctioning of the sensor in the Landsat mapper (www.usgs.gov).

As can be seen in figure 2B the area inundated fluctuates strongly within and between years. It is always small (< 510 ha, n=7) in January, but may be well over 5000 ha in October (years 2000 and 2010). In the years studied it never arrived at the values mentioned by De Naurois (in Mietton & Humbert 1992). When studying the images in detail (see annexes) it appears that the water indeed originates from the sources mentioned above: rainfall supplied with river input via the Trois Marigots (year 1999), the Drain (years 2003, 2005, 2009, 2010, 2013) and the Yéti Yone (year 2013). A sequence of six years from 2004 until 2009 showed inundations of limited surface. The inundation of 2010 (6227 ha) should mainly be attributed to above average rainfall and input via the Drain, and to some extent via the Yéti Yone, as a result of investments made there by local people to remove blockades in the riverbed. October 2013 is characterized by a bigger flood (2750 ha) than October 2012 (1589 ha), in spite of lower annual rainfall. That year as well, some water arrived via the Yéti Yone (pers. obs.). Now as a combined result of the hydrological works for the new agro-business company SENHUILE and the removal of more barriers in the watercourse of the Yéti Yone by local people. It cannot be deduced exactly from the satellite images what quantities of water originated from the drain, but it appears that input via the drain should not be neglected. In January 2014, the area inundated is still 509 ha, which is the highest area inundated since the start of the dataseries.

Fig 2 A The yearly deviation from the average sum of rainfall in St Louis from 1984-2014 (long term average is 281mm).

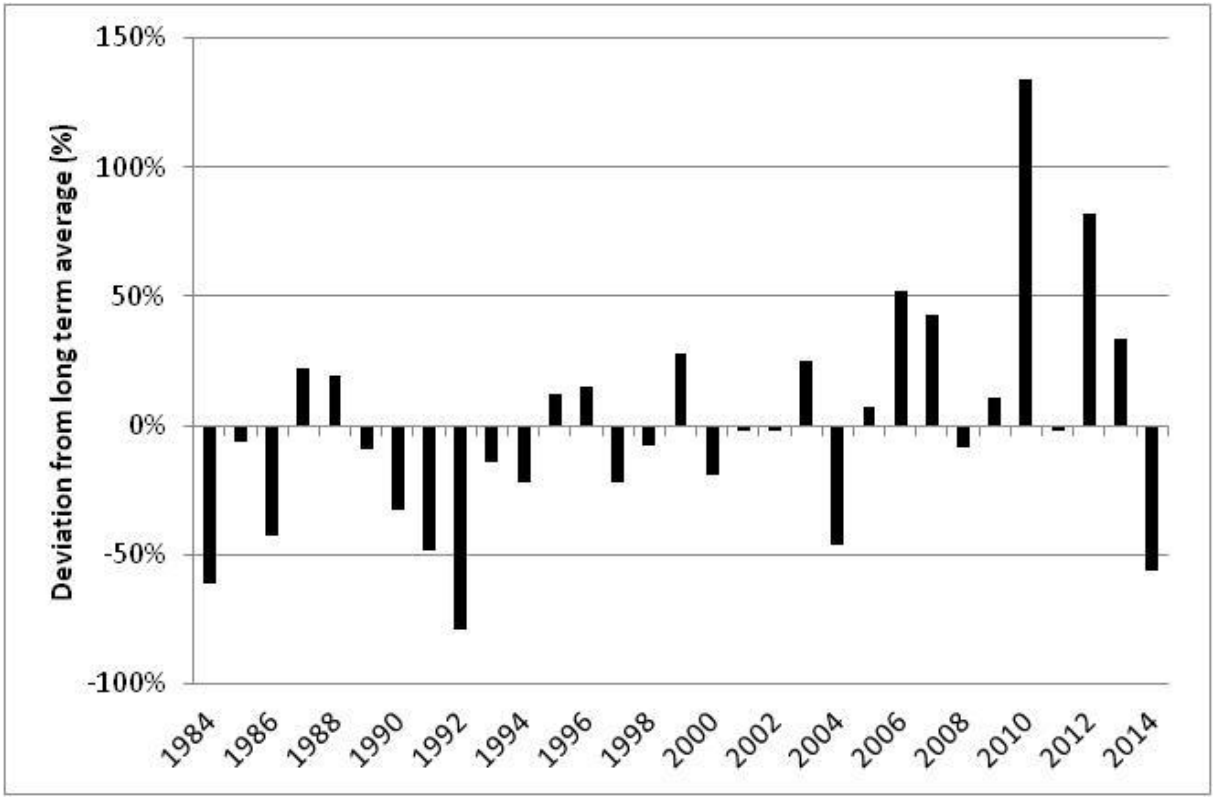
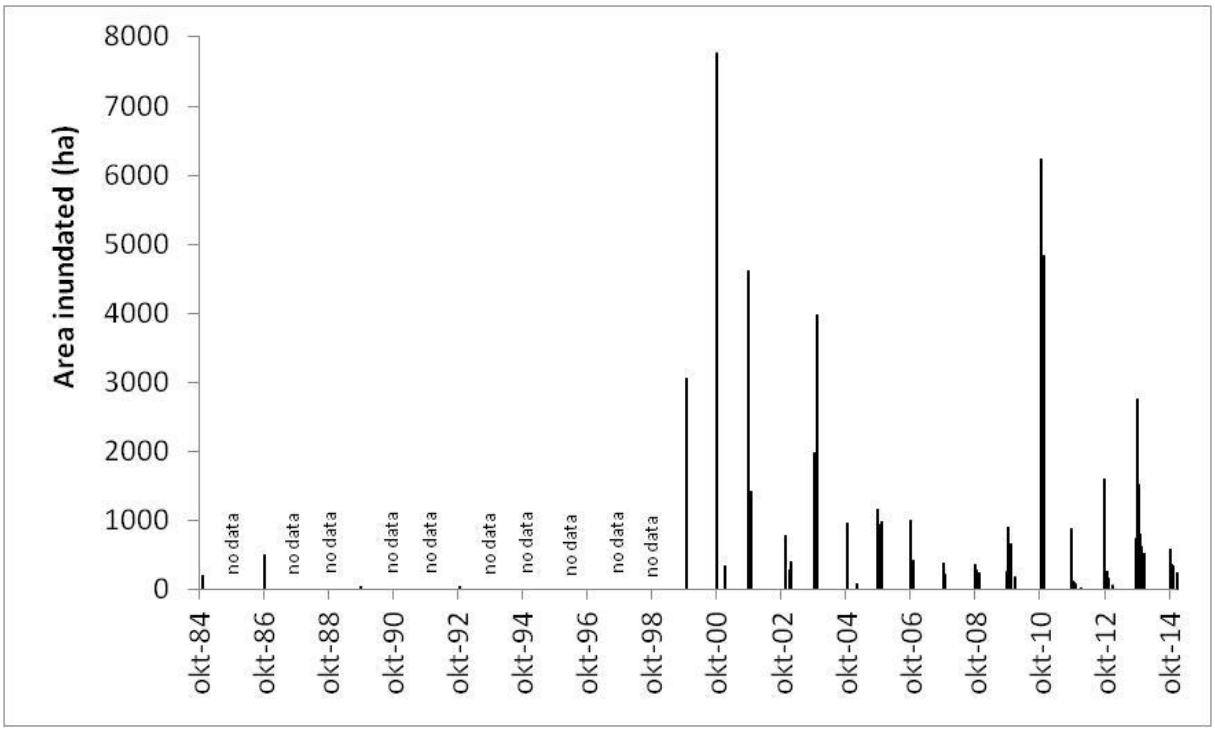


Fig 2B. Developments in rainfall and inundated area.To calculate the inundated area we used an algorithm proposed by Feyisa et al. (2013 ; $AWEI_{nsh}$ formula). Total study area is 52.000 ha.




By January 2013 SENHUILE had elongated Idrissa's channel towards Lac de Guiers (left picture). Over a length of 1.2 km SENHUILE cleared the marigot of the Yéti Yone from Typha with an excavator (right picture). This was also the place where the AIV did manual work to remove Typha within the framework of Ecosystems Alliance/ Living on the Edge.


SENHUILE and OLAG have financed the construction of a new weir at the entrance of the Yéti Yone, near Lac de Guiers (left picture, Jan 2014). By July 2014 this big new weir at the entrance of Lac de Guiers is functional (right picture).



This is where a new channel branches from the Yéti Yone towards the project site of SENHUILE (left picture, Jan 2013). The central picture shows a 2000 hectare SENHUILE project site in Jan 2013, where the first plants (sunflowers) were growing already at that time (right picture).

Left: In September 2011 there is no water at Pont Alain Daniel, just after the rains. The picture shows President Amadou Sow next to the scale at Pont Alain Daniel (PAD). Right: In January 2014 the same scale measures 40 cm of water.

The water attracted large numbers of birds, in the middle of Jan. 2014 we saw large numbers of herons, egrets, Spoonbills, Whistling ducks, Spur winged geese, African pygmy geese and Ruff. On the picture a flock of White Pelican Pelecanus rufescens, present with at least 360 individuals. In Dec. 2013 an estimated 10.000 individuals of Ruff Philomachus pugnax were present in the Ndiael (pers. comm. M. Sikkema).

3 Current state and potential

The majority of people in the 32 villages in or nearby the Ndiael are pastoralists of Peulh origin (70%, Fall 2015). In 2014 the estimated number of heads of cattle was 17600 and 22100 goats and sheep. Some nomadic pastoralism still exists by nomads from the Ferlo (see fig 1), that may find water in the south of the Ndiael and the Trois Marigots (Faye 2015). Pastoralism has suffered from degradation of the area, caused by the virtual absence of significant flooding, and the disappearance of associated flood receding cultures and perennial grasses. The livestock not only depends on grasses, but also on leaves and fruits from the Acacia trees. The Wolof are among the other relevant ethnies near the reserve, with 27% of the population. In total there are an estimated 21.000 inhabitants that have a strong link to the Ndiael (Fall 2015).

Some inhabitants practise small scale irrigated agriculture or horticulture, but the absence of proper infrastructure and equipments thus far did not allow high revenues (Kane *et al.* 1999). Although some species of fish have disappeared (CSE 2008), and the area with permanent or seasonal water has become quite small, some fishing still takes place in the watercourses present, mainly by fishermen from Malinese origin. The number of local fishermen is negligeable. However, the new input of water from the north, as of 2013, already appears to have brought some more fish (no data). Hunting and eco-tourism are absent in the reserve and local artisanat only plays a minor role.

The local population in the 32 villages around the Ndiael are quite well represented in a local association of villages (Association Inter Villageoise Ndiael; AIV) that actively seeks to restore the ecological potential of the Ndiael and performs many activities to sensitise people, protect and restore their tree resources and monitor the ecological developments (AIV 2008).

Land cover

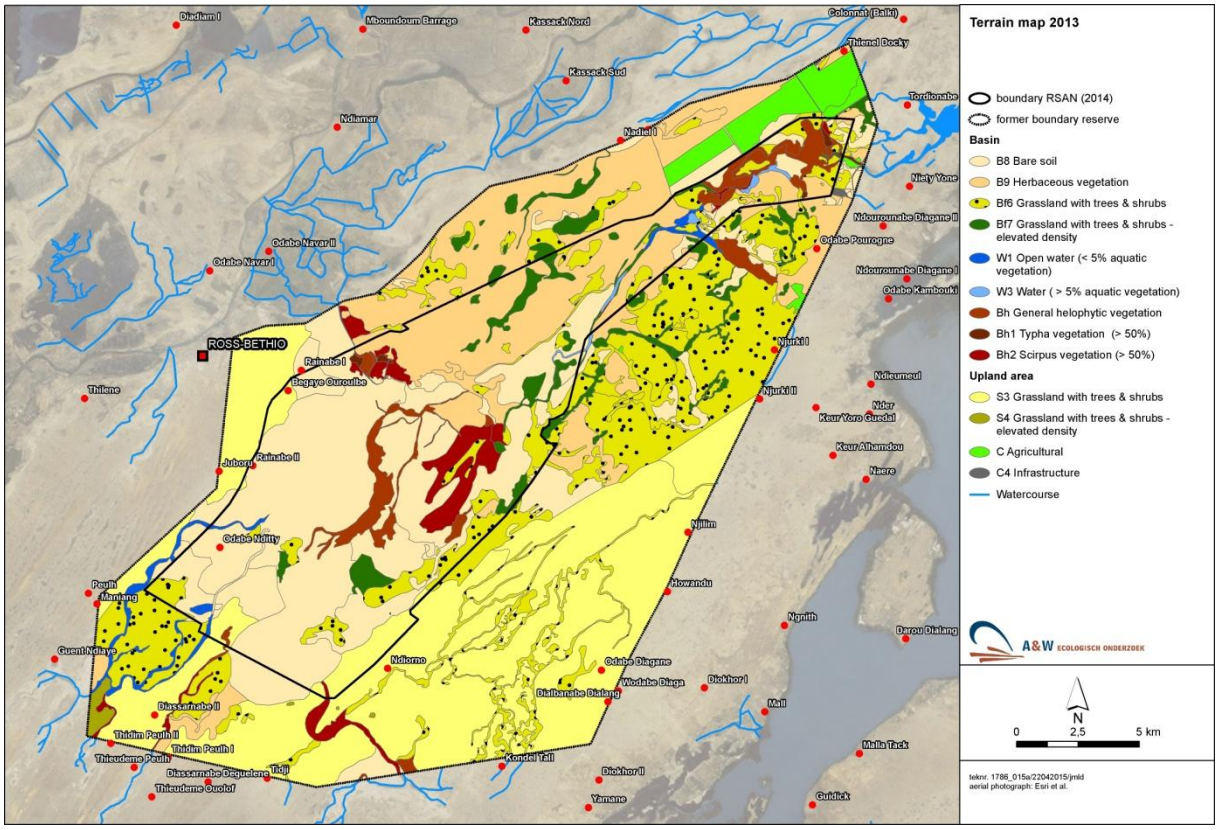
According to former IGN maps (year 1922) the Ndiael consisted of salt marsh. However, already in 1964 (BDPA *et al* 1995 in Kane *et al.* 1999) the major part of the reserve was characterized by bare soil. Nowadays this is stil the case, as can be seen from table 1, in which a comparison is given of the the 2003 and 2013 terrain maps. The terrain map of 2013 is given in figure 3. There are sand dunes in the north-west and the east (upland grassland with trees & shrubs) that harbour herbaceous vegetation, dominated by annual grasses and interspersed with trees (average tree canopy cover of 3% ± 0.4). Dominant trees are *Acacia senegallis*, *A. tortilis* and *Balanites aegyptiaca*. The basin is characterized by bare soil, grassland with trees and shrubs (tree canopy cover 12.6% ± 1.4) and gallery forest (tree canopy cover 27% ± 3.5) around the temporary watercourses and small depressions. Here the dominant trees are *Acacia nilotica* and *Tamarix senegalensis*. Temporary waterbodies, helophytic vegetation and aquatic vegetations, hotspots of biodiversity when wet, together add up to 3200 ha in the current situation. As yet, the area dominated by *Typha domingensis* is negligeable (67 ha). The new agro-business is mainly allocated to areas on the higher grounds. The 2008 terrain map is not inconsistent with these results, but since the methodology to produce both maps has not been the same, the differences are not discussed.

The surface of the cuvette itself is estimated by Humbert *et al.* (1995) at 10.000 ha at a waterlevel of 1.10 m above sea level. Moreover, the area of terrain types that belong to the basin, within the new reserve boundaries, is estimated at 18.700 ha. These terrain types may potentially be flooded. The potentially flooded area in the reserve may thus increase with thousands of hectares, if sufficient water can be transported to the Ndiael.

Table 1. Surface area of terrain types in the Ndiael in 2003 (CSE 2008) and 2013 (own data, Annex 2). The 2003 map is part of a supervised classification from satellite imagery for the entire lower Senegal valley (CSE 2008), the map 2013 is based on a landscape guided approach using google images from 2013, updated by groundtruthing in the field in January 2014.

Global legend	**2003 (ha)**	**2013 (ha)**
bare soil	13852	12594
open permanent water	7	0
open temporary water	3077	465
aquatic vegetation	1110	164
floodplain grassland with trees & shrubs, including gallery forest	14006	23553
upland grassland with trees & shrubs on higher ground	18208	14559
Agriculture	2307	1201
Infrastructure	0	31

Fig 3. Terrain map for the year 2013.



<u>*Birds and other fauna*</u>

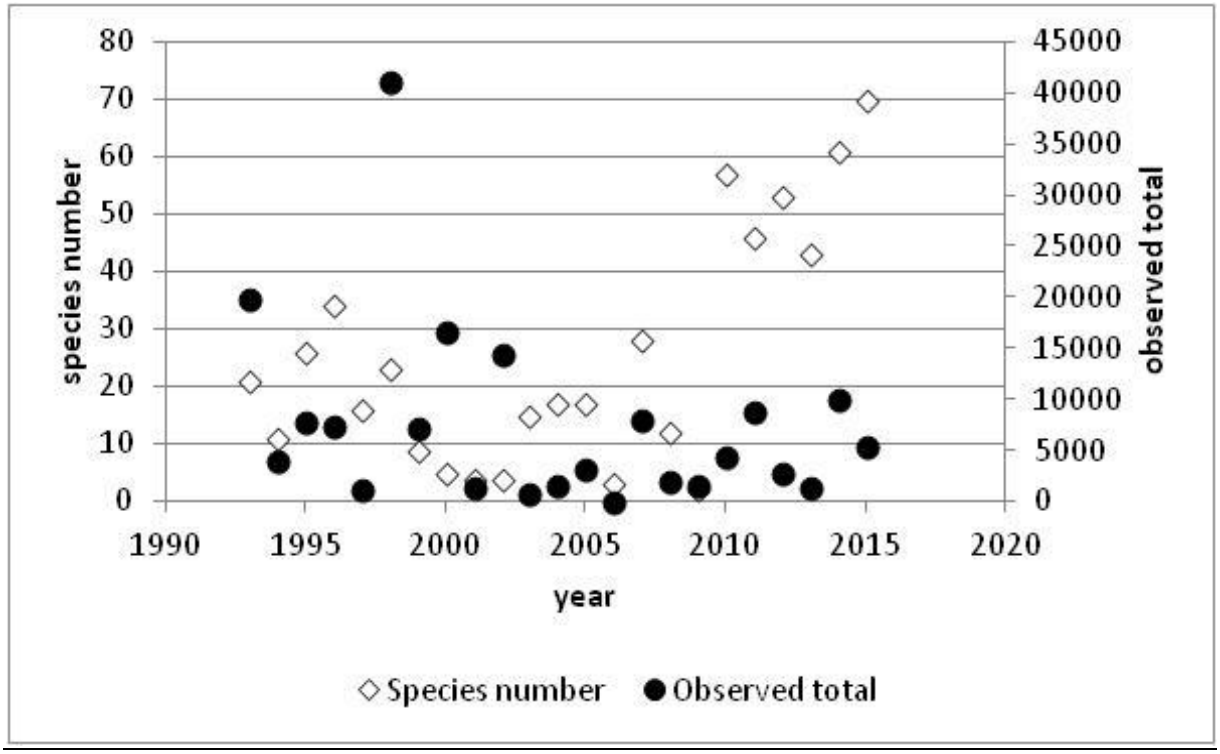
As of 1993, there is an almost uninterrupted series of yearly counts of waterbirds in the Ndiael (figure 4, Triplet *et al.* 2014, Annex 1). This series has been collected in the framework of the International Waterfowl census, executed in January each year. The consistency of the census data in the Ndiael varies due to multiple factors. The availability of vehicles, binoculars and skilled people are among the most important causes of variation. Numbers are strongly fluctuating in general, but also between species. As can be seen in figure 4, there is a sudden change in number of species observed after 2009. This is inevitably the result of a quantitative and qualitative change in observer effort. Another reason is the availability of water in the Ndiael. In the years 2011 and 2014 the number of different groups of species as well as the total number observed is relatively high, in our view because of very good rains in the previous rainy season 2010 and (relatively) high water availability in the mares and

depressions of the former floodplain. Over the past five years Garganey *Anas querquedula* were most important, with average numbers above a thousand individuals. In comparison to the observations of Morel & Roux (1966) in the period 1958-1965, the Eurasian Spoonbill excepted, the numbers nowadays are only a fraction of what has been recorded in the past. Nonetheless, five species are likely to surpass the 1% criterion for the international importance of wetlands according to the Ramsar Convention (see Annex 1, table A1-2).

In order to further establish a quantitative baseline, the bird fauna has also been inventoried using point-transect counts during more than two years. This inventory revealed the relative occurence of 194 species and demonstrates which bird species are present in addition to the waterfowl censused annually (Annex 4). Typical species are, for example, Red-billed Quelea *Quelea quelea,* Sand Martin *Riparia riparia and* Crested Lark *Galerida cristata.* Red-billed Quelea, a gregarious species, occurs in the highest densities of all and is treated as a pest species by killing them and destroying nest locations.

Wild vertrebrate fauna is rare in the Ndiael. The original large herbivore and carnivore species have disappeared, as almost everywhere in West Africa (Olff & Prins 1999). In 2013 and 2014 we observed Patas monkey *Erythrocebus patas, Jackal Canis spp,* African savanna hare *Lepus crawshayi*, Marsh mongoose *Atilax paludinosus* and Whartog *Phacochoerues aethiopicus* in the reserve, as well as the reptiles Nile varan *Varanus niloticus* and the Rock python P*ython de Sebae*. Another 10 small vertebrate species, amongst which Genet *genetta sp*. and Civet *Viverra civetta, but also Hyena crocuta crocuta* have been encountered by the local people in the last ten years (see CSE 2008). Fish species are given in Baldé (2007).

Figure 4. The observed number of species and the total number of birds observed during the International waterfowl census in the Ndiael. Data courtesy of P. Triplet (Triplet et al. 2014).



4 Threats and opportunities

With the coming of more water and the recently installed large-scale agro-business, undoubtedly more people will be attracted to the area (Scholte 2003). The new agro-business itself may have strong repercussions on water availability -quality, and disturbance, threats nicely summarised in Fall (2015). In addition, large tracts of the reserve have lost most of their value as grazing land as a result of this conversion to intensive irrigated agriculture. This greatly increases the pressure on the remaining grazing resources with overgrazing and excessive cutting of branches as the main direct risk. There is a very realistic danger that *T. domingensis* will develop dense stands in the watercourses and mares, as has happened all over in the lower Senegal valley (Cogels *et al.*, 1997) blocking waterways and access to water (OMVS 2013) and reducing biodiversity (Sidaty 2005). Finally, wind erosion may play a negative role by blocking the free flow of water towards the Ndiael.

However, the water and an increased attention may bring back a lot of what has been lost. Already, people eat fish again caught in the Ndiael, which has not been possible for years. A regeneration of trees and shrubs is observed that may provide important forage in the dry season for cattle. If perennial grasses should return, the forage availability per unit area becomes even larger. With increased presence of water the availability of raw material for artisanal use will increase (Hamerlynck & Duvail 2003). The local people furthermore expect to gain from eco-tourism. These assumptions are corroborated by the information from the nearby example of the Diawling (Mauritania), where economic activity was enhanced in many ways when the water returned (Hamerlynck & Duvail 2003, *c.f.* Scholte 2005). The revitalisation of the Ndiael should thus result in a structural improvement for local pastoralists, smallholders and fishermen. The artificial flooding will be a very strong means to counteract climate change. Finally, the Ndiael has the potential to be a breeding area for colony breeding birds and a staging site for many more wintering migrants than it is now (Scholte 2006; Triplet et al. 2014). Next to the Diawling and Djoudj National Parks this reserve may provide the third safe haven for these groups of birds within the RBTDS, significantly reducing the risks of failing years for their populations.

In Jan. 2014 there is water flowing through the Yéti Yone towards the Grande Mare. The left picture shows the mouth of the Yéti Yone close to Grande Mare, where it has become a small channel due to the efforts of the AIV (near the artificial 'butte de nidification').The right picture shows the small scale inundation as a result of this water in the north of the Grande Mare.

5 Updated management plan

In consultation with local stakeholders the reserve authorities (RSAN) have outlined their vision upon the future management (Faye 2015). The plan is highly comparable to previous management plans formulated for the area by Kane *et al.* (1999) and AIV (2008) in the sense that it aims for the restoration of the ornithological potential of the site, a rational use of natural resources by traditional activities of fishing, pastoralism and an active approach to promote reforestation. It is more specific than the previous management plans in the sense that it explicitly opts for a seasonal rather than permanent inundation, options that were left open for public debate by Humbert *et al.* (1995). Seasonal inundation is seen as a key prerequisite in re-creating a diversity of habitats, enhancing biodiversity while preventing the spread of waterborne diseases and infestation by Typha.

At the brink of this important change to come, there is urgent need to maintain the debate on how to divide land and water over different options of land use, i.e. intensive agriculture, pastoralism and natural development. Also the expected re-occurrence of droughts, or at least years with very low precipitation, has to be taken into account, as this may increase pressure on land and water use in the Ndiael, as well as the possibilities for inundation in these years. It is it is self-evident that this needs be to done in an equitable way, taking into account the interests of those who may be hampered to speak out for themselves.

In 2010, the AIV removed obstacles in the bed of the Yéti Yone marigot to allow water to flow to the Grande Mare (left picture, Mbelele Mbaye in 2011, looking to the North - East). In Feb. 2015 a new bridge is being installed near Mblele Mbaye (view to the west) The Yéti Yone is temporarily dammed here during these works (right picture).

Mirador at Yowre mare as an earthen hill in Oct. 2012, Jan. 2014 and in a final state in Feb. 2015.

6 Management recommendations

Given the annual and seasonal variation in the availability of water as well as the suitability of the low-lying wetland zones for agro-economic development, there are obvious potential conflicts of interest around the use of land and water for intensive agriculture, versus pastoralism and ornithological purposes. These interests are not necessarily opposing each other as long as they are managed in an integrative way. The basic idea behind the seasonal inundation of the Ndiael still holds. By refilling natural depressions, such as the Ndiael, the water is put to use for the benefit and empowerment of the rural communities and the strengthening of the ecosystem services and biodiversity in the Ndiael. Moreover, it results in a a) reduced inundation risk in the lower parts of St Louis, b) an enhanced availability of forage for livestock, fish and habitat for wild fauna, and c) in a significant strengthening of the UNESCO Man and Biosphere reserve in the Senegal Delta (RBTDS), as next to the Djoudj and Diawling the Ndiael area will grow to be a third stronghold for wildlife and waterfowl populations, as it was in the past.

It is recommended, in general, to maintain and improve the discussion with local stakeholders on how to understand, tackle and solve the above mentioned conflicts. This should preferebly be organised in a formal management structure. In doing this, much can be learned from the experience in the nearby Djoudj and Diawling. In particular, support for the local population is needed in their long-term protection of the natural resources and the development of sustainable economic activities. There is much to gain in providing positive feedback, training (small) grants and loans.

Natural regeneration of A. Nilotica (Jan. 2014, left picture). The site where tree-planting has been done in Oct. 2013 (right picture, taken Jan 2014), with 120 protected seedlings of Acacia radiana, Prosopis juliflora and Parkinsonia adansionata.

Piste de desenclavement (7 km) towards Mblele Mbaye (Feb. 2015).

7 Conclusions

Since 1960, the Ndiael became isolated from the natural flood in the Senegal river. During more than fifty years there has been only limited inflow of water. But even in the current state its remaining waterbodies have important value for resident and wintering migrant birds, as well as other resident fauna. The potential of the reserve is much larger, as can be deduced from historical and spatial reference. With limited effort and investments, the local population has achieved some increase in inundated area, setting the stage for much larger investments within the framework of a recently started scheme run by the recently installed governmental water body OLAG. This raises high expectations. The baseline situation has been mapped and a local team is monitoring change in habitat and bird density. Parallel to these developments almost half of the reserve has been de-classified for the benefit of a large agro-business company. This will lead to an increased pressure on the remaining grazing grounds, making the challenge for a long-term sustainable protection and development of the Ndiael even larger.

In the new setting it will be essential to mitigate tensions between this agro-business, small holder interests and ecological restoration. Existing conflicts of interest and an inevitable increase in human pressure will require continuous dialogue to arrive at an integrated water management as well as increased vigilance against illegal use of resources.

Mis en Defense near Nguenth implemented in 2013 (left) and Mis en Defense since 2003 (right).

The operations by SENHUILE in the periphery of the Ndieal in 2014. Photos courtesy AIV.

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Annex 1. Results of the annual bird census in the Ndiael.

As of 1993 there is an uninterrupted series of yearly counts of waterbirds in the Ndiael (figure 4. Triplet *et al*. 2014). This series has been collected in the framework of the International Waterfowl census, executed in January each year. The yearly count is performed on foot by multiple teams of three people or more. Each team had at least one pair of binoculars. As of 2012 the number of bird identification guides and binoculars has increased.Depending on the availability of vehicles, binoculars, people, and the presence of water, the study area was subdivided in different counting zones. The subdivision for January 2014 is given in Map A1-1. Each team covers all places with water within these zones.

The counting results are presented in table A1-1. The results have been published and discussed until 2014 by Triplet *et al*. (2014) The consistency of the census data in the Ndiael varies due to multiple factors. The availability of vehicles, binoculars and skilled people are among the most important causes of variation. Numbers are strongly fluctuating in general, but also between species. As can be seen in figure A1-2, there is a sudden change in number of species observed after 2009. This is inevitably the result of a quantitative and qualitative change in observer effort. Another reason is the availability of water in the Ndiael. In the years 2011 and 2014 the number of different groups of species as well as the total number observed is relatively high, in our view because of very good rains in the previous rainy season 2010 and (relatively) high water availability in the mares and depressions of the former floodplain. Over the past five years Garganey *Anas querquedula* were most important, with average numbers above a thousand individuals. Several species pass the 1% level of presence in the Ndiael (see table A1-2). For the period 2011-2015, the majority of individuals belongs to the group of Ducks & Geese, followed by Waders. There is also a large contingent of and Herons, Storks, Ibises, Flamingo, Pelican & Spoonbills (see figure A1-3).

Figure A1-2. The observed number of species and the total number of birds observed during the International waterfowl census in the Ndiael. Data courtesy of P. Triplet (Triplet et al. 2014).

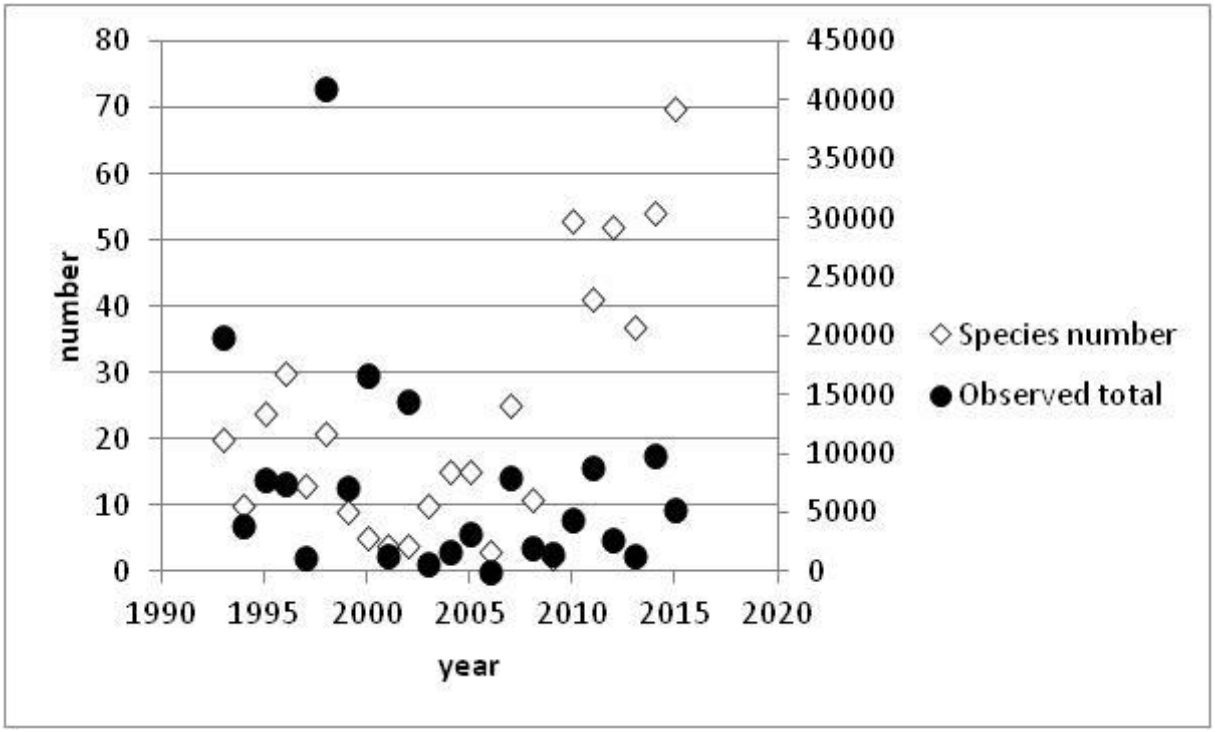
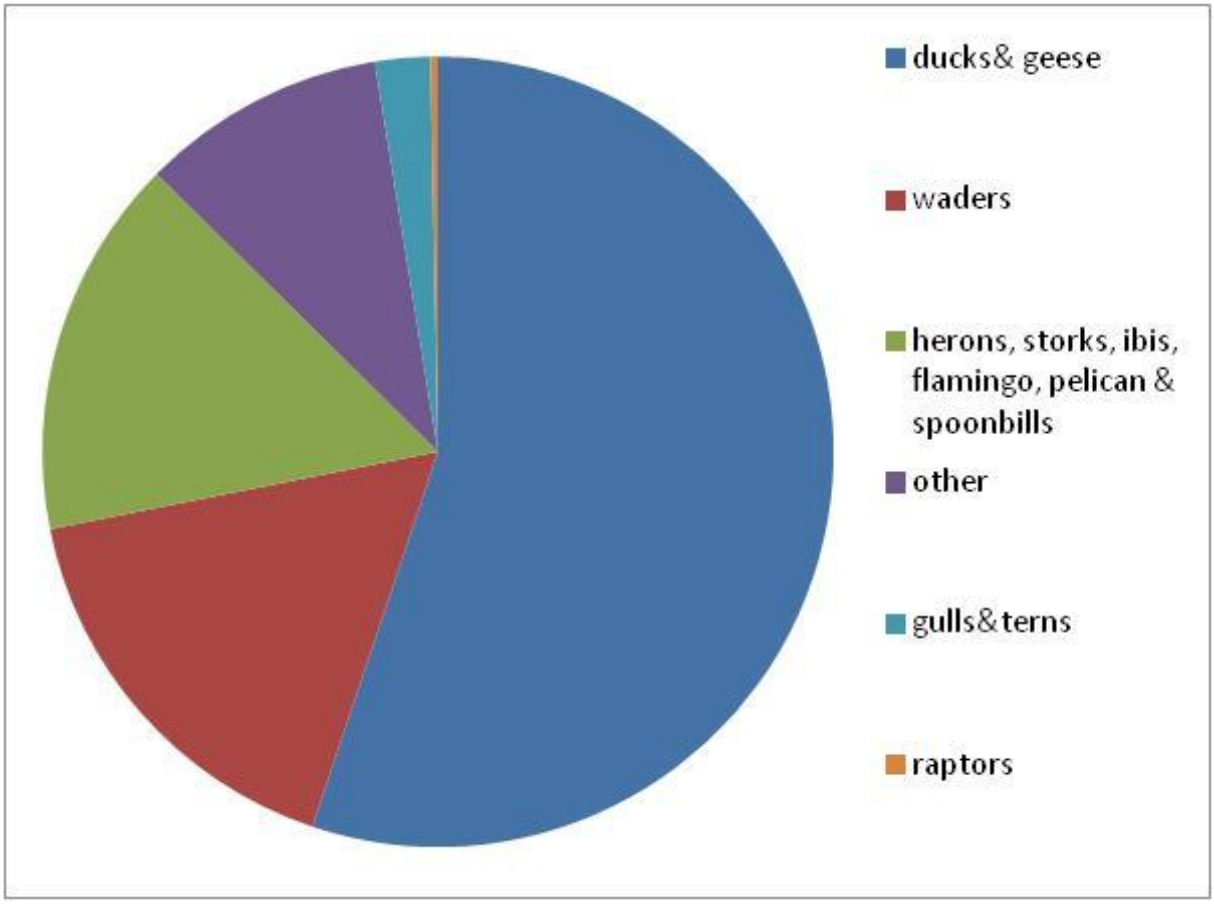


Figure A1-3. Composition of the avifauna according to the results of the International Waterfowl Census for the period 2011-2015.



Map A1-1. In January 2014 the International Waterfowl Census in the Ndiael was implemented by 4 teams, counting all wet areas in four zones.

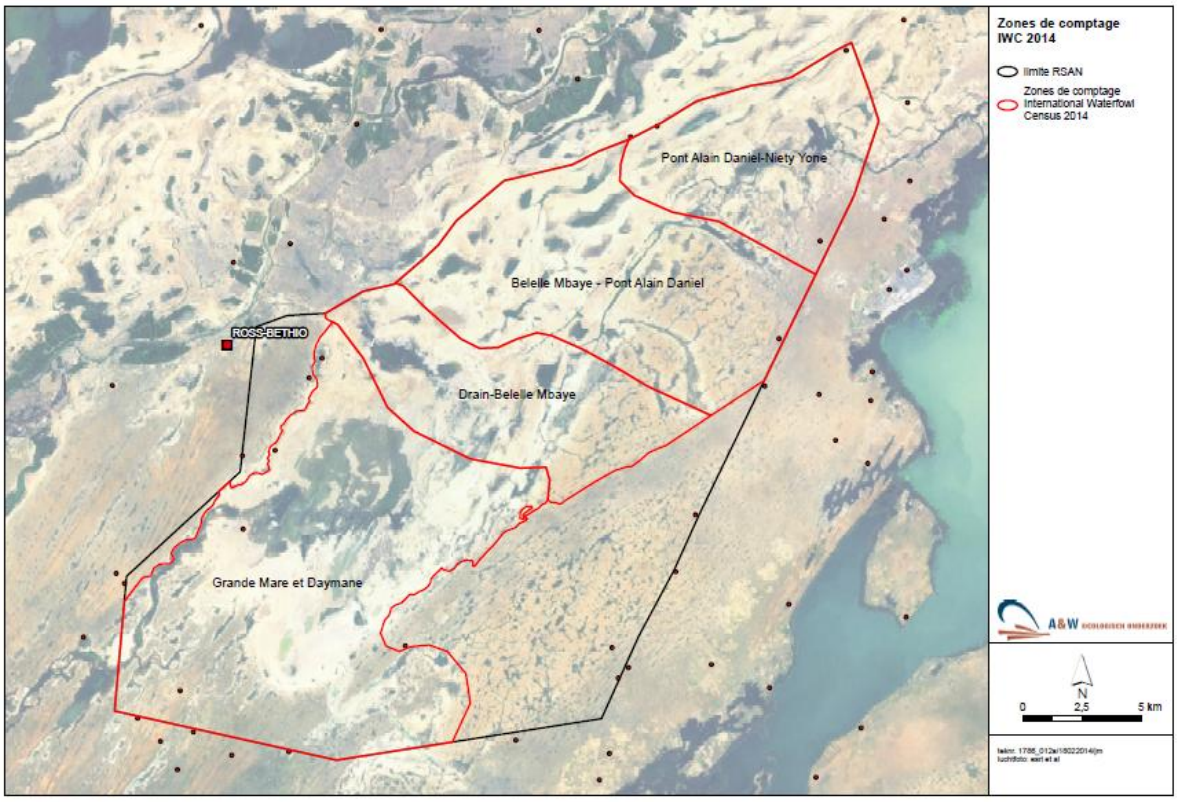


Table A1-1. Results of the yearly International Waterfowl Census in the Ndiael for the years 1993-2015 (source until 2014: P. Triplet). Note that some years (e.g. 1997-99, 2002, 2004, 2006 and 2009) are highly incomplete.

Group	Latin	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ducks& geese																								
	Anas crecca	6																					2	
	Aythya fuligula																		23	38				
	Nettapus auritus																		13	3			55	76
	Alopochen aegyptiaca				2												20		58	125	24	1	63	27
	Sarkidiornis melanotos																		24	140		2	41	12
	Anas clypeata	420		263	32				400	200		220		110		79	75		100	38			5	25
	Plectropterus gambensis																		524	179	94	19	69	47
	Dendrocygna viduata															100			581	635	14	40	71	1335
	Dendrocygna bicolor																		220	1449			576	272
	Anas querquedula	600		240	1680				5005	1000		210	800	534		1815	610		517	3268	128		5839	490
	Anas acuta	60		2430	2660						14200			20		11			12	29			69	
gulls&terns																								
	Chroicocephalus ridibundus																						1	
	Chroicocephalus genei																		2					
	Hydroprogne caspia															13					5		1	
	Chlidonias hybrida											9					4					1		12
	Sternula albifrons																				3		1	22
	Gelochelidon nilotica	3																					15	12
	Chlidonias leucopterus							6											36		4			
	Thalasseus sandvicensis											1								107	6		1	15
	Sterna maxima																			86	12	2		11
	Chroicocephalus cirrocephalus																			65				
herons, storks, ibis, flamingo, pelican & spoonbills																								
	Ardea goliath																							1
	Pelecanus rufescens																		1					
	Ardea melanocephala																		1	1	4	1		
	Mycteria ibis				4															1				
	Threskiornis aethiopicus											1							1	36			1	
	Platalea alba			8																		2		23
	Ciconia ciconia		40	21	4						12	12	17			3					2		1	2
	Ciconia nigra	13	3		1			2		2		1	16			4			4	1	11		109	10
	Egretta gularis			4	2		20													4				40

Group	Latin	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Egretta intermedia	50			3	6														15	8	24	6	19
	Ardea purpurea				3		10									1			6	16	47	4	38	32
	Bubulcus ibis															1			10	38	22	27	16	12
	Phoenicopterus ruber/roseus	90		23							2		1	3			28		70					17
	Ardea cinerea			9	52	19	60	6								5			21	47	61	10	96	29
	Ardea alba	12		80	36	1	20									5			35	128	50	20	87	40
	Egretta ardesiaca						28												2	9			146	50
	Nycticorax nycticorax																				171	3	2	48
	Ardeola ralloides				16		20												26	96	136	35	78	94
	Pelecanus onocrotalus	195	260				13							18		3			4	358	38	2	96	18
	Plegadis falcinellus																			203			13	
	Egretta garzetta			25	110		56	4						4					63	75	337	104	230	239
	Platalea leucorodia			3	2		259						69	4		310			59	139	92		563	19
	Phoenicopterus minor								1500	150			300			310								4
raptors																								
	Circus pygargus																							2
	Haliaeetus vocifer																		3		5	1		7
	Pandion haliaetus																		7	2	4		6	5
	Circus aeruginosus																		18	11	5	10	8	23
waders																								
	Calidris temminckii				1																	1		
	Lymnocryptes minimus															1								
	Rostratula benghalensis																		2		1			
	Numenius phaeopus																				2			
	Numenius arquata				1		4																	
	Charadrius Alexandrinus																							5
	Calidris ferruginea	19		6		1								6						15	14	2	2	18
	Calidris canutus					1													36				8	2
	Burhinus senegalensis																		13		5	11	18	12
	Tringa spp																							12
	Charadrii spp																							14
	Vanellus tectus												5		8	2	4	3	12		43			37
	Charadrius dubius			1	19		16												22			13	17	16
	Tringa glareola				7											6			31		50	8	8	11
	Charadrius pecuarius		4	46			37									4								12
	Tringa ochropus						1												4	47	34		27	16

Group	Latin	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Charadrius hiaticula	4	37	98	46	13	15	4					1	1		11			4		37	48	34	14
	Vanellus senegallus				6														14		14	70	10	34
	Actitis hypoleucos																		7	4	55	18	18	51
	Tringa nebularia	50		5	2	5	1						11	1		2	1		212	34	104	25	19	18
	Tringa stagnatilis		236	3		7	15					1	3						2		15		12	
	Calidris alpina	45	43	16	1	7	25	28				8	34	205		5				1	146	24	40	
	Vanellus spinosus			37	51								3						18		12		154	52
	Tringa erythropus				3	29													303		5	38	10	
	Gallinago gallinago			1															12	12	259			41
	Tringa totanus	1			3														358		12	25	10	
	Himantopus himantopus	29	6	45	173	160	176	82				62	100	207		57	58		85		95	129	169	100
	Recurvirostra avosetta	390			364	9					210	100		102		159	6						8	75
	Kentish Plover	82	1410	133	70	128	143	19											3				1	
	Calidris minuta	2610	1890	247	14	148	70					25	15	1040		5			310	124	144	83	204	41
	Limosa limosa	10935		41	295	16			425							8	80		79		10	5	84	86
	Philomachus pugnax	4280	1	4069	1672	700	40000	7000	9340			3	261	700	30	5030	1130	1500	320	216	257	463	362	80
other																								
	Cursorius temminckii																							2
	Cursorius cursor																							4
	Balearica pavonina													11						1				
	Cursorius sp.											8											4	
	Tachybaptus ruficollis																		5	2		7		11
	Microparra capensis																							12
	Anhinga rufa						2												8	27	11	1	26	
	Gallinula angulata																							16
	Amaurornis flavirostra																				3	10	30	53
	Gallinula chloropus																		13		9	8	20	106
	Glareola pratincola			9	17		19					1	2	297	7	8	5		1				2	30
	Ceryle rudis																							42
	Phalacrocorax carbo												6			13			16	257	2	26	9	86
	Porphyrio porphyrio																			31	9	49	112	60
	Actophilornis africanus																		30	152	34	8		227
	Microcarbo africanus				95														17	486	2	36	190	813

Criteria for assessing the international importance of wetlands have been agreed by the Contracting Parties to the Ramsar Convention on Wetlands of International Importance (Ramsar Convention Bureau 1988). Under criterion 6, a wetland is considered internationally important if it regularly holds at least 1% of the individuals in a population of one species or subspecies of waterbird, while criterion 5 states that any site regularly supporting 20,000 or more waterbirds also qualifies (http://www.bto.org/). At least five species have an average or maximum number over the years 2010-2015 that exceed this 1% criterion.

Table A1-2. The selection of species in the Ndiael that pass the 1% level (taken from Wetlands International 2012).

Français	Latin	Anglais	avg 2011-15	max (2011-2015)	1% level
Ouette d'Égypte	Alopochen aegyptiaca	Egyptian Goose	48	125	70
Dendrocygne fauve	Dendrocygna bicolor	Fulvous Whistling Duck	766	1449	140
Crabier chevelu	Ardeola ralloides	Squacco Heron	88	136	40
Cigogne noire	Ciconia nigra	Black Stork	33	109	25
Spatule blanche	Platalea leucorodia	Eurasian Spoonbill	203	563	110

A comparison to the findings by Morel & Roux (1966) in the period 1958-1965 is given in table A1-3. Except for the Eurasian Spoonbill the numbers are only a fraction of what has been recorded in the past.

Table A1-3. A comparison of the mean number of a selection of bird species to the findings by Morel & Roux (1966) in the period 1958-1965 in the Ndiael.

Français	Latin	Anglais	2010	2011	2012	2013	2014	2015	Mean no 1958-65 (Morel & Roux 1966)	mean (2010-2015)
Canard pilet	Anas acuta	Northern Pintail	12	29			69		11000	37
Canard souchet	Anas clypeata	Northern Shoveler	100	38			5	25	>1000	42
Sarcelle d'été	Anas querquedula	Garganey	517	3268	128		5839	490	50000	2048
Flamant rose	Phoenicopterus ruber/roseus	Greater Flamingo	70					17	> 5000	44
Spatule blanche	Platalea leucorodia	Eurasian Spoonbill	59	139	92		563	19	> 100	174
Ibis falcinelle	Plegadis falcinellus	Glossy Ibis		203			13		> 1000	108
Barge à queue noire	Limosa limosa	Black-tailed Godwit	79		10	5	84	86	thousands	53

Annex 2. Terrain map of the Ndiael

In order to be able to measure quantitatively what changes will occur as a result of the rewetting of the Ndiael we created an update for the existing terrain maps (CSE 2008). Using google images from 2013, and guided by the temporary watercourses indicated on the map by CSE (year 2003, CSE 2008), a preliminary terrain map was created in GIS by delineating the different terrain types by eye. This preliminary map was updated by groundtruthing in the field in January 2014. Updating was done by Babacar DIAGNE (AIV), Daan Bos (A&W) and Mahmoud Fall (AIV). We used a scale of 1:25000, so the minimal size of a polygon was 1 * 1 cm on the fieldmap. We applied a legend that overlaps with the one used by the Biodiversity project (CSE 2008). All relevant areas and terrain types have been (re)visited. The legend used is given below in french.

Plaines d'inondations

W	Eaux permanentes ou temporaires	
	W1	Eau temporaire ouverte (Lac ou Marigot,<5% végétation)
	W2	Eau permanente ouverte (Lac ou Marigot, <5% végétation)
	W3	Nénuphares (Lotus, Nymphaea, >5% végétation)
Bh	Basin – vegetation avec Helofytes	
	Bh1	Typha-vegetation (>50%)
	Bh2	Scirpus-vegetation (>50%)
	Bh3	Phragmites – vegetation (>50%)
	Bh4	Sporobolus vegetation (>50%)
	Bh5	Autre helophytes (>50%)
Bf	Basin – forets / arbustive	
	Bf6	Basin versant avec arbres (e.g. Acacia nilotica ou A. seyal, densitée basse)
	Bf7	Basin versant avec arbres (e.g. Acacia nilotica ou A. seyal, densitée elevée)
Sn	Basin –sol nu ou herbacees	
	B8	plaines d'inondations – (vegetation <5%)
	B9	plaines d'inondations avec vegetation herbeuse (5-50%)
B10	plaines d'inondations avec vegetation herbeuse (>50%)	
C	Cultures	
	C1	Culture de riz
	C2	Culture maraichages
	C3	Culture autre
	C4	infrastructure

Steppes, savanes, levees, dunes

Sh	Steppes herbacées ou sol nul	
	S1	Sol nu (vegetation <5%)
	S2	Steppe herbacées (arbres < 5%, graminées généralement pas 80cm)
Sa	Steppes et savanes	
	S3	Steppe arbustive/ arborée (couverture arbres : densitée basse; A. seyal, senegalensis, tortilis, Balanites etc.)
	S4	Steppe arbustive/ arboree (couverture arbres : densitée elevée)
	S5	plantation des arbres endémique
	S6	plantation des arbres exotique (Neem ou Eucalypte)
	S7	Savane (arbres < 5%, graminées généralement au moins 80cm)

S8 Savane arbustive/ arborée (couverture arbres: densitée basse)

S9 Savane arbustive/ arborée (couverture arbres: densitée elevée)

Af Affleurement rocheux /Cuirasse

A1 Affleurement rocheux /Cuirasse

Steppe correspond a une formation herbeuse ouverte avec des graminées vivaces largement espacées, n'atteignant généralement pas 80 cm, des plantes annuelles abondantes entre les vivaces, parfois mêlées de petits arbres, d'arbustes et d'arbrisseaux

Savane correspond a une formation herbeuse comportant une strate graminéenne continue d'au moins 80 cm de hauteur, ordinairement brulée annuellement.

Density of trees

After producing the terrain map we estimated the average tree cover per terrain type from Google Earthe Images. We used the same images that had been used to create the terrain map itself. Stratified randomly, a number of plots of 50m diameter were located per terraintype. In these plots, we estimated the relative area covered by tree canopy (in %) and the number of trees by eye. The results are provided in table A2-1.

Results

The updated terrain map for 2013 is given in map A2-1. There are sand dunes in the north-west and the east (upland grassland with trees & shrubs) that harbour herbaceaous vegetation, dominated by annual grasses and interspersed with trees (average tree canopy cover of 3% ± 0.4). Dominant trees are *Acacia senegallis*, *A. tortilis* and *Balanites aegyptiaca*. The basin is characterized by bare soil, grassland with trees & shrubs (tree canopy cover 12.6% ± 1.4) and gallery forest (tree canopy cover 27% ± 3.5) around the temporary watercourses and small depressions. Here the dominant trees are Acacia nilotica and Tamarix senegalensis. The new agro-business is mainly allocated to areas on the higher grounds.

The surface area of terrain types in the Ndiael is given in table A2-1. The total area within the former reserve boundaries was 52.567 ha. Note that this is 6.000 hectares larger than the 46.550 hectares mentioned in the Presidential decision of 1965 (Kane *et al*. 1999) and what thus is assumed by several authors and the Senegalese authorities.

A comparison to the map for 2003 (CSE 2008) is given in table A2-2. For this comparison we aggregated terraintypes of the 2013 map to arrive at a globalised legend. The 2008 terrain map is not inconsistent with the above results, but since the methodology to produce both maps has not been the same, the differences are not discussed.

The surface of the cuvette itself is estimated by Humbert *et al.* (1995) at 10.000 ha at a waterlevel of 1.10 m above sea level. Moreover, the area of terrain types that belong to the basin, within the new reserve boundaries, is estimated at 18.700 ha. These terrain types may potentially be flooded. The potentially flooded area in the reserve may thus increase with thousands of hectares, if sufficient water can be transported to the Ndiael.

Map A2-1 Terrain map of the Ndiael in 2013. The map is based on a landscape guided approach using google images from 2013, updated by groundtruthing in the field in January 2014. All relevant areas and terrain types have been (re)visited.

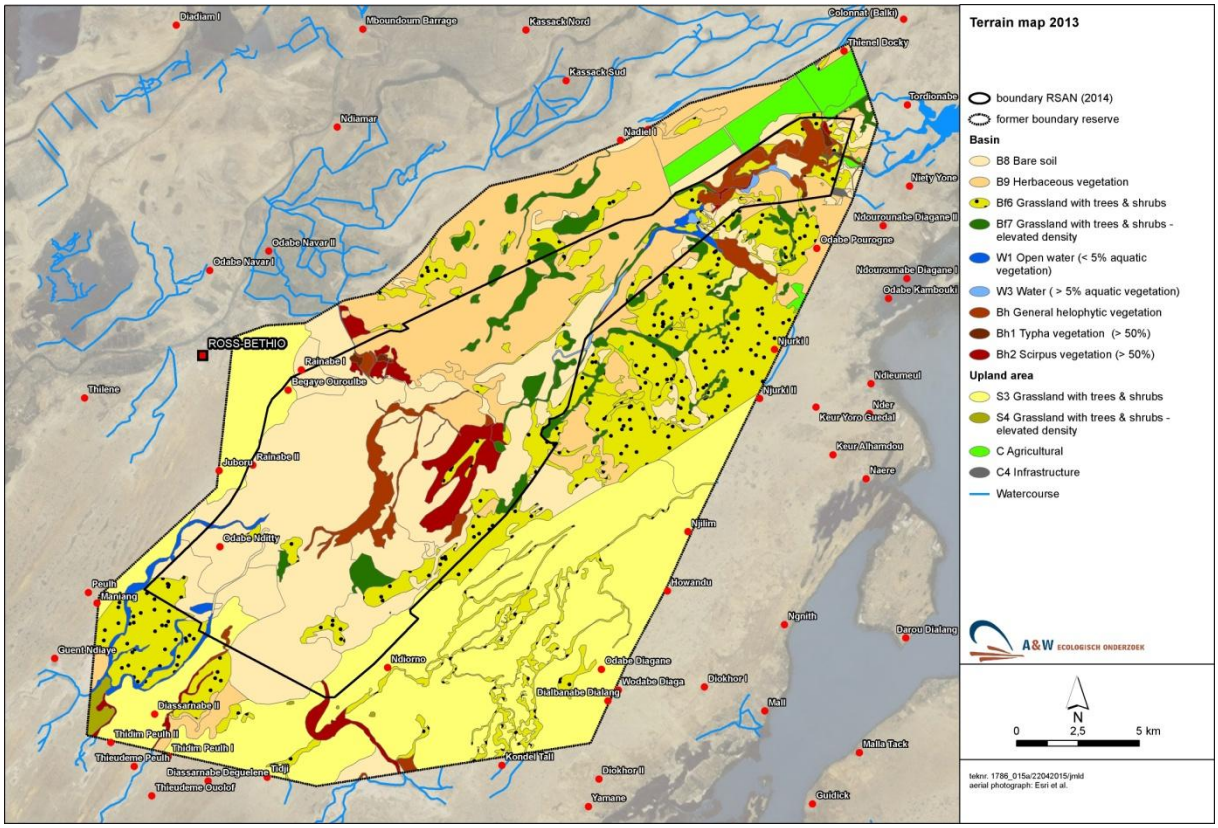


Table A2-1. Surface area of terrain types in the Ndiael in 2013. The map for 2013 is based on a landscape guided approach using google images from 2013, updated by groundtruthing in the field in January 2014. The tree cover (plus standard error) and density of trees (plus standard error) per terrain type in the Ndiael is given, as estimated from Google images (dec 2013, sample size (n) varies between 3 and 52 sample plots per terrain type).

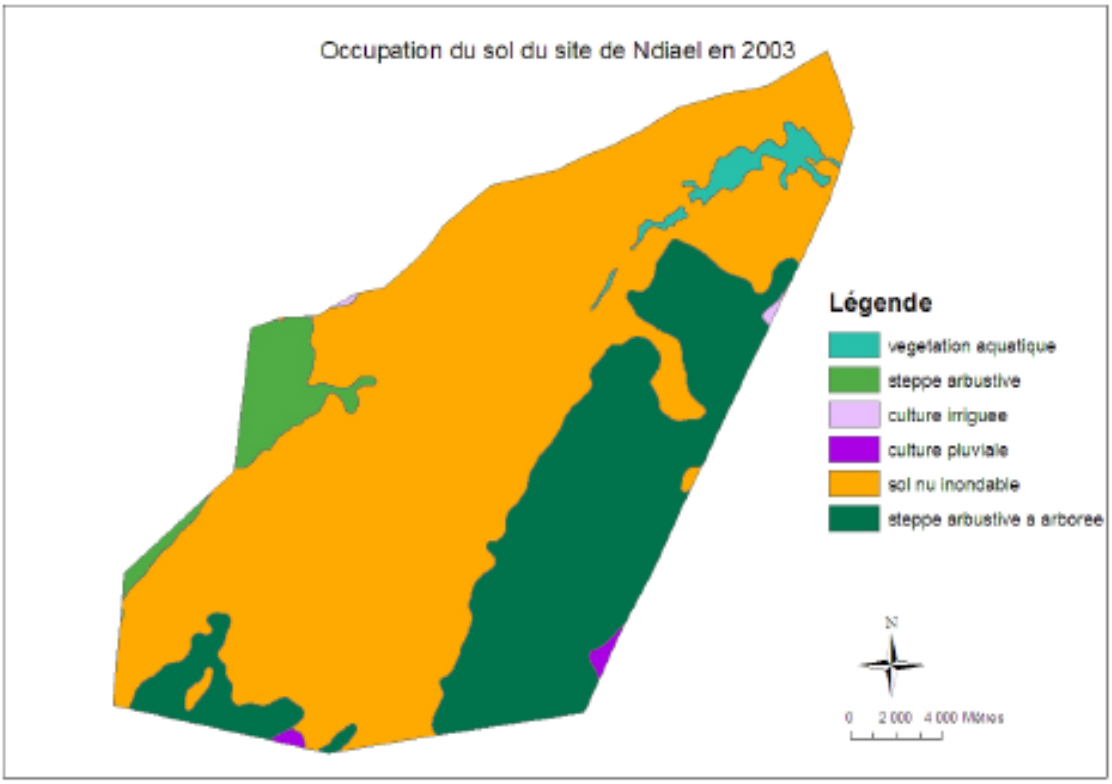
Terrain type	code	area (ha)	relative area (%)	tree cover (%)	*s.e.*	tree density (no/ha)	*s.e.*	*n*
Basin								
Bare soil	B8	12594	24,0%	1,6	*1,2*	16	*12*	*13*
Herbaceous vegetation	B9	9050	17,2%	2,9	*1,4*	25	*18*	*8*
Grassland with trees & shrubs	Bf6	10125	19,3%	12,6	*1,4*	82	*9*	*52*
Grassland with trees & shrubs - elevated density	Bf7	1798	3,4%	27,0	*3,5*	148	*13*	*31*
Temporary water	W1	465	0,9%	0,0	*0,0*	0	*0*	*3*
Temporary water with > 5% aquatic vegetation	W3	97	0,2%					
General helophytic vegetation	Bh	1431	2,7%	2,1	*1,7*	12	*9*	*7*
Helophytic vegetation dominated by Typha	Bh1	67	0,1%					
Helophytic vegetation dominated by Scirpus	Bh2	1149	2,2%	3,8	*1,5*	38	*20*	*6*
Upland area								
Grassland with trees & shrubs	S3	14416	27,4%	3,0	*0,4*	23	*3*	*40*
Grassland with trees & shrubs - elevated density	S4	143	0,3%					
Agricultural fields	C	1201	2,3%	1,3	*0,6*	10	*4*	*20*
Infrastructure	C4	31	0,1%					
Total area		52567						

Table A2-2. Surface area of globalised terrain types in the Ndiael in 2003 (CSE 2008) and 2013 (own data). The 2003 map is part of a supervised classification from satellite imagery for the entire lower Senegal valley (CSE 2008), the map 2013 is based on a landscape guided approach using google images from 2013, updated by groundtruthing in the field in January 2014.

Global legend	Global legend	2003 (ha)	2013 (ha)
Culture irriguée / pluviales	agriculture	2307	1201
Eau permanente	open permanent water	7	0
Eau temporaire	open temporary water	3077	465
Sol nu inondable	bare soil	13852	12594
Steppe arbustive sur dépréssion innondables	tree & shrub savanne in floodplain	14006	23553
Steppe arbustive/arbustive à arborée	tree & shrub savanne on higher ground	18208	14559
Végétation aquatique	aquatic vegetation	1110	164
Infrastructure	infrastructure	0	31

The reserve size had changed by Presidential decree in 2012. As of 2012 the reserve boundaries are not clear. There are several maps circulating (source: SAED) from 2012, 2013 and 2014. We did not find an official document presentng the defenitive boundary of the reserve, and thus we have taken the boundaries as shown on an image by SAED in 2014 as the best approximation. The surface within these new boundaries (shown in figure 1, 3 and A2-1) is ca. 19.500 ha.

Fig A2-2 A and B previous terrain maps for the Ndiael (CSE 2008).



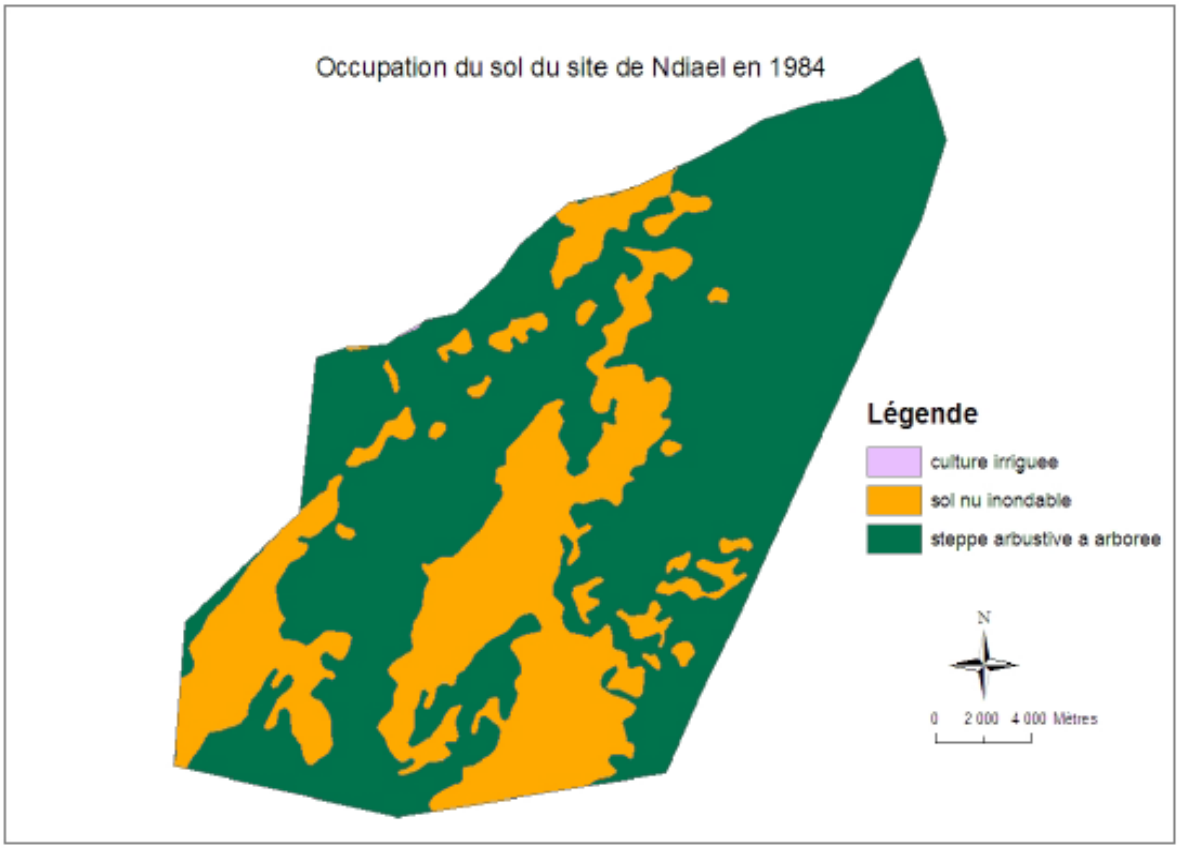


Fig A2-3. Recent terrain map for the zone of intervention of the PREFELAG project, which includes the Ndiael. The map is based upon satellite image classification (BA & BOCOUM, 2015).

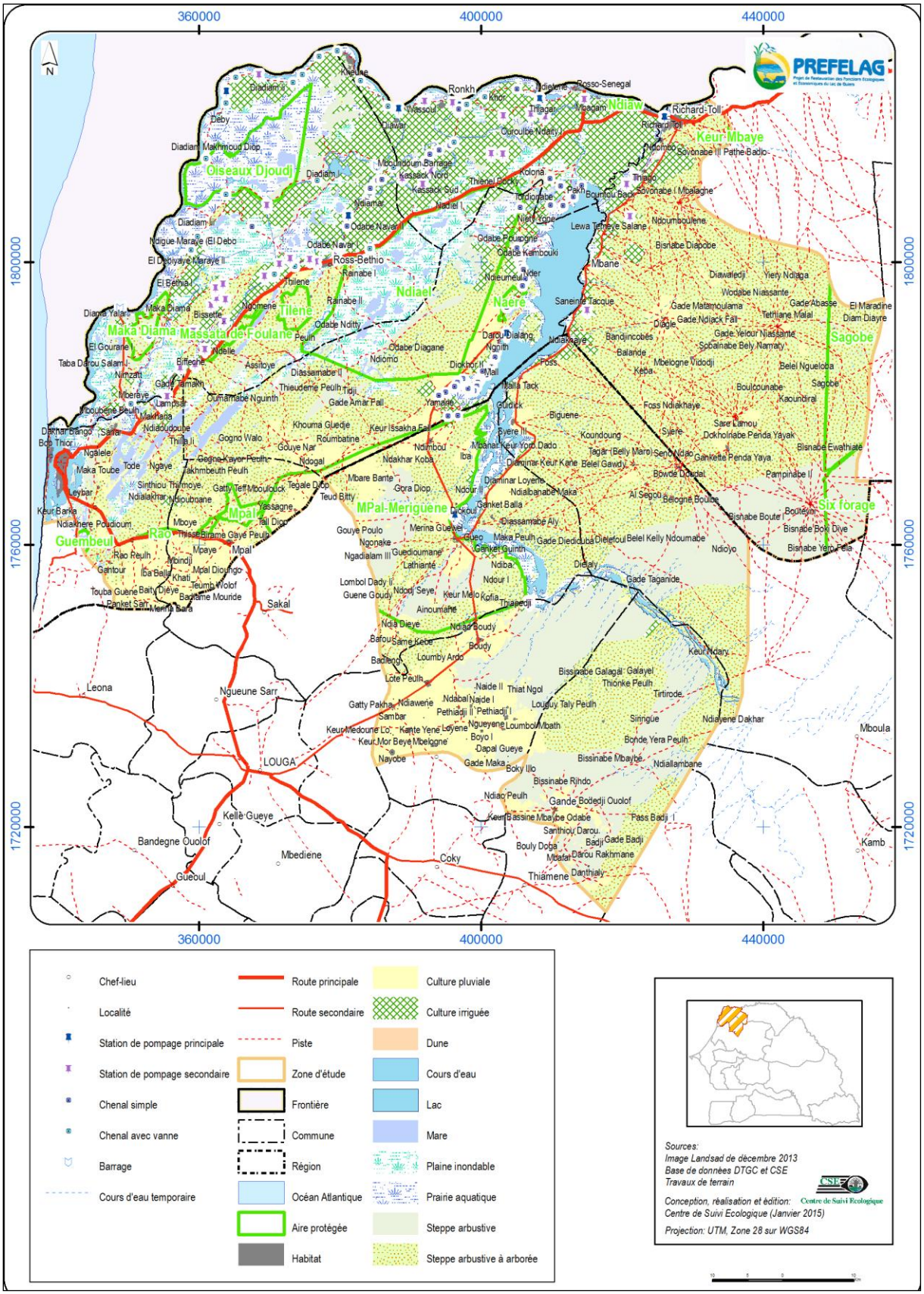
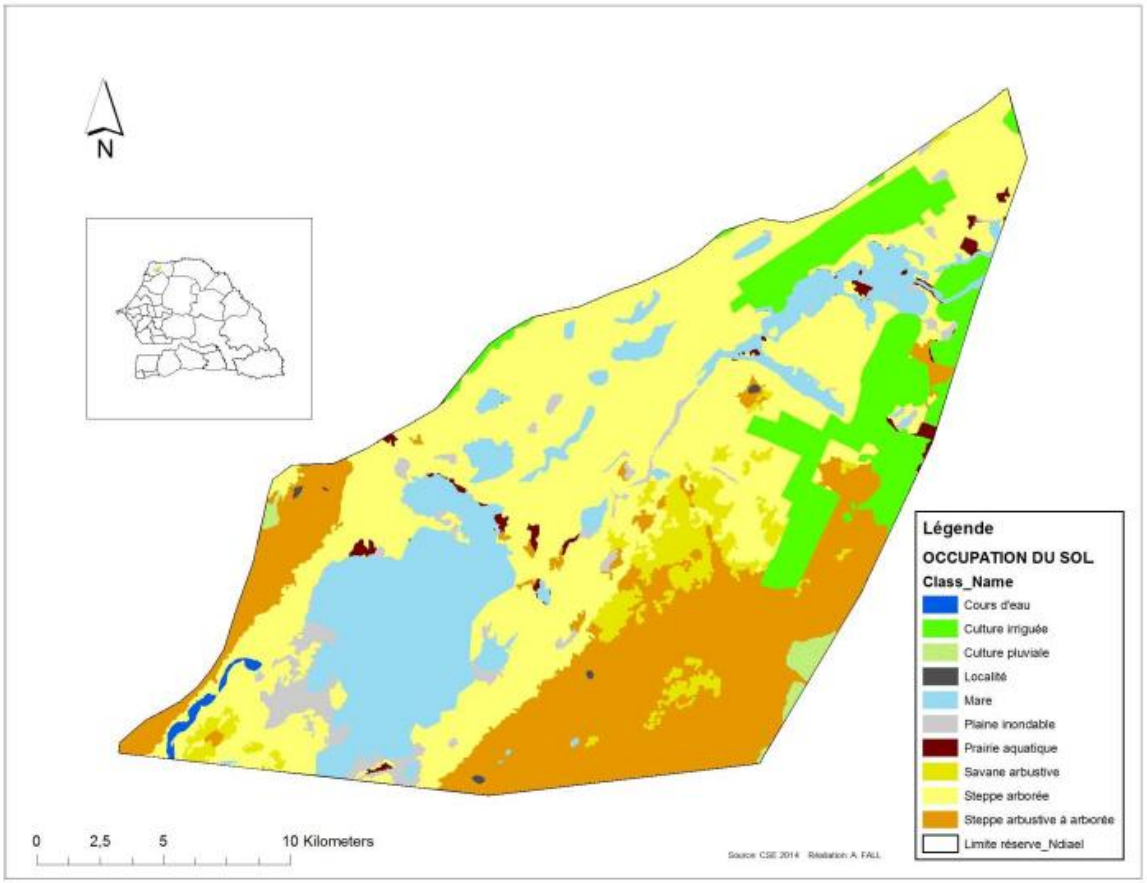


Fig A2-4. Recent terrain map for the Ndiael in 2014 as presented by Fall (2015). The map is based upon satellite image classification by CSE (unpublished) but is not the same as in fig A2-3.



On the next pages some pictures are presented of the different terraintypes encountered in the Ndiael.

Bare soil

Herbaceous vegetation in the Basin of the Ndiael

Grassland with trees & shrubs

Grassland with trees & shrubs - elevated density (Acacia nilotica "flood forest")

Temporary water

Temporary water with aquatic vegetation

Helophytic vegetation dominated by Typha (left) and Helophytic vegetation dominated by Scirpus (right)

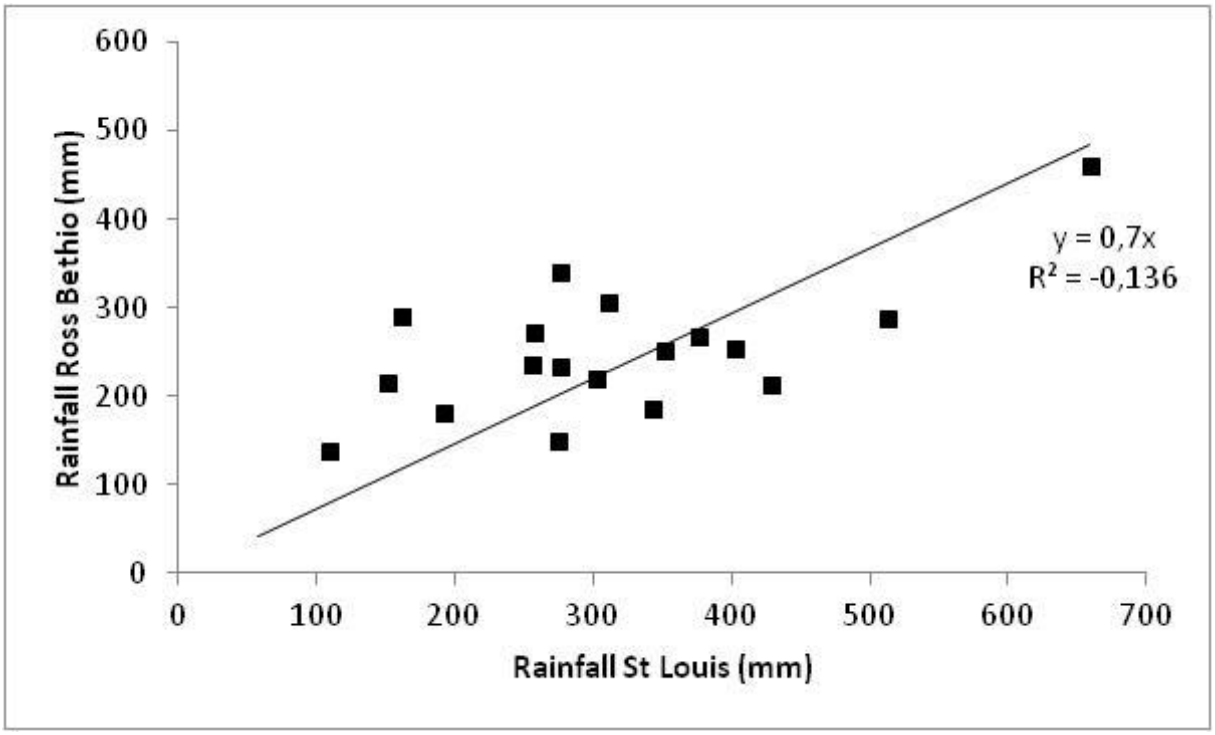

Upland area: Grassland with trees & shrubs (left picture) and Grassland with trees & shrubs - elevated density (right)


Annex 3. Rainfall and area inundated

The information on evaporation, wind, and rainfall (but also geology and socio-economics) is nicely described in Fall (2015). From December until May there is a dry season with a negligible amount of rain. July, August and Septembre bring most of he rain. Annual rainfall data for St Louis and Ross Béthio are presented in Figure A3-1 and table A3-1. There is less rainfall in Ross Béthio, compared to St Louis, but the available series of data we have for Ross Béthio is not long enough for our purposes.

Evaporation varies between 1400-1900mm/yr between 1983 and 2012 in St Louis (Fall 2015).

Figure A3-1. The correlation between rainfall in St Louis and Ross Bethio (nearest to Ndiael).



Local fishing gear in the Ndiael (left picture) and bull kept in the village for fattening (right picture).

Table A3-1. Rainfall in St Louis and Ross Bethio (nearest to Ndiael).

Year	Rainfall St-Louis (mm)	Ross Béthio (station)
1965	325	
1966	439	
1967	275	
1968	235	
1969	532	
1970	180	
1971	181	
1972	156	
1973	189	
1974	197	
1975	414	
1976	205	
1977	102	
1978	224	
1979	220	
1980	354	
1981	375	
1982	192	182
1983	100	
1984	109	138
1985	263	
1986	161	291
1987	343	186
1988	335	
1989	256	236
1990	189	
1991	145	
1992	58	
1993	242	
1994	220	
1995	315	
1996	323	
1997	220	
1998	260	
1999	359	
2000	227	
2001	276	340
2002	276	233
2003	351	253
2004	151	215
2005	302	221
2006	428	213
2007	402	253
2008	257	271
2009	311	306
2010	659	461
2011	275	149
2012	513	289
2013	376	268
2014	123	

Inundated area

We acquired Landsat TM images for several moments in the months of October-January between years 1984 and January 2015 and estimated the surface of inundated area in the Ndiael using the 'no shade' algorithms provided by Feyisa *et al*. (2013) for all Landsat images except Landsat TM8. As of January 2014 we used the 'shade-algorithm' because that formula provide better results with the Landsat TM 8 images available from that moment onward (In comparison to the previous Landsat TM images (TM 7 and lower) they are 16 bit unsigned, rather than 8 bit usigned). The selection of images was made such that it allowed us to arrive at the best possible estimate for maximal inundated surface in each of the years studied. Assuming that maximum inundation would occur in October, we concentrated on images for October and Novembre. If the inundated area was higher than 1000 ha in any of these months we also estimated the inundation in January. We only selected images with cloud cover < 10 % and visually inspected those with for presence of clouds in the study area. For many years in the late eighties and early nineties we did not succeed in obtaining images that met our criteria, mainly due to malfunctioning of the sensor in the Landsat mapper (www.usgs.gov). In figure A3-2 a comparison is given between fielddata for the area inundated January 15th 2015 in the Ndiael (walking on foot around the area with a GPS) and the classified Landsat TM images of a week before, January 8th 2015. The agreement is perfect. Figure A3-3 provides three examples of maps that were created to calculate the inundated area in the Ndiael.

As can be seen in figure 2B (main text), Figure A3-4 and table A3-2 the area inundated fluctuates strongly within and between years. It is always small (< 510 ha, n=7) in January, but may be well over 5000 ha (years 2000 and 2010). When studying the images in detail (Bos *et al* 2015) it appears that the water indeed originates from the sources mentioned above: rainfall supplied with river input via the Trois Marigots (year 1999), the Drain (years 2003, 2005, 2009, 2010, 2013) and the Yéti Yone (year 2013). A sequence of six years from 2004 until 2009 showed inundations of limited surface. The inundation of 2010 (6227 ha) should mainly be attributed to above average rainfall and input via the Drain, and to some extent via the Yéti Yone, as a result of investments made there by local people to remove blockades in the riverbed. October 2013 is characterized by a bigger flood (2750 ha) than October 2012 (1589 ha), in spite of lower annual rainfall. That year as well, some water arrived via the Yéti Yone (pers. obs.). This year as a combined result of the hydrological works for the new agro-business company SENHUILE and the removal of more barriers in the watercourse of the Yéti Yone by local people. It may be seen from the satellite image as a small channel. It cannot be deduced exactly from the satellite images what quantities of water originated from the drain, but it appears that input via the drain should not be neglected. In January 2014 the area inundated is still 509 ha, which is the highest area inundated for that month since the start of the dataseries.

Figure A3-2. Groundtruthing of the calculation of the inundated surface. A comparison is given between fielddata for the area inundated January 15th 2015 (walking on foot around the area) in comparison to the classified Landsat TM images of a week before, January 8th 2015. The agreement is perfect.

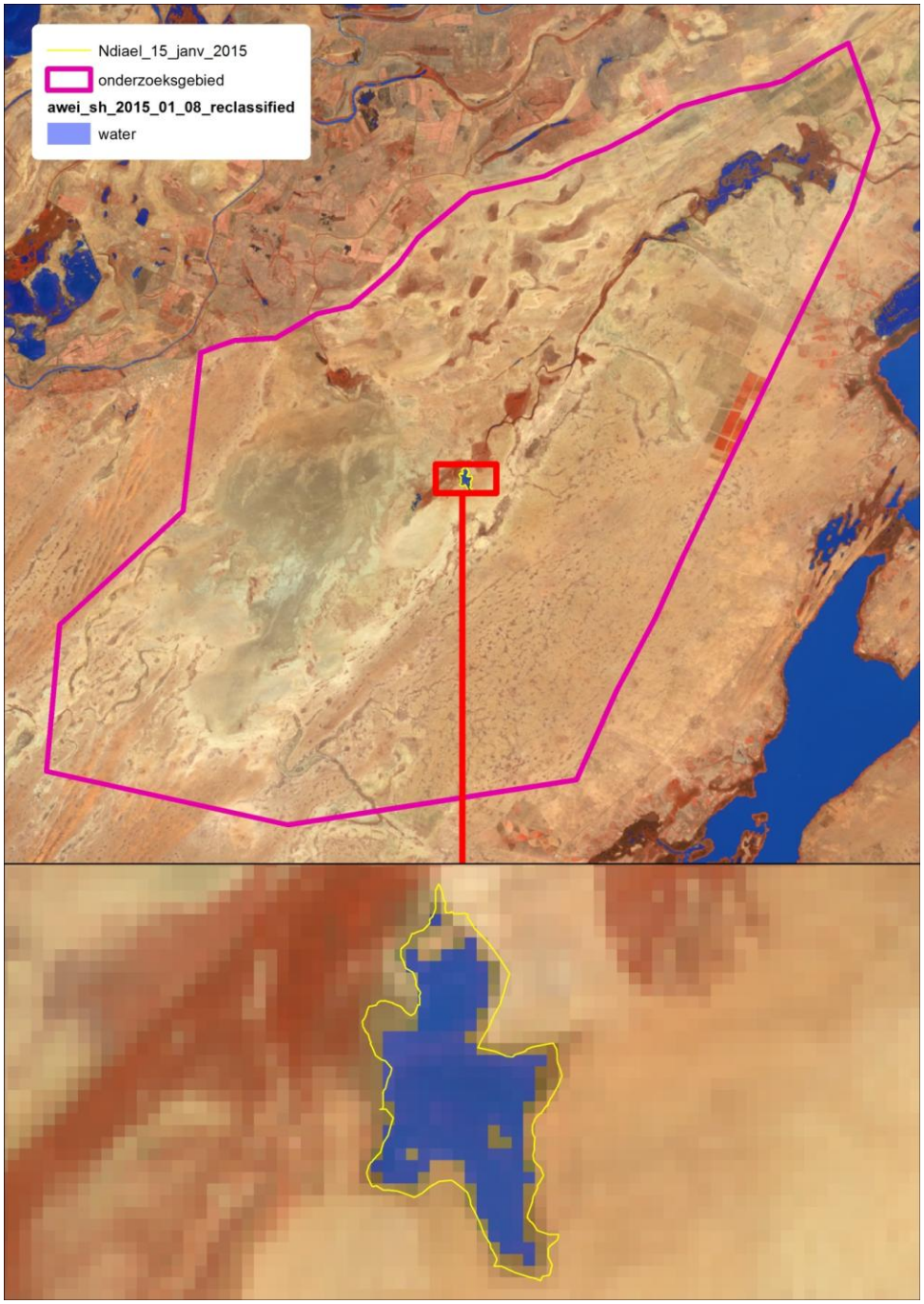
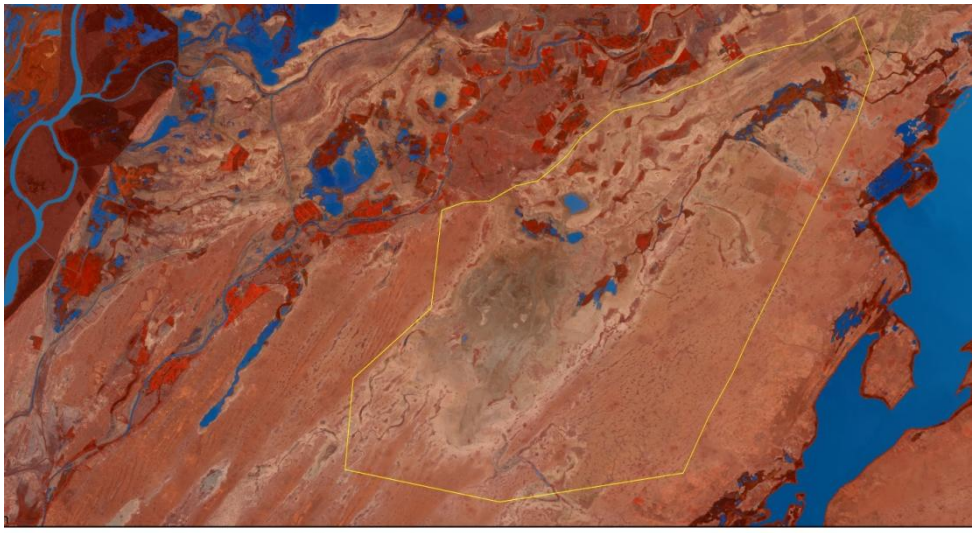
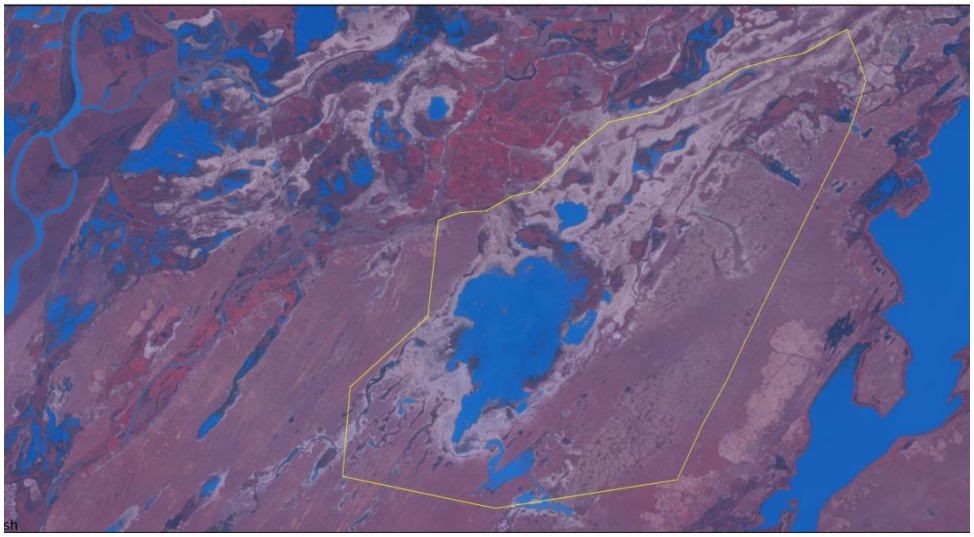


Figure A3-3 Examples of classified Landsat TM images for the calculation of the inundated surface for the dates Oct. 2014, Oct. 2010 and Oct. 2000.

20-10-2014



25-10- 2010



21-10-2000

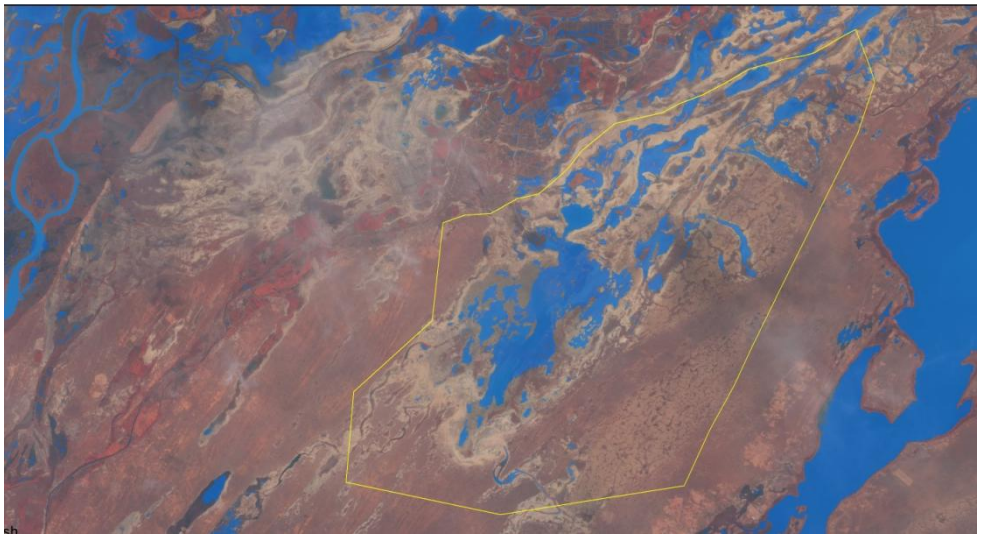
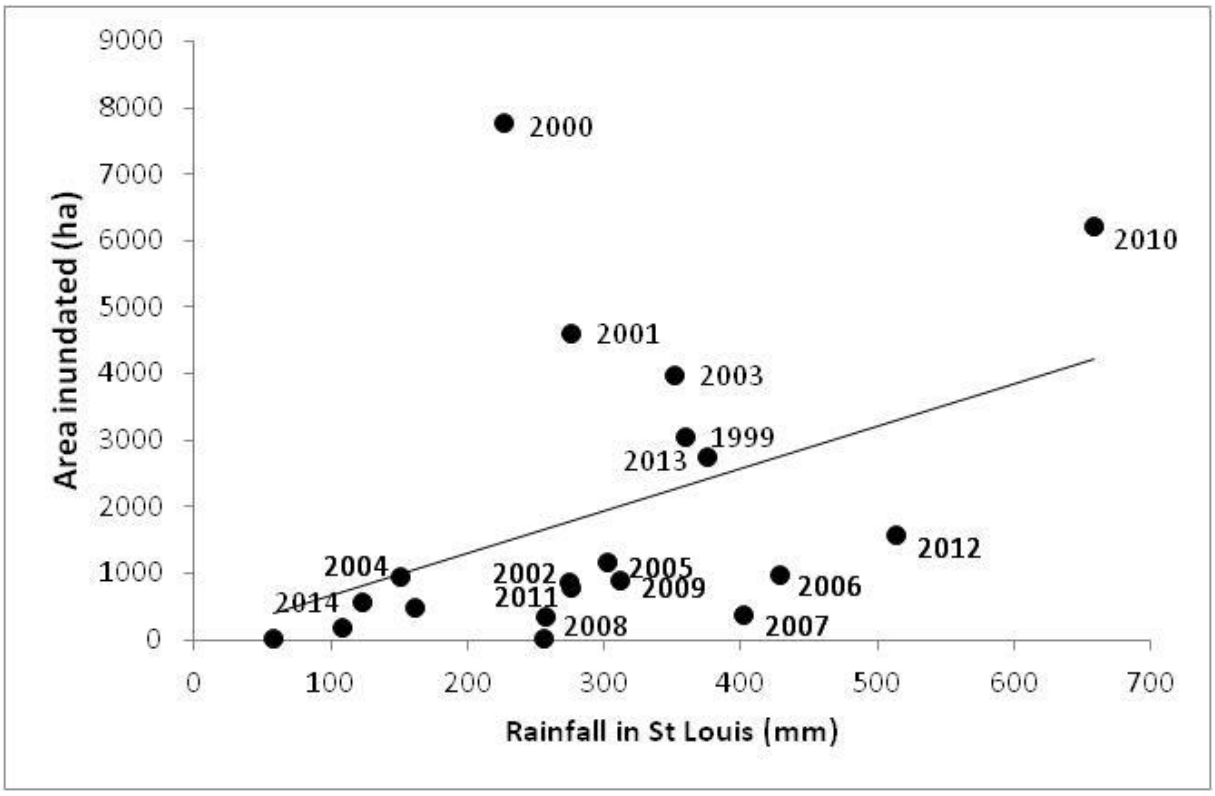


Table A3-2 Historical fluctuations in the inundated area in the Ndiael from 1984 –Jan. 2015, as derived from satellite imagery. Same data as in figure A3-2.

Date	January	February	October	Novembre
17 October 1984			0	
18 November 1984				200
23 October 1986			490	
15 October 1989			38	
31 October 1992			30	
04 November 1999				3063
21 October 2000			7775	
09 January 2001	342			
08 October 2001			4622	
09 November 2001				1416
28 November 2002				786
15 January 2003	281			
31 January 2003	398			
14 October 2003			1972	
15 November 2003				3975
01 November 2004				954
05 February 2005		73		
03 October 2005			1166	
04 November 2005				928
20 November 2005				977
06 October 2006			990	
22 October 2006			376	
30 October 2006			305	
07 November 2006				426
15 November 2006				250
25 October 2007			375	
10 November 2007				217
11 October 2008			363	
27 October 2008			285	
28 November 2008				238
06 October 2009			259	
22 October 2009			889	
07 November 2009				359
15 November 2009				650
23 November 2009				215
02 January 2010	179			
25 October 2010			6227	
26 November 2010				4828
04 October 2011			871	
12 October 2011			112	
05 November 2011				100
13 November 2011				26
21 November 2011				84
24 January 2012	11			
06 October 2012			1589	
07 November 2012				257
23 November 2012				159
10 January 2013	65			
01 October 2013			741	

09 October 2013		2750	
17 October 2013		521	
25 October 2013		1508	
10 November 2013			799
26 November 2013			618
05 January 2014	509		
20 October 2014		579	
05 November 2014			355
21 November 2014			330
8 January 2015	233		

Figure A3-4. The correlation between rainfall in St Louis and the maximum inundated area in the Ndiael.



Annex 4. Monthly bird sampling in the Ndiael via the Transect Point method

From October 2012 until December 2014 the bird fauna was inventoried using the Transect-Point Method. A description of the methodology is given in Annex 6 and at http://www.worldbirds.org, and soon at http://www.bto.org/volunteer-surveys/birdtrack. The method was chosen to harmonise methodology between the four Living on the Edge (LoTe) case studies in the Sahel, but also because of the following reasons:

- The method provides a link between area, habitat characteristics and birds.
- It is systematic and quantitative.
- It can – in theory- be executed by a single observer in a relatively short time.

We selected 11 transects, within the new boundaries of the reserve, perpendicular to the gradients in elevation. We distributed the transects over the reserve and chose locations where we expected changes to occur in vegetation and birds as a result of rewetting (see map A4-1). The majority of censuses was done before 11 A.M. or after 15 P.M.

Map A4-1. Spatial position of 11 transects monitored for bird density using the point – transect method (RSPB). These data will provide a baseline for the current situation with regard to habitat and birds. Bird data and method are to be found in the RSPB data base (www.worldbirds.org).

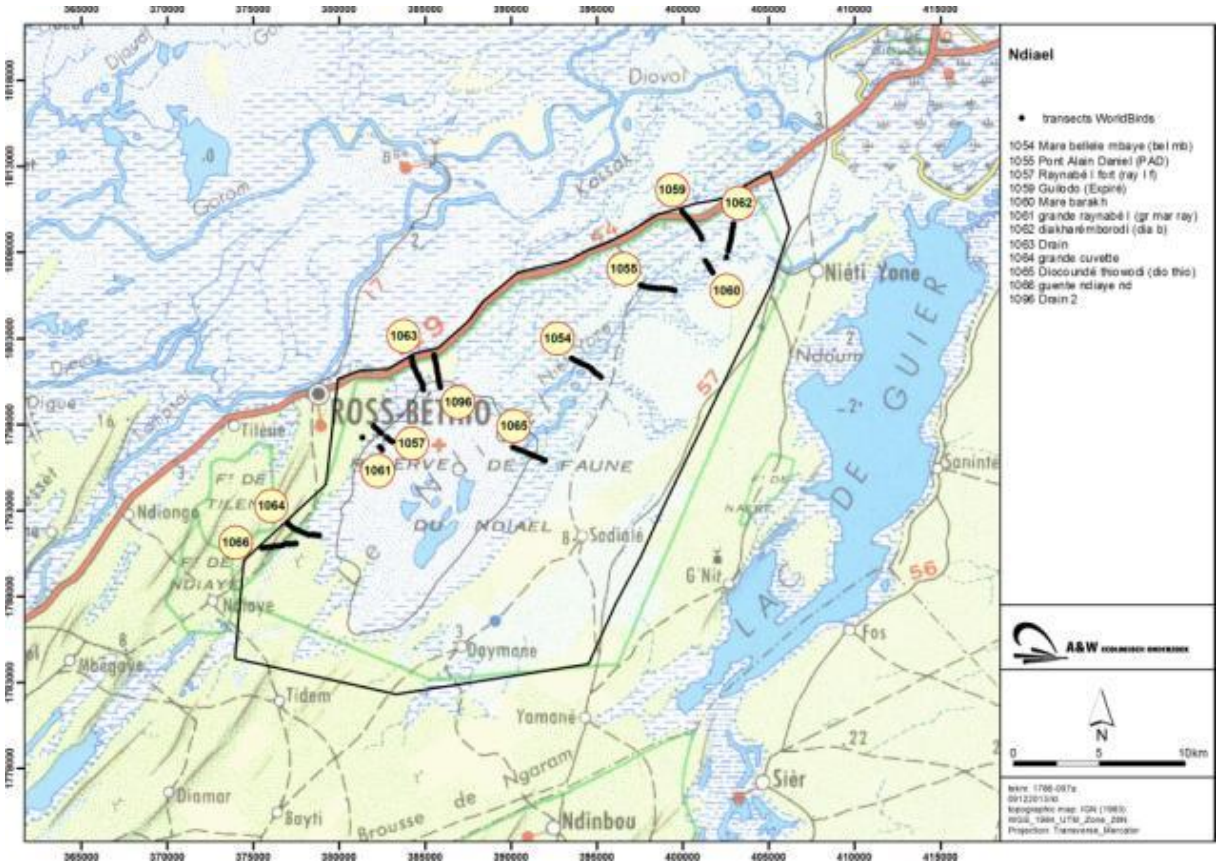


Table A4-1 provides the names of the different transects and the terrain type of the plots sampled. The total number of of plots is 112. Four transects have plots in the uplad herbaceous vegetation. A large number of plots is characterized as bare soil on the terrain map of 2013.

Table A4-1 The number of plots sampled per transects and class of terrain type.

Class of terrain types	Ndiael diakharémborodi (dia b)	Ndiael Diocoundé thiowodi (dio thio)	Ndiael Drain	Ndiael grande cuvette	Ndiael grande raynabé l (gr mar ray)	Ndiael guente ndiaye nd	Ndiael Mare barakh	Ndiael Mare bellele mbaye (bel mb)	Ndiael Pont Alain Daniel (PAD)	Ndiael Raynabé l fort (ray l f)	NdiaelDrain 2	Total
Basin - bare soil	3	4		7	8	5		4	3	6		39
Basin - herbaceous vegetation							4	4	6		9	23
Basin - herbaceous vegetation with trees	4	1						3	1		1	8
Basin - helophytic vegetation	4	6	11				1				1	15
temporary water (<5% vegetation)				1		1			1			3
upland - herbaceous vegetation with trees				3	3	5				2		13
Totals	11	11	11	11	11	11	5	11	11	8	11	112

A total of 194 species have been positively identified in 26 months, on 2519 plots or 210 hours of net observation time. Table A4-2 provides a list with the relative occurence of *bird species.* Eleven species have been observed more than once per hour (see also table A4-3), about 50 species have been seen more than once every ten hours during the surveys. The remainder has been observed incidentally. The survey results show that the diversity in the Ndiael is much larger than what is noted during the annual census. The data provide another quantitative baseline against which changes as a result of rewetting can be measured.

Coumba Ly-Tiamm and Abdoulaye Ka during the monthly bird counting.

Table A4-2 The relative occurence of *bird species in the Ndiael as derived from sample counting (frequency of observation/hr).*

English	Latin name	Basin - herbaceous vegetation with trees	Basin - helophytic vegetation	Basin - bare soil	Basin - herbaceous vegetation	temporary water (<5% vegetation)	upland - herbaceous vegetation with trees	total
Red-billed Quelea	Quelea quelea	3,3	3,5	0,7	1,2	2,4	4,0	2,1
Sand Martin	Riparia riparia	1,3	2,2	2,4	1,0	4,2	2,7	2,1
Crested Lark	Galerida cristata	1,7	1,8	1,6	2,1	3,4	2,9	1,9
Laughing Dove	Stigmatopelia (Streptopelia) senegalensis	1,9	1,3	0,2	0,4	1,6	3,7	1,1
Namaqua Dove	Oena capensis	1,5	1,1	0,4	0,5	2,6	2,4	1,0
Chestnut-backed Sparrow-lark	Eremopterix leucotis	1,0	0,6	0,8	1,1	1,2	1,8	1,0
Spur-winged Lapwing	Vanellus spinosus	1,1	2,1	0,2	0,6	2,6	0,9	0,9
Chestnut-bellied Sandgrouse	Pterocles exustus	1,3	0,8	0,7	1,0	0,8	0,7	0,8
Reed Cormorant	Phalacrocorax africanus	0,4	2,7	0,1	0,3	1,0	0,0	0,8
White-faced Whistling-duck	Dendrocygna viduata	0,6	1,6	0,1	1,0	0,4	0,1	0,7
Squacco Heron	Ardeola ralloides	0,4	1,5	0,2	0,3	0,4	0,0	0,5
Cattle Egret	Bubulcus ibis	0,9	0,5	0,3	0,4	0,8	0,5	0,5
Little Egret	Egretta garzetta	0,6	1,2	0,1	0,4	0,2	0,1	0,5
Red-eyed Dove	Streptopelia semitorquata	0,9	1,1	0,1	0,2	0,6	0,3	0,4
Singing Bushlark	Mirafra cantillans	0,4	0,2	0,3	0,0	0,6	1,7	0,4
Great Egret	Casmerodius albus / Egretta alba	0,3	1,0	0,0	0,4	0,2	0,0	0,4
Grey Heron	Ardea cinerea	0,7	0,8	0,2	0,2	0,0	0,0	0,4
Black-headed Weaver	Ploceus melanocephalus	1,0	0,6	0,1	0,3	0,4	0,2	0,3
Black Crake	Amaurornis flavirostra	0,3	1,3	0,0	0,0	0,0	0,0	0,3
Purple Swamphen	Porphyrio porphyrio	0,2	0,9	0,1	0,2	0,4	0,0	0,3
Spur-winged Goose	Plectropterus gambensis	0,2	0,5	0,2	0,5	0,4	0,2	0,3
Pied Kingfisher	Ceryle rudis	0,1	1,3	0,0	0,1	0,2	0,0	0,3
Yellow Wagtail	Motacilla flava	0,3	0,2	0,2	0,1	0,4	1,0	0,3
Purple Heron	Ardea purpurea	0,5	0,8	0,1	0,1	0,4	0,0	0,3
Zitting Cisticola	Cisticola juncidis	0,4	0,7	0,1	0,3	0,4	0,1	0,3
Black-winged Stilt	Himantopus himantopus	0,1	0,8	0,0	0,2	0,8	0,2	0,3
White-billed Buffalo-weaver	Bubalornis albirostris	0,1	0,3	0,0	0,1	0,6	1,2	0,3
Greater Blue-eared Glossy-starling	Lamprotornis chalybaeus	0,4	0,3	0,1	0,2	0,4	0,6	0,2
Egyptian Goose	Alopochen aegyptiaca	0,1	0,7	0,0	0,3	0,0	0,0	0,2
African Jacana	Actophilornis africanus	0,3	0,5	0,1	0,2	0,2	0,0	0,2
Senegal Thick-knee	Burhinus senegalensis	0,1	0,4	0,0	0,1	0,4	0,6	0,2
Abyssinian Roller	Coracias abyssinicus	0,3	0,3	0,0	0,1	0,2	0,8	0,2
Barn Swallow	Hirundo rustica	0,3	0,4	0,1	0,2	0,2	0,0	0,2
Sudan Golden Sparrow	Passer luteus	0,1	0,1	0,1	0,1	0,4	0,9	0,2
Great Cormorant	Phalacrocorax carbo	0,2	0,5	0,1	0,1	0,0	0,0	0,2
Chestnut-bellied Starling	Lamprotornis pulcher	0,0	0,0	0,0	0,1	0,2	1,2	0,2
Little Bee-eater	Merops pusillus	0,2	0,3	0,1	0,1	0,2	0,5	0,2
Comb Duck	Sarkidiornis melanotos	0,3	0,3	0,1	0,2	0,0	0,1	0,2
Common Swift	Apus apus	0,2	0,1	0,2	0,4	0,0	0,0	0,2
Fulvous Whistling-duck	Dendrocygna bicolor	0,3	0,3	0,0	0,2	0,0	0,0	0,2
Black-crowned Night-heron	Nycticorax nycticorax	0,2	0,4	0,0	0,0	0,8	0,0	0,1
Little Stint	Calidris minuta	0,1	0,3	0,0	0,2	0,2	0,0	0,1
Blue-cheeked Bee-eater	Merops persicus	0,2	0,3	0,0	0,1	0,0	0,1	0,1
Zebra Waxbill	Amandava subflava	0,1	0,5	0,0	0,0	0,0	0,0	0,1
Black-headed Lapwing	Vanellus tectus	0,2	0,2	0,0	0,2	0,6	0,0	0,1
Garganey	Anas querquedula	0,1	0,2	0,1	0,1	0,2	0,2	0,1
Vitelline Masked-weaver	Ploceus vitellinus	0,2	0,4	0,0	0,0	0,0	0,2	0,1
Cream-coloured Courser	Cursorius cursor	0,1	0,0	0,2	0,1	0,2	0,3	0,1
Mourning Collared-dove	Streptopelia decipiens	0,4	0,2	0,1	0,1	0,2	0,0	0,1

English	Latin name	Basin - herbaceous vegetation with trees	Basin - helophytic vegetation	Basin - bare soil	Basin - herbaceous vegetation	temporary water (<5% vegetation)	upland - herbaceous vegetation with trees	total
Ruff	Philomachus pugnax	0,0	0,4	0,0	0,2	0,2	0,0	0,1
White Wagtail	Motacilla alba	0,2	0,1	0,0	0,1	0,2	0,4	0,1
Woodchat Shrike	Lanius senator	0,0	0,0	0,0	0,1	0,2	0,6	0,1
Wattled Lapwing	Vanellus senegallus	0,2	0,1	0,0	0,2	0,0	0,2	0,1
Collared Pratincole	Glareola pratincola	0,0	0,1	0,1	0,0	0,6	0,2	0,1
Glossy Ibis	Plegadis falcinellus	0,1	0,3	0,0	0,1	0,4	0,0	0,1
Kittlitz's Plover	Charadrius pecuarius	0,0	0,1	0,0	0,2	0,2	0,1	0,1
Temminck's Courser	Cursorius temminckii	0,1	0,0	0,1	0,1	0,4	0,3	0,1
Western Marsh-harrier	Circus aeruginosus	0,0	0,1	0,1	0,1	0,2	0,3	0,09
Blue-naped Mousebird	Urocolius macrourus	0,1	0,0	0,0	0,0	0,2	0,6	0,09
Intermediate Egret	Mesophoyx (Egretta) intermedia	0,1	0,3	0,0	0,1	0,2	0,0	0,08
Red-billed Hornbill	Tockus erythrorhynchus	0,0	0,1	0,0	0,0	0,0	0,5	0,08
African Darter	Anhinga rufa	0,0	0,2	0,0	0,1	0,0	0,0	0,07
Senegal Coucal	Centropus senegalensis	0,1	0,2	0,0	0,0	0,4	0,0	0,07
African Fish-eagle	Haliaeetus vocifer	0,0	0,1	0,0	0,2	0,0	0,0	0,07
Black-crowned Sparrow-lark	Eremopterix nigriceps	0,0	0,0	0,1	0,0	0,4	0,2	0,07
Common Ringed Plover	Charadrius hiaticula	0,0	0,1	0,0	0,1	0,2	0,0	0,07
Goliath Heron	Ardea goliath	0,0	0,3	0,0	0,0	0,0	0,0	0,07
Great White Pelican	Pelecanus onocrotalus	0,2	0,2	0,0	0,1	0,0	0,0	0,07
Gull-billed Tern	Sterna nilotica	0,2	0,2	0,0	0,0	0,0	0,0	0,07
Yellow-crowned Bishop	Euplectes afer	0,1	0,2	0,0	0,1	0,0	0,0	0,07
African Sacred Ibis	Threskiornis aethiopicus	0,0	0,2	0,0	0,1	0,0	0,0	0,06
Black Tern	Chlidonias niger	0,0	0,3	0,0	0,0	0,0	0,0	0,06
Common Greenshank	Tringa nebularia	0,1	0,1	0,0	0,1	0,2	0,0	0,06
Beautiful Sunbird	Nectarinia (Cinnyris) pulchella	0,2	0,0	0,0	0,0	0,0	0,2	0,06
Grey-headed Gull	Larus cirrocephalus	0,1	0,2	0,0	0,1	0,0	0,0	0,06
Whiskered Tern	Chlidonias hybrida	0,0	0,2	0,0	0,0	0,4	0,0	0,06
Bronze-tailed Glossy-starling	Lamprotornis chalcurus	0,05	0,19	0,00	0,00	0,00	0,00	0,05
Eurasian Spoonbill	Platalea leucorodia	0,05	0,17	0,00	0,03	0,00	0,00	0,05
Green Sandpiper	Tringa ochropus	0,05	0,11	0,00	0,08	0,20	0,00	0,05
Montagu's Harrier	Circus pygargus	0,05	0,00	0,08	0,08	0,00	0,00	0,05
Osprey	Pandion haliaetus	0,00	0,04	0,05	0,08	0,00	0,04	0,05
Black Kite	Milvus migrans	0,16	0,00	0,05	0,00	0,20	0,04	0,04
Black Stork	Ciconia nigra	0,11	0,04	0,03	0,08	0,00	0,00	0,04
Eurasian Hoopoe	Upupa epops	0,00	0,00	0,01	0,00	0,00	0,30	0,04
European Turtle-dove	Streptopelia turtur	0,11	0,11	0,00	0,05	0,00	0,00	0,04
Sedge Warbler	Acrocephalus schoenobaenus	0,00	0,17	0,00	0,00	0,00	0,04	0,04
Western Reef-egret	Egretta gularis	0,05	0,04	0,01	0,13	0,00	0,00	0,04
Sandwich Tern	Sterna sandvicensis	0,00	0,15	0,00	0,03	0,00	0,00	0,04
White-throated Bee-eater	Merops albicollis	0,05	0,04	0,00	0,10	0,00	0,04	0,04
Black Heron	Egretta ardesiaca	0,00	0,04	0,00	0,08	0,20	0,04	0,03
Black-tailed Godwit	Limosa limosa	0,00	0,13	0,00	0,03	0,00	0,00	0,03
Common Moorhen	Gallinula chloropus	0,00	0,15	0,00	0,00	0,00	0,00	0,03
Northern Grey-headed Sparrow	Passer griseus	0,16	0,04	0,00	0,05	0,00	0,00	0,03
Northern Wheatear	Oenanthe oenanthe	0,05	0,02	0,01	0,05	0,00	0,08	0,03
Common Coot	Fulica atra	0,00	0,13	0,00	0,00	0,00	0,00	0,03
Little Ringed Plover	Charadrius dubius	0,00	0,04	0,04	0,03	0,00	0,00	0,03
Red-billed Firefinch	Lagonosticta senegala	0,16	0,04	0,00	0,00	0,00	0,04	0,03
Speckled Pigeon	Columba guinea	0,00	0,08	0,01	0,00	0,00	0,04	0,03
Wood Sandpiper	Tringa glareola	0,00	0,11	0,00	0,03	0,00	0,00	0,03
African Silverbill	Lonchura cantans	0,05	0,00	0,01	0,00	0,00	0,11	0,02
Ring-billed Gull	Larus delawarensis	0,00	0,08	0,00	0,03	0,00	0,00	0,02

English	Latin name	Basin - herbaceous vegetation with trees	Basin - helophytic vegetation	Basin - bare soil	Basin - herbaceous vegetation	temporary water (<5% vegetation)	upland - herbaceous vegetation with trees	total
African Grey Hornbill	Tockus nasutus	0,00	0,02	0,01	0,00	0,00	0,08	0,02
African Pygmy-goose	Nettapus auritus	0,11	0,02	0,01	0,00	0,00	0,00	0,02
Black Crowned-crane	Balearica pavonina	0,05	0,04	0,00	0,03	0,00	0,00	0,02
Black Scrub-robin	Cercotrichas podobe	0,00	0,04	0,00	0,00	0,20	0,04	0,02
Common Chiffchaff	Phylloscopus collybita	0,05	0,02	0,03	0,00	0,00	0,00	0,02
Common Quail	Coturnix coturnix	0,00	0,02	0,00	0,03	0,00	0,08	0,02
Curlew Sandpiper	Calidris ferruginea	0,00	0,02	0,01	0,05	0,00	0,00	0,02
Double-spurred Francolin	Francolinus bicalcaratus	0,11	0,00	0,01	0,03	0,00	0,00	0,02
Greater Short-toed Lark	Calandrella brachydactyla	0,00	0,00	0,01	0,00	0,00	0,11	0,02
Heuglin's Masked-weaver	Ploceus heuglini	0,11	0,00	0,00	0,05	0,00	0,00	0,02
Little Tern	Sterna albifrons	0,00	0,00	0,04	0,00	0,20	0,00	0,02
Northern House-martin	Delichon urbicum	0,00	0,08	0,00	0,00	0,00	0,00	0,02
Red-cheeked Cordonbleu	Uraeginthus bengalus	0,11	0,02	0,00	0,00	0,00	0,04	0,02
Sanderling	Calidris alba	0,00	0,08	0,00	0,00	0,00	0,00	0,02
Subalpine Warbler	Sylvia cantillans	0,00	0,02	0,01	0,00	0,20	0,04	0,02
Black-headed Heron	Ardea melanocephala	0,11	0,00	0,00	0,03	0,00	0,00	0,01
Caspian Tern	Sterna caspia	0,00	0,04	0,01	0,00	0,00	0,00	0,01
Common Redshank	Tringa totanus	0,00	0,04	0,00	0,03	0,00	0,00	0,01
Common Snipe	Gallinago gallinago	0,00	0,02	0,00	0,00	0,20	0,04	0,01
Little Grebe	Tachybaptus ruficollis	0,00	0,06	0,00	0,00	0,00	0,00	0,01
Malachite Kingfisher	Alcedo cristata	0,00	0,04	0,00	0,00	0,20	0,00	0,01
Red-headed Quelea	Quelea erythrops	0,00	0,00	0,01	0,03	0,00	0,04	0,01
River Prinia	Prinia fluviatilis	0,00	0,06	0,00	0,00	0,00	0,00	0,01
Short-toed Snake-eagle	Circaetus gallicus	0,00	0,00	0,00	0,08	0,00	0,00	0,01
Slender-billed Gull	Larus genei	0,00	0,06	0,00	0,00	0,00	0,00	0,01
Tree Pipit	Anthus trivialis	0,00	0,02	0,01	0,03	0,00	0,00	0,01
White Stork	Ciconia ciconia	0,05	0,04	0,00	0,00	0,00	0,00	0,01
African Spoonbill	Platalea alba	0,00	0,04	0,00	0,00	0,00	0,00	0,01
Common Kestrel	Falco tinnunculus	0,00	0,00	0,01	0,00	0,00	0,04	0,01
Common Sandpiper	Actitis hypoleucos	0,00	0,02	0,00	0,03	0,00	0,00	0,01
Desert Sparrow	Passer simplex	0,05	0,02	0,00	0,00	0,00	0,00	0,01
Dunlin	Calidris alpina	0,00	0,04	0,00	0,00	0,00	0,00	0,01
European Pied Flycatcher	Ficedula hypoleuca	0,00	0,00	0,00	0,00	0,00	0,08	0,01
Grey Kestrel	Falco ardosiaceus	0,00	0,00	0,01	0,03	0,00	0,00	0,01
Hadada Ibis	Bostrychia hagedash	0,05	0,00	0,00	0,03	0,00	0,00	0,01
House Sparrow	Passer domesticus	0,00	0,04	0,00	0,00	0,00	0,00	0,01
Lesser Black-backed Gull	Larus fuscus	0,00	0,04	0,00	0,00	0,00	0,00	0,01
Lesser Blue-eared Glossy-starling	Lamprotornis chloropterus	0,00	0,02	0,00	0,00	0,00	0,04	0,01
Little Bittern	Ixobrychus minutus	0,00	0,04	0,00	0,00	0,00	0,00	0,01
Northern Pintail	Anas acuta	0,00	0,02	0,00	0,00	0,00	0,04	0,01
Orphean Warbler	Sylvia hortensis	0,00	0,00	0,00	0,00	0,00	0,08	0,01
Pied Avocet	Recurvirostra avosetta	0,00	0,04	0,00	0,00	0,00	0,00	0,01
Rufous-crowned Roller	Coracias naevius	0,11	0,00	0,00	0,00	0,00	0,00	0,01
Saddle-billed Stork	Ephippiorhynchus senegalensis	0,00	0,04	0,00	0,00	0,00	0,00	0,01
Shikra	Accipiter badius	0,05	0,00	0,00	0,00	0,00	0,04	0,01
Southern Grey Shrike	Lanius meridionalis	0,00	0,02	0,00	0,00	0,00	0,04	0,01
Winding Cisticola	Cisticola galactotes (marginatus)	0,00	0,04	0,00	0,00	0,00	0,00	0,01
African Collared-dove	Streptopelia roseogrisea	0,00	0,00	0,00	0,00	0,00	0,04	0,00
African Harrier-hawk	Polyboroides typus	0,00	0,00	0,00	0,00	0,00	0,04	0,00
African Quailfinch	Ortygospiza atricollis	0,00	0,00	0,00	0,00	0,20	0,00	0,00
African Reed Warbler	Acrocephalus baeticatus	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Black Scimitarbill	Rhinopomastus aterrimus	0,00	0,00	0,01	0,00	0,00	0,00	0,00

English	Latin name	Basin - herbaceous vegetation with trees	Basin - helophytic vegetation	Basin - bare soil	Basin - herbaceous vegetation	temporary water (<5% vegetation)	upland - herbaceous vegetation with trees	total
Black-winged Bishop	Euplectes hordeaceus	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Black-winged Kite	Elanus caeruleus	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Bonelli's Warbler	Phylloscopus bonelli	0,05	0,00	0,00	0,00	0,00	0,00	0,00
Cricket Longtail	Spiloptila clamans	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Cut-throat	Amadina fasciata	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Greater Flamingo	Phoenicopterus ruber/roseus	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Greater Hoopoe-lark	Alaemon alaudipes	0,00	0,00	0,01	0,00	0,00	0,00	0,00
Greater Spotted Eagle	Aquila clanga	0,00	0,00	0,00	0,03	0,00	0,00	0,00
Green-backed Camaroptera	Camaroptera brachyura	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Grey-backed Camaroptera	Camaroptera brevicaudata	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Kentish Plover	Charadrius alexandrinus	0,05	0,00	0,00	0,00	0,00	0,00	0,00
Lesser Flamingo	Phoeniconaias minor	0,00	0,00	0,00	0,03	0,00	0,00	0,00
Lesser Kestrel	Falco naumanni	0,00	0,00	0,01	0,00	0,00	0,00	0,00
Lesser Moorhen	Gallinula angulata	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Little Green Bee-eater	Merops orientalis	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Little Weaver	Ploceus luteolus	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Long-tailed Glossy-starling	Lamprotornis caudatus	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Long-tailed Nightjar	Caprimulgus climacurus	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Northern Crombec	Sylvietta brachyura	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Northern Shoveler	Anas clypeata	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Orange Bishop	Euplectes franciscanus	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Pink-backed Pelican	Pelecanus rufescens	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Red-billed Quailfinch	Ortygospiza gabonensis	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Red-chested Swallow	Hirundo lucida	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Red-pate Cisticola	Cisticola ruficeps	0,05	0,00	0,00	0,00	0,00	0,00	0,00
Red-throated Bee-eater	Merops bulocki	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Rufous Cisticola	Cisticola rufus	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Rufous-tailed Scrub-robin	Erythropygia (Cercotrichas) galactotes	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Senegal Batis	Batis senegalensis	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Spotted Thick-knee	Burhinus capensis	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Standard-winged Nightjar	Macrodipteryx longipennis	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Striated Heron	Butorides striata	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Striped Kingfisher	Halcyon chelicuti	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Tawny Pipit	Anthus campestris	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Tawny-flanked Prinia	Prinia subflava	0,00	0,00	0,01	0,00	0,00	0,00	0,00
Village Indigobird	Vidua chalybeata	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Vinaceous Dove	Streptopelia vinacea	0,05	0,00	0,00	0,00	0,00	0,00	0,00
White-winged Tern	Chlidonias leucopterus	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Willow Warbler	Phylloscopus trochilus	0,05	0,00	0,00	0,00	0,00	0,00	0,00
Woodland Kingfisher	Halcyon senegalensis	0,00	0,02	0,00	0,00	0,00	0,00	0,00
Yellow-billed Stork	Mycteria ibis	0,00	0,02	0,00	0,00	0,00	0,00	0,00

Table A4-3 Average density (no/ha/5 minutes) per class of terrain type for the most frequently observed species. The last column indicates the relative occurence expressed as the number of observations of the species in twelve five minute blocks (an hour).

Latin	English	Basin - arbustive/arbustive	Basin - avec helophytes	Basin - sol nu	Basin - végétation herbeuse	Eau - temporaire ouverte (<5% végétation)	Steppes - arbustive/arborée (5-50%)	relative occurence
Quelea quelea	Red-billed Quelea	23,7	37,5	4,0	4,2	6,6	31,3	2,1
Riparia riparia	Sand Martin	0,8	4,4	1,5	0,5	3,1	2,2	2,1
Galerida cristata	Crested Lark	0,3	0,4	0,4	0,5	0,7	0,7	1,9
Stigmatopelia (Streptopelia) senegalensis	Laughing Dove	0,4	0,3	0,0	0,1	0,5	1,4	1,1
Oena capensis	Namaqua Dove	0,4	0,5	0,1	0,1	0,4	0,4	1,0
Eremopterix leucotis	Chestnut-backed Sparrow-lark	0,3	0,2	0,3	0,3	0,2	1,1	1,0
Vanellus spinosus	Spur-winged Lapwing	0,2	0,7	0,1	0,2	0,7	0,2	0,9
Pterocles exustus	Chestnut-bellied Sandgrouse	1,2	0,7	0,6	0,9	0,7	0,3	0,8
Phalacrocorax africanus	Reed Cormorant	0,1	2,5	0,0	0,1	0,2	0,0	0,8
Dendrocygna viduata	White-faced Whistling-duck	4,3	20,6	0,4	9,0	6,0	1,1	0,7

Other observations

During the observations the local team has made several other remarkable observations in the reserve, such as Patas monkey *Erythrocebus patas, Jackal Canis spp,* African savanna hare *Lepus crawshayi*, Marsh mongoose *Atilax paludinosus*, Whartog *Phacochoerues aethiopicus*, Nile varan *Varanus niloticus*, Rock python P*ython de Sebae and* an encounter with a group of 19 Black Storks *Ciconia nigra*. Another 10 small vertebrate species, amongst which Genet *genetta sp*. and Civet *Viverra civetta, but also Hyena crocuta crocuta* have been encountered by the local people in the last ten years (see CSE 2008). Fish species are given in Baldé 2007.

The rare white-bellied bustard (*Eupodotis senegalensis*) is reproducing in the area. The presence of Aquatic warblers (*Acrocephalus paludicola*) cannot be excluded.

Table A4-4 the spatial coordinates of the points and the transects (next pages)

Transect	WorldBirdsID	Section/point	LAT	LON	AW	Type de terrain (AW_legenda)	class de terrain
PAQ	1096	1	1802020,67	385545,51	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	2	1801871,73	385573,16	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	3	1801724,86	385603,69	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	4	1801527,74	385638,98	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	5	1801330,83	385675,35	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	6	1801134,39	385710,12	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	7	1800936,95	385743,6	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
PAQ	1096	8	1800741,35	385783,51	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	9	1800545	385820,3	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	10	1800343,98	385860,5	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PAQ	1096	11	1800145,56	385890,88	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DB	1062	1	1809657,35	402961,97	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
DB	1062	2	1809459,87	402937,59	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
DB	1062	3	1809264,68	402896,66	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
DB	1062	4	1809067,3	402873,03	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
DB	1062	5	1808874,1	402831,47	B8	Basin - sol nu	Basin - sol nu
DB	1062	6	1808677,19	402803,67	B8	Basin - sol nu	Basin - sol nu
DB	1062	7	1808487,6	402748,24	Bh	Basin - avec helophytes	Basin - avec helophytes
DB	1062	8	1808296,11	402695,47	Bh	Basin - avec helophytes	Basin - avec helophytes
DB	1062	9	#N/B	#N/B	Bh	Basin - avec helophytes	Basin - avec helophytes
DB	1062	10	1808100,02	402657,1	Bh	Basin - avec helophytes	Basin - avec helophytes
DB	1062	11	1807717,94	402548,15	B8	Basin - sol nu	Basin - sol nu
DJKODI 1	1065	1	1795903,43	391997,02	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
DJKODI 1	1065	2	1795988,42	391813,93	B8	Basin - sol nu	Basin - sol nu
DJKODI 1	1065	3	1796065,12	391628,02	B8	Basin - sol nu	Basin - sol nu
DJKODI 1	1065	4	1796140,73	391440,82	B8	Basin - sol nu	Basin - sol nu
DJKODI 1	1065	5	1796210,26	391251,89	B8	Basin - sol nu	Basin - sol nu
DJKODI 1	1065	6	1796283,65	391065,43	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DJKODI 1	1065	7	1796374,83	390884,41	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DJKODI 1	1065	8	1796456,39	390702,48	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DJKODI 1	1065	9	1796525,38	390513,23	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DJKODI 1	1065	10	1796602,99	390326,05	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DJKODI 1	1065	11	1796654,3	390131,9	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DRAIN	1063	1	1801876,97	384243,62	Bh2	Basin - Scirpus-végétation (>50%)	Basin - avec helophytes
DRAIN	1063	2	1801679,75	384276,02	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	3	1801486,18	384310,68	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	4	1801298,74	384375,94	W1"	Basin - avec helophytes	Basin - avec helophytes

DRAIN	1063	5	1801120,04	384463,15	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	6	1800939,68	384550,46	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	7	1800761,31	384639,27	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	8	1800585,78	384733,88	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	9	1800412,88	384834,05	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	10	1800220,13	384880,16	W1"	Basin - avec helophytes	Basin - avec helophytes
DRAIN	1063	11	1800020,35	384895,46	Bh	Basin - avec helophytes	Basin - avec helophytes
GC	1064	1	1792245,29	377018,32	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GC	1064	2	1792105,65	377159,08	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GC	1064	3	1791993,09	377324,57	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GC	1064	4	1791892,1	377497,94	W1	Eau - temporaire ouverte (<5% végétation)	Eau - temporaire ouverte (<5% végétation)
GC	1064	5	1791805,79	377678,77	B8	Basin - sol nu	Basin - sol nu
GC	1064	6	1791733,06	377864,91	B8	Basin - sol nu	Basin - sol nu
GC	1064	7	1791657,35	378049,43	B8	Basin - sol nu	Basin - sol nu
GC	1064	8	1791593,35	378239,37	B8	Basin - sol nu	Basin - sol nu
GC	1064	9	1791579,41	378438,35	B8	Basin - sol nu	Basin - sol nu
GC	1064	10	1791559,05	378638,26	B8	Basin - sol nu	Basin - sol nu
GC	1064	11	1791543,56	378838,72	B8	Basin - sol nu	Basin - sol nu
RAYENABE	1061	1	1797226,06	381363,79	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
RAYENABE	1061	2	#N/B	#N/B		Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
RAYENABE	1061	3	#N/B	#N/B		Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
RAYENABE	1061	4	#N/B	#N/B		Basin - sol nu	Basin - sol nu
RAYENABE	1061	5	#N/B	#N/B		Basin - sol nu	Basin - sol nu
RAYENABE	1061	6	#N/B	#N/B		Basin - sol nu	Basin - sol nu
RAYENABE	1061	7	1796675,77	382382,57	B8	Basin - sol nu	Basin - sol nu
RAYENABE	1061	8	1796517,46	382503,77	B8	Basin - sol nu	Basin - sol nu
RAYENABE	1061	9	#N/B	#N/B		Basin - sol nu	Basin - sol nu
RAYENABE	1061	10	#N/B	#N/B		Basin - sol nu	Basin - sol nu
RAYENABE	1061	11	#N/B	#N/B		Basin - sol nu	Basin - sol nu
GUÈ	1066	1	1790817,98	375518,72	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GUÈ	1066	2	1790837,76	375717,58	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GUÈ	1066	3	1790858,99	375916,66	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GUÈ	1066	4	1790886,75	376114,38	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GUÈ	1066	5	1790927,02	376309,93	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
GUÈ	1066	6	1790926,12	376510,38	W1	Eau - temporaire ouverte (<5% végétation)	Eau - temporaire ouverte (<5% végétation)
GUÈ	1066	7	1790974,71	376703,95	B8	Basin - sol nu	Basin - sol nu
GUÈ	1066	8	1791056,55	376886,58	B8	Basin - sol nu	Basin - sol nu
GUÈ	1066	9	1791045,92	377086,01	B8	Basin - sol nu	Basin - sol nu

GUÈ	1066	10	1791048,56	377286,26	B8	Basin - sol nu	Basin - sol nu
GUÈ	1066	11	1791065,04	377485,52	B8	Basin - sol nu	Basin - sol nu
MB	1060	1	1806816,32	401753,09	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
MB	1060	2	1806993,78	401655,08	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
MB	1060	3	1807169,56	401559,52	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
MB	1060	4	1807338,64	401454,11	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
MB	1060	5	1807498,5	401334,66	Bh	Basin - avec helophytes	Basin - avec helophytes
BELALMB	1054	1	1800749,84	395253,32	Bf7	Basin - arbustive/arborée (>50%)	Basin - arbustive/arbustive
BELALMB	1054	2	1800873,07	395094,91	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
BELALMB	1054	3	1800990,13	394931,03	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
BELALMB	1054	4	1801120,42	394778,75	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
BELALMB	1054	5	1801279	394632,59	Bf7	Basin - arbustive/arborée (>50%)	Basin - arbustive/arbustive
BELALMB	1054	6	1801377,14	394471,08	B8	Basin - sol nu	Basin - sol nu
BELALMB	1054	7	1801461,66	394288,88	B8	Basin - sol nu	Basin - sol nu
BELALMB	1054	8	1801541,88	394103,88	B8	Basin - sol nu	Basin - sol nu
BELALMB	1054	9	1801627,63	393921,05	B8	Basin - sol nu	Basin - sol nu
BELALMB	1054	10	1801722,42	393743,39	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
BELALMB	1054	11	1801827,7	393570,38	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
RY	1057	1	1797885,45	382019,29	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
RY	1057	2	1797758,17	382172,18	S3	Steppes - arbustive/arborée (5-50%)	Steppes - arbustive/arborée (5-50%)
RY	1057	3	1797626,37	382321,84	B8	Basin - sol nu	Basin - sol nu
RY	1057	4	1797486,64	382465,16	B8	Basin - sol nu	Basin - sol nu
RY	1057	5	1797487,08	382465,16	B8	Basin - sol nu	Basin - sol nu
RY	1057	6	1797240,66	382779,01	B8	Basin - sol nu	Basin - sol nu
RY	1057	7	1797105,35	382925,13	B8	Basin - sol nu	Basin - sol nu
RY	1057	8	1796997,31	383100,26	B8	Basin - sol nu	Basin - sol nu
PONTAD	1055	1	1805783,65	399555,57	B8	Basin - sol nu	Basin - sol nu
PONTAD	1055	2	1805832,78	399360,09	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PONTAD	1055	3	1805863,25	399159,39	B8	Basin - sol nu	Basin - sol nu
PONTAD	1055	4	1805902,23	398960,77	W1	Eau - temporaire ouverte (<5% végétation)	Eau - temporaire ouverte (<5% végétation)
PONTAD	1055	5	1805890,99	398761,16	Bf6	Basin - arbustive/arborée (5-50%)	Basin - arbustive/arbustive
PONTAD	1055	6	1805891,92	398560,54	C4	Infrastructure	Basin - végétation herbeuse
PONTAD	1055	7	1805918,97	398360,69	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PONTAD	1055	8	1805942,7	398159,75	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PONTAD	1055	9	1805984,77	397962,85	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PONTAD	1055	10	1806029,73	397765,96	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse
PONTAD	1055	11	1806078	397570,7	B9	Basin - végétation herbeuse (5-50%)	Basin - végétation herbeuse

Harvesting of underground edible tubers of plants from the Cyperaceae family.

There is a need for surveillance to prevent illegal off take of firewood (picture taken Jan. 2014).

Annex 5. Bi-annual habitat monitoring

Although during the monthly Bird Survey basic habitat information was collected for each visit to a point, a more detailed set of habitat information was collected twice a year. This detailed habitat monitoring programme is designed to provide information on year-to-year changes in habitats of the LoTE project site. Knowing to what extent habitat is changing around LoTE project sites is fundamental to understanding the success of the conservation measures designed to restore, protect and regenerate habitats around the core project area. The protocol was designed by the RSPB for the Living on the Edge project sites in West Africa.

The detailed Habitat Recording collects information on, for example, dominant landcover, vegetation, water regime, tree cover, shrub cover, wood removal, grazing and the occurence of fire. A detailed protocol is provided in annexes 6 and 7.

Habitat information has been collected per plot (and thus per transect) from Oct 2012 until October 2014. An elaborate analysis of the results, and an interpretation in relation to the bird data, falls beyond the scope of this annex, and the purpose of collecting baseline information. We therefore just provide a short summary of the main findings.

The plots represent the Ndiael in its current state, a generally dry environment. In april none of the plots carry water, 80% of the plots is potentially tempororay inundated for less than four months per year. Differences between years and seasons are reflected in the results of the survey (see table A5-1): the Ndiael is dry in October 2014. Whereas the vegetation in the majority of plots had been characterised as 'green' in 2012 and 2013, the larger share was already senescent in October 2014

Table A5-1 State of the vegetation (% of plots per class) during the bi-annual habitat monitoring.

	2012	2013		2014		Total
Vegetation character	**October**	**April**	**October**	**April**	**October**	
Dry	11,5%	5,7%	2,2%	12,5%	15,5%	9,6%
Senescent	10,3%	50,0%	28,3%	63,5%	58,3%	42,0%
Green	78,2%	44,3%	69,6%	24,0%	26,2%	48,5%
Total	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**

The average number of trees per plot shows no trend over time. Table A5-2 provides the relative occurence of tree species in the sample plots surveyed. *Acacia nilotica* occurs most frequently in the sample (7% of the plots), in the basin near water. Surprisingly, it is also found in 10% of the plots classified as upland herbaceous vegetation with trees. A signal of the degraded state of the Ndiael is the fact that *Tamarix senegalensis* is the species encountered most frequently, after *A. Nilotica.* T. Senegalensis tolerates the dry conditions and the enrichment with salt better than many of the other characteristic floodplain species.

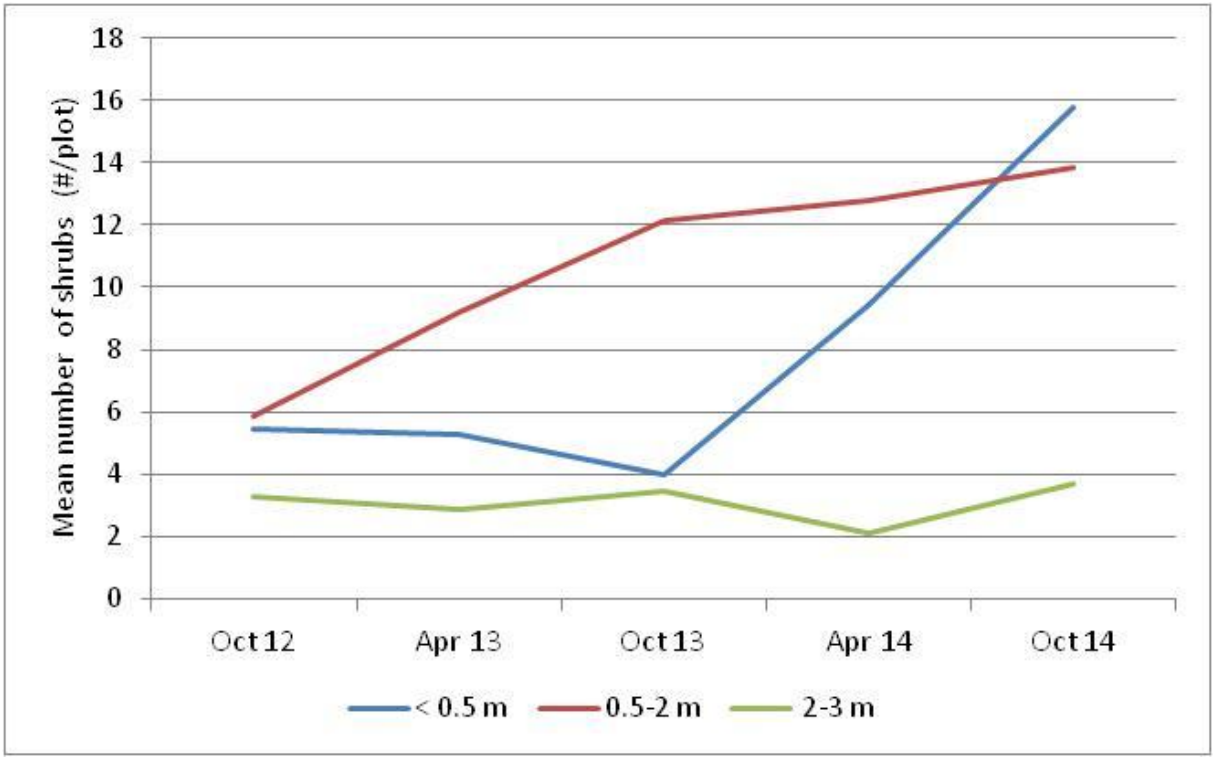
Table A5-2 Relative occurence of tree species in the sample plots surveyed per class of terrain type.

	Basin				Upland		
Tree name	herbaceous vegetation with trees	helophytic vegetation	bare soil	herbaceous vegetation	temporary water (<5% vegetation)	herbaceous vegetation with trees	Total
Acacia nilotica	13%	5%	5%	6%	13%	10%	7%
Tamarix senegalensis	3%	10%	5%	2%	17%	2%	5%
Balanites aegyptiaca	11%	1%	1%	3%	0%	15%	4%
Acacia senegal	8%	1%	1%	8%	2%	8%	4%
Acacia tortilis ssp radiana	6%	1%	2%	2%	2%	11%	3%
calatropis procera	0%	0%	3%	1%	0%	0%	1%
Salvadora persica	3%	0%	1%	1%	0%	3%	1%
Prosopis juliflora	1%	3%	0%	0%	2%	0%	1%
Acacia seyal	2%	1%	0%	2%	2%	1%	1%
Prosopis spec	0%	2%	0%	0%	5%	0%	1%
ziziphus mauritiana	2%	1%	0%	0%	0%	0%	0%
Acacia spec	0%	0%	0%	0%	2%	1%	0%
Boscia senegalensis	1%	0%	0%	0%	0%	0%	0%
Leptadonia pyrotechnica	0%	0%	0%	1%	0%	0%	0%
Combretum glutinosum	1%	0%	0%	0%	0%	0%	0%
leptadenia hastata	0%	0%	0%	0%	0%	1%	0%
Anogeissus leiocarpa	0%	0%	0%	0%	0%	0%	0%
Bauhinia rufescens	0%	0%	0%	0%	0%	0%	0%
Grewia bicolor Juss.	0%	0%	0%	0%	0%	0%	0%
Mitragyna inermis	0%	0%	0%	0%	0%	0%	0%

Seventy –five percent of the plots has been characterized as having little or light grazing. The proportion of plots where branches were cut increased from less than 10% in 2013 to 22-37% in 2014. This is to be explained from the dry conditions in 2014, forcing the herdsman to provide their livestock with edible leaves. In our survey we only observed the cutting of entire trees once.

The number of shrubs < 2m strongly increased, especially in the south and the south-west of the reserve (*Figure A5-1)*. Signs of bush fire are rare (0.6% of the plots on average).

Figure A5-1. The mean number of shrubs per plot in different size classes in the Ndiael over time.



Mahmoud Fall (left) and Abdoulaye Ka (right)

Annex 6. BirdLife Lote - Bird Monitoring Instructions

The LoTE bird monitoring programme is designed to provide information on year-to-year changes in population levels for a wide range of migratory and resident birds across a variety of habitats in the Sahel and Guinea savannah at LoTE project sites in Burkina Faso, Ghana, Mauritania, Nigeria and Senegal. Knowing to what extent bird populations are increasing or decreasing around LoTE project sites is fundamental to understanding the success of LoTE habitat restoration. Monitoring birds has the added advantage that they act as indicators to the health of the environment.

LoTE monitoring forms

- Bird Survey Instruction sheet
- Additional Information Sheet
- Field Recording Sheet
- Habitat Recording Sheet

We recommend that observers take a copy of the Field Recording Sheet out in the field to record their sightings on. The sheet provides space for you to record birds of each species as you see them at each point count station and a column for you to sum the counts from all points to give a total count for each species. Once completed, the form should be returned to the national LoTE coordinator.

Bird Survey format

The bird survey will take the form of a point count transect, each containing 11 counting points (numbered 1 to 11) 200m apart, covering a total distance of 2.0km. On your first visit to the site, please make a note of any additional information that you may wish to provide about your point count transect using the additional information sheet. This should include the GPS waypoint reference for each point. **Please try to ensure that the location of each counting point is the same as on previous visits**.

When to visit

Ideally, each point should be surveyed once a month between October and April (seven visits per year), to coincide with the period when there are migratory birds in the region. The first point count should ideally start around 07h00 and the last finished before 11h00. Please try to keep the starting times similar within and across years. Please also try to keep visit dates similar across the years. Counts will be more productive earlier in the day, with birds generally becoming quiet and inactive during the middle of the day.

Weather

Please do not attempt to carry out surveys in conditions of heavy rain, poor visibility or strong wind. Birds generally become inactive in windy and wet conditions. However, activity often increases considerably after rain showers and therefore showery weather is generally okay for conducting surveys. Please record weather conditions in the boxes provided on the forms that describe cloud cover, rain, wind speed, and visibility. Choose one number (1-3) from each of the four headings below and enter these in the box provided. If the weather conditions change during your survey visit, please select a single weather category that best represents the overall conditions.

Cloud cover	Rain	Wind	Visibility
0 – 1/3rd = 1	None = 1	Calm = 1	Good = 1
1/3 – 2/3rds = 2	Light = 2	Light = 2	Moderate = 2
2/3rds– total = 3	Heavy = 3	Strong = 3	Poor = 3

8.1.2 Recording birds

If you are working in a team of two, ideally, only one observer should record birds whilst the other is completing the Field Recording Sheet. Birds that are flushed as you approach a point may be recorded in the totals for that point, **but do not record birds whilst moving the 200m between points**. On arrival at each point start counting birds immediately.

Record the time that the count started at each point in the space provided on the recording forms, and then begin the count, recording and identifying all birds that you see or hear from the point where you are standing, up to a maximum distance of 50m. Continue the count for a set period of 5 minutes. Do not exceed 5 minutes because you are sure a certain 'good bird' is there but not yet recorded. Remember to scan for birds flying overhead and include these in the count. Record all the birds you see and hear on the Field Recording Sheet in the appropriate columns for points 1-11. Each transect has 11 points, each point being 200m from the next (for guidance and help in estimating distances, 200m is the length of two football pitches). Try not to record the same individual bird twice, e.g. an individual that can be heard singing from several points should be recorded once, at the point where it was first detected. If you observe a bird during the point count but do not identify it, it is OK to spend time after the end of the 5-minute period working on the id, recording the individual as being in the count at that point. Do not use any method of coaxing birds during the count – it is important that all counts are done consistently to produce reliable results. Please note the starting time of each 5-minute count period using a 24-hour clock, e.g. 0730 for 7:30am, 1300 for 1pm. As a guide, an average visit should last around 2 hours.

1. Do not record birds you see or hear whilst walking to your first point count station or between points along your transect route.
2. On arriving at the point count station, start your count immediately. Birds flushed as you approach your stop should be recorded and included in the totals for that point if they are no longer present during the counting period.
3. For the count, record all birds seen or heard during a 5-minute counting period. Do not record any birds that you see or hear at that point after then end of the 5-minute period.
4. Bird species names are recorded on the Field Recording Sheet in the order in which you observe them.
5. Ensure that only the number of birds recorded is written in each box on the count summary forms. Additional information such as '+', '>' or 'many' complicates the forms and should be avoided.

We would strongly encourage observers to use standard species names (e.g. those used in the Helm Field Guide to the Birds of West Africa by Nik Borrow). These should be written in the appropriate space on the Field Recording Sheet.

Left picture: Local elders in the village of Niety Yonne with Capt. M. Tall in the middle and Bouna Diagne on the right. In a period of severe drought in 1991, four men, including Bouna Diagne, desperate for water, dug through the dike with their bare hands. Water soon arrived in their village of Nietty Yone and flowed into the Grande Mare after 72 hours. The police arrested and jailed Bouna and the flow of water was stopped. Rather than stay in their village to die without water, all the remaining villagers, including wives and children demanded to be put in jail as well. The crisis prompted a presidential decree granting the Ndiaël a minimal amount of water (text by Paul Brotherton).

Chef de village at Mbelele Mbaye (left picture) and the treasurer of the AIV (right picture).

Annex 7. BirdLife LoTe Habitat Monitoring Instructions

Although LoTE Bird Survey Field Sheets allow basic habitat information to be collected for each visit to a point, at many sites it will be desirable to collect a more detailed set of habitat information. This detailed habitat monitoring programme is designed to provide information on year-to-year changes in habitats around LoTE project sites in Burkina Faso, Ghana, Mauritania, Nigeria and Senegal. Knowing to what extent habitat is changing around LoTE project sites is fundamental to understanding the success of LoTE conservation measures designed to restore, protect and regenerate habitats around core project areas.

All instructions refer to assessment of the area within a 50 metre radius of the central point except where otherwise stated.

When to undertake detailed habitat surveys

Each point that is used for bird survey work will automatically have a basic set of habitat information collected on every visit (number of trees and shrubs and evidence of grazing and wood removal). However, this information should be regarded as the absolute minimum set of habitat information collected from each point, with the ultimate aim being to additionally collect more detailed information from every point at which repeated bird surveys are conducted. Bird surveys take place at each point once a month between October and April (seven visits per year), to coincide with the period when there are migratory birds in the region. However, detailed habitat surveys only need to be undertaken twice in each year – once in March and then again in November. These surveys need not be undertaken at the same time as the bird surveys, though it may be easier to do so.

Notes on completing the LoTE detailed Habitat Recording Sheet

Numbers here match those on the relevant sections of the recording sheet.

1) Fill in the **Site** / **Transect** / **Point** identity, the **Date**, your **Name** and the **Lat / Long** of the central point in the top three lines of the form.

2) **Dominant landcover:** Tick the landcover that covers the most of the survey radius out of those on the list provided. If the land within the radius is comprised by more than one landcover, you may use a '1' and '2' in place of a tick to record the primary and secondary landcovers. 'Nat/Agric mosaic' implies the presence of some agriculture and semi-natural vegetation e.g. along field boundaries.

3) **Vegetated**: Tick 'Vegetated' if the area is covered in plants; 'Unvegetated' if it is covered in rocks, earth, concrete/tarmac etc; and 'Mixed' if it is covered by a combination of the two.

4) **Artificial**: Tick 'Managed' if the area is influenced by human actively; 'Natural' if the area is not; and 'Mixed' if both of the above apply to parts of it.

5) **Dominant Layer**: Tick the box corresponding to the vegetation layer that is most well developed. You may use a '1' and '2' etc to tick more than one if it is not possible to identify a single dominant layer.

6) **State**: Tick the box corresponding to the most common state of vegetation within the radius. Senescent refers to vegetation which is dying off but not yet completely dry.

7) **Water Regime**: Tick 'Terrestrial' if the land appears mainly dry; 'Regularly flooded' if it is either wet / with standing water or there is evidence of flooding occurring and 'Mixed' if it's a mixture of both (e.g. on the edge of inundated land).

8) **Water Seasonality**: Tick the appropriate box for any water features present. Note that '<4 months' would be appropriate for features that are only present during the height of the wet season. Any present at the end of the wet season / in the dry season should be classified as '>4 months' unless they are 'Permanent' (i.e. they never dry up). It may not be clear which is the most appropriate classification for some pools and watercourses but a judgement should be made based on the presence of aquatic and fringing vegetation, local knowledge etc.

9) **Water Quality**: Tick 'Fresh' unless you know that the water is either 'Saline' or 'Brackish'.

10) **Bare Soil**: Tick the boxes for any types of bare ground present, using a '1' and '2' for the primary and secondary categories if there is more than one.

11) **Tree Cover**: Estimate the total canopy cover of the radius and tick the box for the class within which your estimate falls. This is the % of the area that would be covered by the canopy of trees as if viewed from above.

12) **Number of trees in each height class**: This is actually where we record both *Tree Height* and *Tree Number*. In the box next to each height category, record the ***number*** of trees in that height category that are ***within 50 meters*** of the point. [chosen by the local team in Senegal to record evrything within the same circle!]

13) **Leaf Type**: Most trees will be 'Broadleaved'; Acacias are classified as 'Needleleaved'. Tick 'Mixed' if both of these types of trees are present.

14) **Wood Removal**: Tick the box or boxes next to the type of wood removal detected. Tick 'Firewood' if there are piles of firewood present ready for collecting.

15) **Shrub Cover**: Estimate the percentage cover of shrubs (as if viewed from above) within the radius and tick the relevant box. Shrubs are woody plants, mostly below 3m in height and often with branches reaching or close to the ground around multiple stems.

16) **Number of shrubs**: This is actually where we record both *Shrub Height* and *Shrub Number*. In the box next to each height category, record the ***number*** of shrubs in that height category that are ***within 50 meters*** of the point. [chosen by the local team in Senegal to record evrything within the same circle!]

17) **Leaf Type**: As above

18) **Grazing**: Evidence for grazing includes obviously-grazed stems, dung present, livestock present and the presence of browse lines either limiting the height or lower extent of vegetation. 'Light' is for a little evidence, 'Heavy' for very short vegetation and extensive amounts of dung.

19) **Grass/crop Cover**: Herbaceous vegetation – grasses, crops, weeds, herbs, shoots etc. Estimate cover as for shrubs and trees.

20) **Grass/crop Height**: Simply tick the box for each height-class present.

21) **Crop Type**: Space is provided to list out the different crops being grown within 50m of the point – you may use a '1', '2' etc to represent the order of dominance where more than one is specified. List 'Fallow' to indicate the presence of regenerating vegetation on previously cultivated land.

22) **Burning Period**: Based on remaining ash and burnt vegetation – burning from previous fire season may be extremely difficult to see but often burnt tree stems are visible where burning in a previous season has been severe.

23) **Strata Burnt**: Tick as appropriate.

24) **Burnt Vegetation**: Percentage of the vegetation present that has signs of burning.

25) **Fire Severity**: 'Light' if only grass and smaller items burnt, 'medium' if shrubs also burnt, 'severe' if damage also apparent on trees, 'very severe' if trees badly damaged or killed.

26) **Notes on tree species which migrants are recorded in**: Where possible, identify the species of trees that migrants are observed using whilst conducting the survey.

After work with mist nets dec 2013 B. Diagne, I. Ndiaye, M. Sikkema, O. Niang.

Planting of trees (Photos by Coumba Ly in 2014)

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