Methods to count birds and trees in the Sahel

Field work in Mauritania and Senegal, January-February 2011

A&W-report 1658

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Degraded parkland in mid-Senegal; 5 February 2011 Leo Zwarts

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Contents

1 Introduction

Many migratory birds from Palearctic breeding grounds spend the northern winter in Africa south of the Sahara. Most species migrating to Africa show a – often catastrophic – decline, especially those wintering in the Sahel (Zwarts *et al.* 2009). The vicissitudes of wetland-inhabiting long-distance migrants depend largely on the meteorological and hydrological conditions in their wintering area. If corrected for that, the apparent long-term decline in these species disappears. This is very different in migrants wintering in savannah and wooded savannah: the decline remains, independent of rainfall. What is going on south of the Sahara? What has changed in the habitat where the woodland species spend the northern winter?

Thanks to the financial support of Vogelbescherming-Nederland, we were able to conduct a pilot study, aiming at optimisation of methods to describe the zoning of woodland bird species from desert to tropical forests and the tree preference of different bird species. This information is necessary to understand why these woodland species are in decline. This report describes the methods such as elaborated beforehand, but also the adaptations made in the field. The pros and con of the different methods are shortly discussed.

Oumar Ba was a valuable counterpart and a good fellow traveller in often harsh circumstances. We thank Arie van Kooten (OMVS) for writing the letter of endorsement preventing (potential) problems in Mauritania. We are grateful to Rob Bijlsma for his keen interest and carefully reading this text. We thank Bernd de Bruijn of Vogelbescherming Nederland for his enthusiastic support and trust in our approach.

Fig. 1*. Fully different habitats at 500 km from each other: Sahara dunes* Acacia tortilis *in mid-Mauritania (top) and marshes with* Mimosa pigra *bushes in mid-Senegal (bottom).*

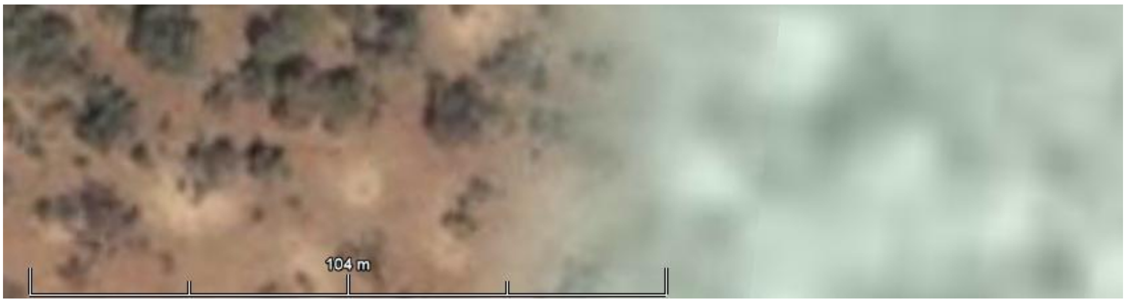

Fig. 2. *Individual trees may be recognized on recent Google Earth high resolution images, but not on older ones which have a much lower resolution of about 30 m (right part of the map).*

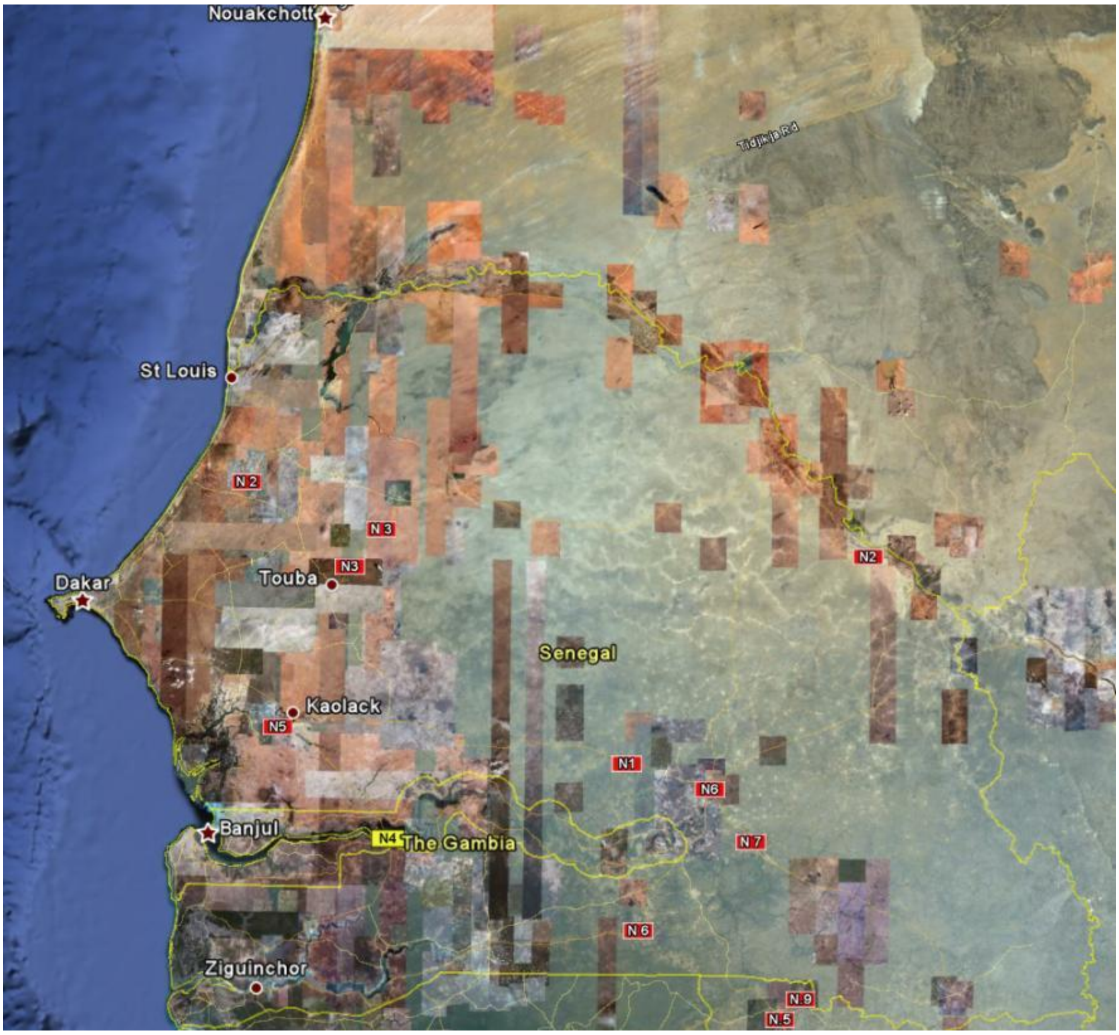

Fig. 3. *At present, high resolution Google Earth images are available for SW Mauritania, W and NE Senegal, but hardly so for the eastern part of both countries. Note: the HR images are recognizable on this map as reddish rectangles; the low resolution images are greenish.*

2 Selection of sampling sites

2.1 Selection of Google images with a high resolution (HR) images

We conducted our fieldwork in the western part of the Sahel, the zone where the major part of western Palearctic migratory breeding birds is wintering (Zwarts *et al.* 2009).

Our intention was to collect data for a large number of sites between the Sahara in the north and the tropical forests in the south. The sites should be representative for the zone with a similar latitude and longitude. We had to deal with two restrictions, however. First, some areas are at present no-go areas (for instance the area north of the Niger River in Mali). Secondly, we wanted to select sites for which Google Earth gives high resolution images (Fig. 2; Fig. 3).

2.2 Selection of sites within the area covered by the HR images

Within the HR images, we searched for roads with a predominantly N-S direction. Sites were selected where the road intersected the latitude rounded at exactly one decimal (*e.g*. 15.1˚N, 15.2˚N, 15.3˚N). Hence, the sites were situated at a mutual latitudinal distance of 0.1˚, corresponding with 5.5 km if the road were running exactly N-S. The distance could increase to 20 km or more if the direction of the read was more W-E. The sites along the road were numbered: sites with even numbers were situated to the west of the road, uneven numbers to the east. The next step was to amalgamate these data requirements into the shortest possible route (Fig. 4).

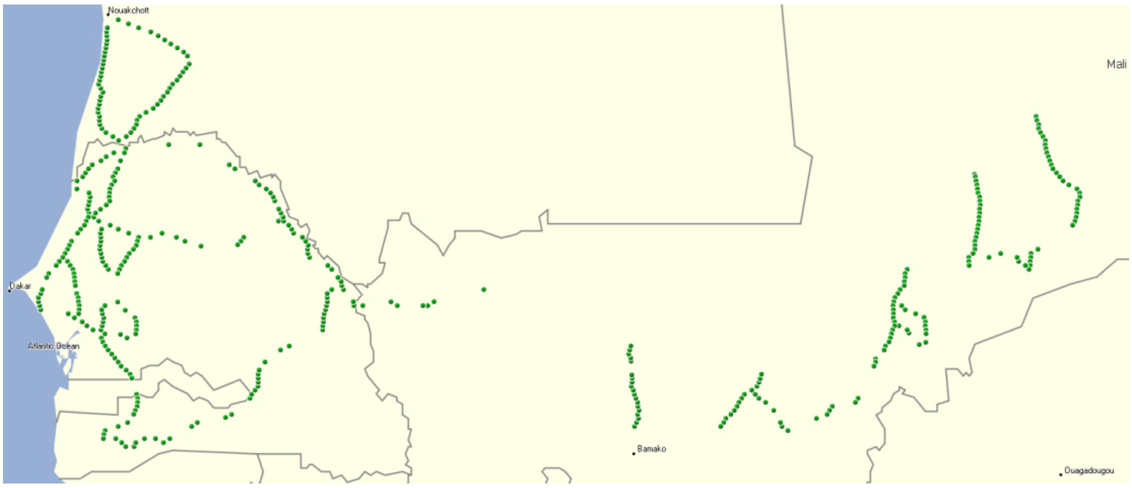

Fig. 4*. Potential sites in SW Mauritania, Senegal and Mali (600 x 1600 km) situated along roads covered by Google high resolution images (compare with Fig. 3 for Senegal and SW Mauritania). All 422 sites are situated between 13 and 18°N and 1 and 17°W.*

During 26 field days between 21 January 16 February 2011, we visited 111 of the 422 sites shown in Fig. 4 (Fig. 5). All sites were situated in SW Mauritania and Senegal. In addition, we performed counts in (1) arable land near Saint Louis and (2) *Acacia nilotica* forests near Matam.

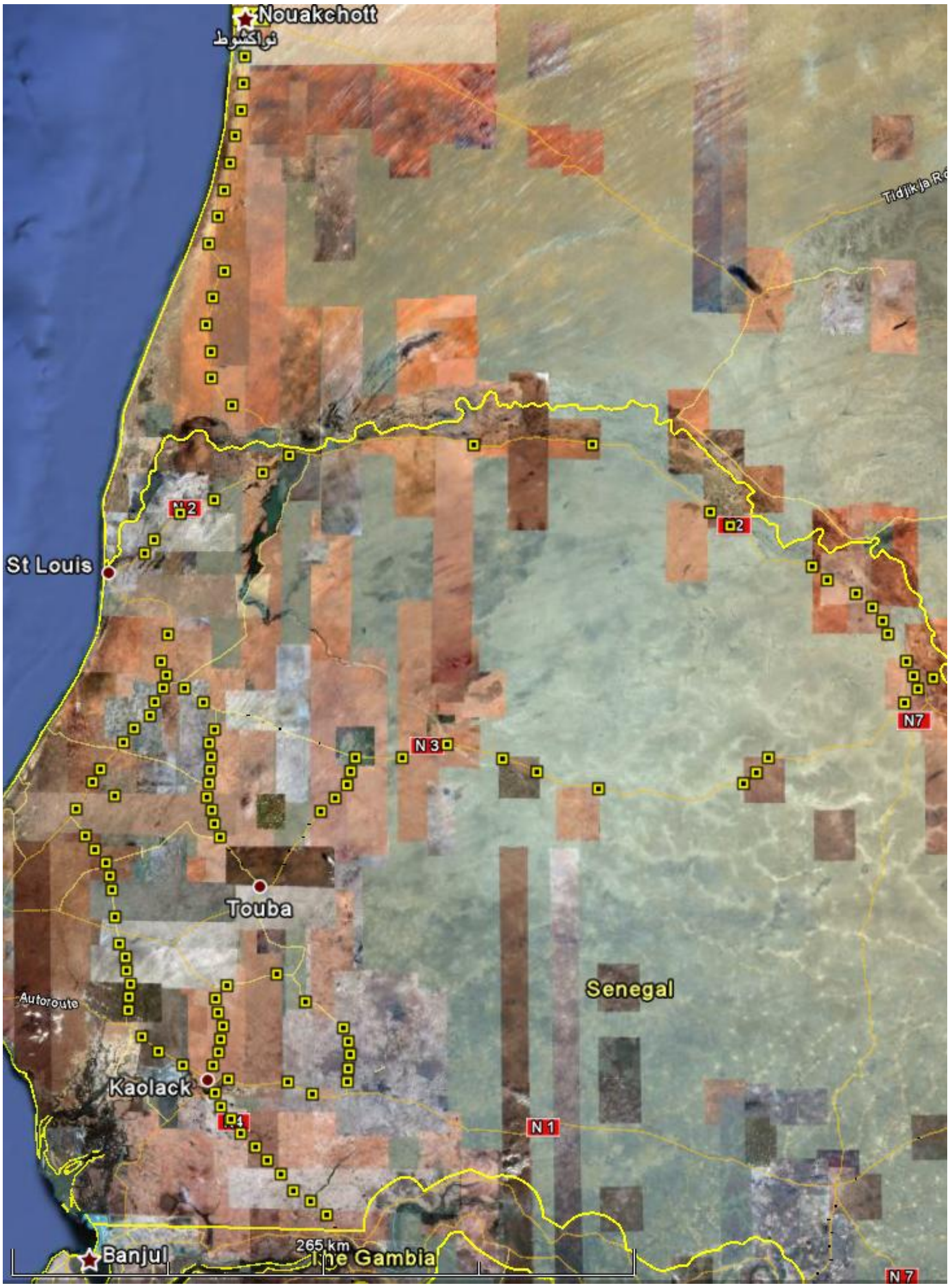

***Fig. 5**. The 113 sites, visited between 21 January and 16 February 2011 , shown on a Google Earth map.*

2.3 Are the selected sites representative per latitude?

The bird density measured in the sites can be averaged per latitude, but when these data are used to estimate tree - and bird numbers, the sampling sites should provide an unbiased presentation of the latitudes concerned. The selection of sites, as described above, is no guarantee that this is the case, however.

The first bias may arise when sites alongside roads and tracks, and thus more often near villages, have fewer trees than more remote sites. One way to check this possible bias is to randomly select samples within the HR images and compare the total canopy of trees in these samples to that obtained at sites along roads. An alternative is to determine density and total canopy of trees on Google Earth images at different distances from roads. For each plot we determined the distance to the nearest road and village to determine its potential confounding impact on tree density.

The second bias may arise when HR images refer to areas with relatively few trees, especially in Mauritania and Senegal where HR images cover the most densely populated part of the countries (arable land in the west and the Senegal valley further inland; compare Figs. 7 and 8). This bias can be corrected when the density of the human population correlates with tree - and bird density. It should be noted that this problem is typical for this part of the Sahel. In the near future, similar exercises may be feasible in Mali and Burkina Faso, countries with much lower population densities, now that HR images are increasingly becoming available for these countries.

In conclusion, the sites are not likely to be fully representative for the latitudes concerned. This is not to be expected, given the large differences within each latitudinal zone in human population density (Fig. 7) and vegetation cover (Fig. 8). A statistical analysis may reveal to what extent tree - and bird densities can be explained by these variables, or by ecotype (Fig. 9), in addition to potentially dominant factors as latitude or rainfall. If so, the estimation of the total number of trees or birds will be based on more than one variable.

Fig. 6. *Many trees species in the Sahel are shedding their leaves during the dry period.*

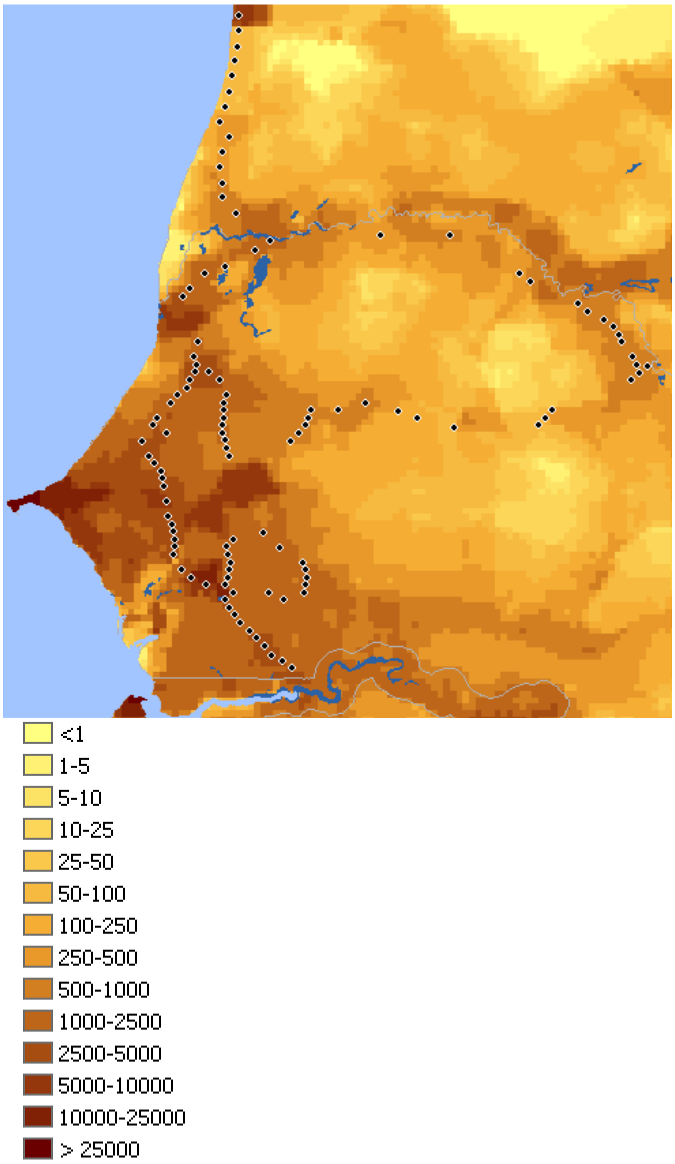

Fig. 7. *The same 113 sites as Fig. 5 projected on a map showing the density (n/km^2) of the human population.*

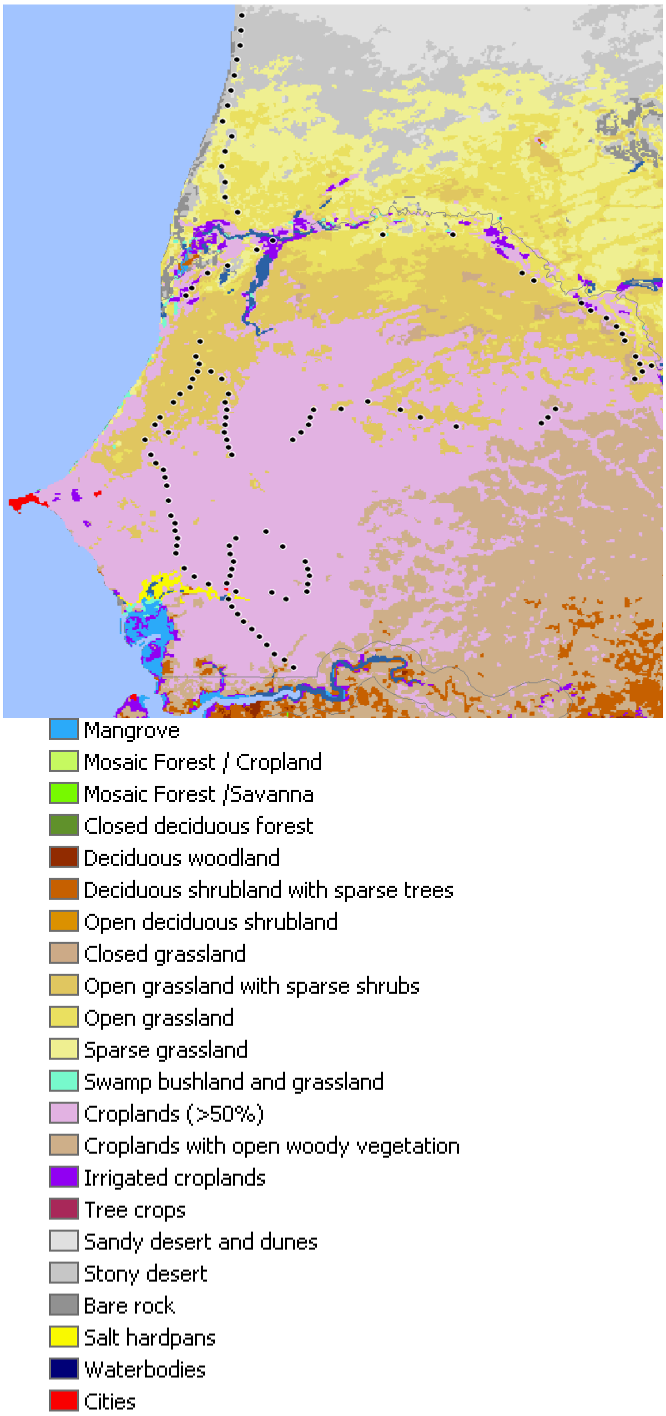

Fig. 8. *The same 113 sites as Fig. 5 projected on a map showing the vegetation zones.*

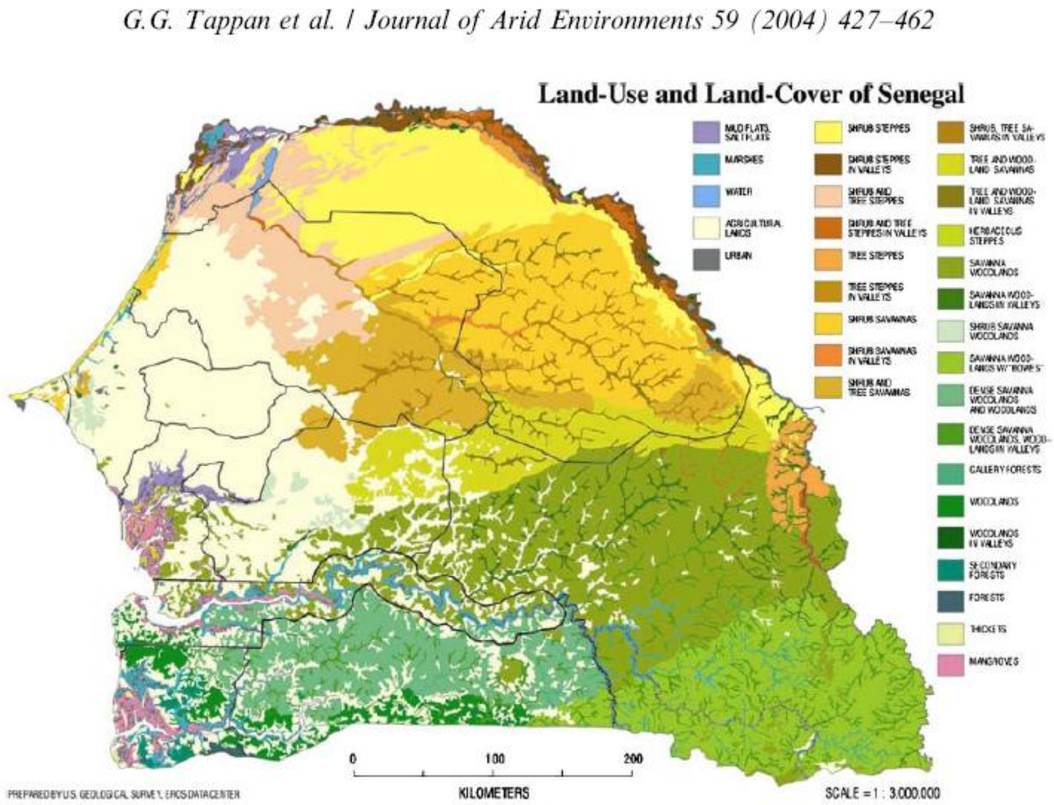

Fig. 9. *The ecotypes in Senegal, as distinguished by Tappan* et al. *(2004). Classification is based on land use and land cover.*

2.4 Actual area covered on the site, compared to the area selected beforehand

For each site, we prepared a grid of 1000 x 200 m in GIS, always exactly along the W-E axis. The grid was subdivided into 4 x 8 plots, each covering 250 x 50 m. Counting trees and birds would be easy in open, nearly treeless landscape, but time-consuming in an area with many bushes and large trees. The subdivision in plots allowed us to count fewer plots of 250 x 25 m (e.g. only two middle rows) in areas with a higher tree density than in sites with few trees (middle 4 rows, or even more).

Fig. 10. *The grid of 4 x 8 plots of 250 x 50 m drawn on a Google image. Large as well as small trees are clearly visible.*

The grid was also entered into a TRIMBLE (advanced GPS with large screen; Fig. 11), with which we could permanently determine our actual position in the field, and also relative to the gridlines of the 32 plots in each site. Before we started field work, we prepared A3- and A4-prints of the counting sites, inclusive the grid (Fig. 13), to help us delimit the site and its subplots in the field.

Fig. 11. *The Trimble used by MS to determine our position.*

Fig. 12*. The NIKON laser 550 AS was primarily used to measure tree height, but it was also handy to determine whether a tree had to be included in the transect (<25 m from the middle line) or not (>25 m).*

2.5 Selection of the sampling area on the site

The Google Earth images, although not always recent (up to 5 years old) were helpful in the field, especially when trees were large and tree density was low. The Trimble worked as anticipated. However, its use was time-consuming and rather impractical when trying to adhere to the strict format of pre-selected plots, for at least four reasons:

- First, physical barriers, such as thorny hedges, made it sometimes impossible to complete a count within a plot.
- Secondly, due to the position of the sites, we had to walk “against the sun” during early morning and late evening. By adjusting the walking direction a bit, we could walk with skimming light.
- Thirdly, it was not always possible to stop the car at exactly the preselected position.
- Fourthly, we did the field work with three persons. LZ walked in a straight line counting and measuring height and width of all scrubs and trees within a distance of 25 m (sometimes 50 m or 12.5 m) to the left and right, thus counting along a track of usually 50 m (sometimes 25 or 100 m) wide. MS en JK searched for birds on the ground and in the trees on the left or the right half of the same track. To fit this counting system within the pre-selected grid, was very time-consuming. The person using the Trimble also had to keep track of the whereabouts of his companions, apart from performing his own tasks, a difficult combination.

Hence, we decided to keep using the selected sites as fixed starting point, but not the preselected 32 plots within each site. Instead, we walked the 250 m in a more or less straight line. In total, we counted trees and birds along 487 transects. The number of transects per site varied between 1 and 10 (Fig. 13).. In principle, the transects should be 250 m long, but for practical reasons it varied a bit (Table 1). Plot width was 25, 50 or 100 m, but on two occasions plots were wider.

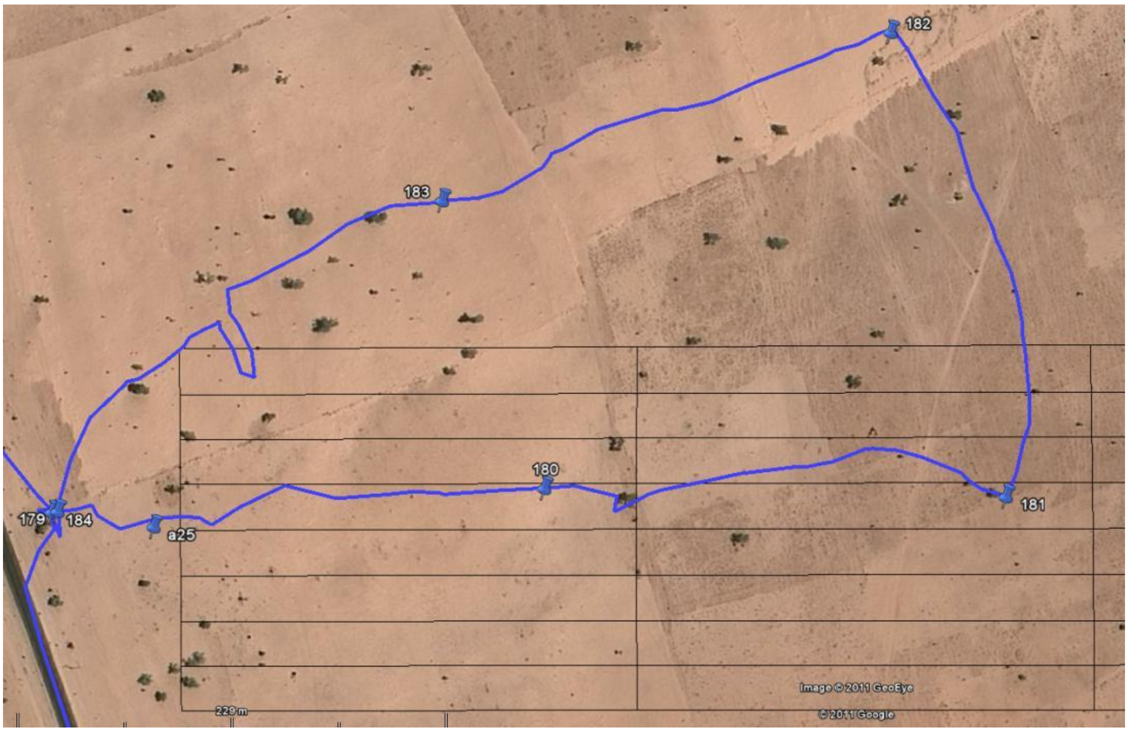

Fig. 13. *The grid with the black lines gives the pre-selected plot(250 x 25 m each) for site "a25". The blue line shows the actual GPS-track. The waypoints indicate where the data were split up into five different transects being each 250 m long and 50 m wide.*

Our deviation from using the pre-selected grids, hence potentially compromising the random sample, increased the risk of subjectively counting areas with fewer or more trees. We solved this problem by walking one or more transects in an east-west direction, then bending at a more or less right angle to walk the other transects before returning to the point of departure. The decision to turn south or north halfway the transect was determined by the position of the sun. We also adjusted direction when encountering inaccessible areas. If possible, we used conspicuous features on the horizon, such as an electricity pylon, to walk in a straight line, since that was easier than steering solely by compass.

The number of transects per site depended on several factors, for instance, the time still available before sunset. We also covered fewer transects when the habitat was homogeneous. More transects could be covered in sites where scrubs and trees were of smaller height (hence, easier to scan for birds). During the first 10 days, we walked 5-10 transects per site, but since this limited the number of sites covered per day, we decided to do fewer transects per site, hence more sites per day.

Six times we used another approach. On two plots, very few trees were present, allowing to visit all trees within an area of 150 x 200 m and of 200 x 400 m. In contrast, tree density in four sites was so high that we walked from tree to tree and in this way systematically covered a larger area varying in size between

0.33 and 1.28 ha. While doing so, Google Earth images were essential to delimit the counted plot. The GPS-tracks were analyzed afterwards to be sure that no trees were missed.

Length \ width	25	50	100	150	250	∑
100		2	1			3
150		3				3
170		1				1
200	1	19	1	1		22
230		1				1
250	33	312	7			352
270		2				2
280		3				3
300	5	50				55
350		17	2			19
400		6	2		1	9
450		2				2
500		5	1			6
600		2	2			4
720	1					1
∑	**40**	**425**	**16**	**1**	**1**	**483**

Table 1. *Length and width (m) of the transects. Four transects were not rectangular but had surface areas of 0.33, 0.36, 1.15 and 1.28 ha. The surface area of 487 transects averaged 1.3475 ha; the total area counted was 656 ha*

Fig. 14. *Balanitus aegyptiaca*

3 Trees

3.1 Identification

We tried to identify all trees and shrubs within the plots, using Arbonnier (2002) as field guide. This sometimes proved to be problematic, especially when without leaves, flowers or fruit. Some trees and shrubs could not be immediately identified in the field. Only 46 of the 57,899 trees and shrubs remained unidentified.

Many hundreds of photos were made to check tree identity. In total, we identified 67 tree species. Most trees and scrubs were identified from a distance. Mistakes may have occurred in the identification of tree species resembling each other. The common tree species, where almost all Palearctic bird species were detected, were easy to identify.

3.2 Circumference and canopy

Height and width of each tree were measured in meters, but for small trees we added the subcategory of 0.5 m. Height was estimated from a distance, often measured with the Nikon laser. After tree height was determined, it was easy to estimate the width of the tree. The width of large trees was also regularly measured by pacing.

The circumference of large trees were estimated and/or measured separately. When many small trees or scrubs were found close together, we made a combined assessment, for instance "*Guiera*: 17 times 1x1 m and 3 times 2x1 m". Tree width as measured in the field could often be compared to tree width on Google Earth images (Fig. 15).

Based on the radius of tree width, we calculated tree coverage per plot, i.e. the contribution of each tree species per height category relative to total canopy coverage. Total relative canopy coverage may have been higher than calculated, since scrubs and small trees might be found below higher trees.

Tree density and total canopy coverage may also be derived from the Google Earth images (Fig. 16). As Google intends to replace the available images with more recent (HR) images each 4 or 5 years, this offers an easy opportunity to quantify changes in tree density and canopy in the Sahel across time.

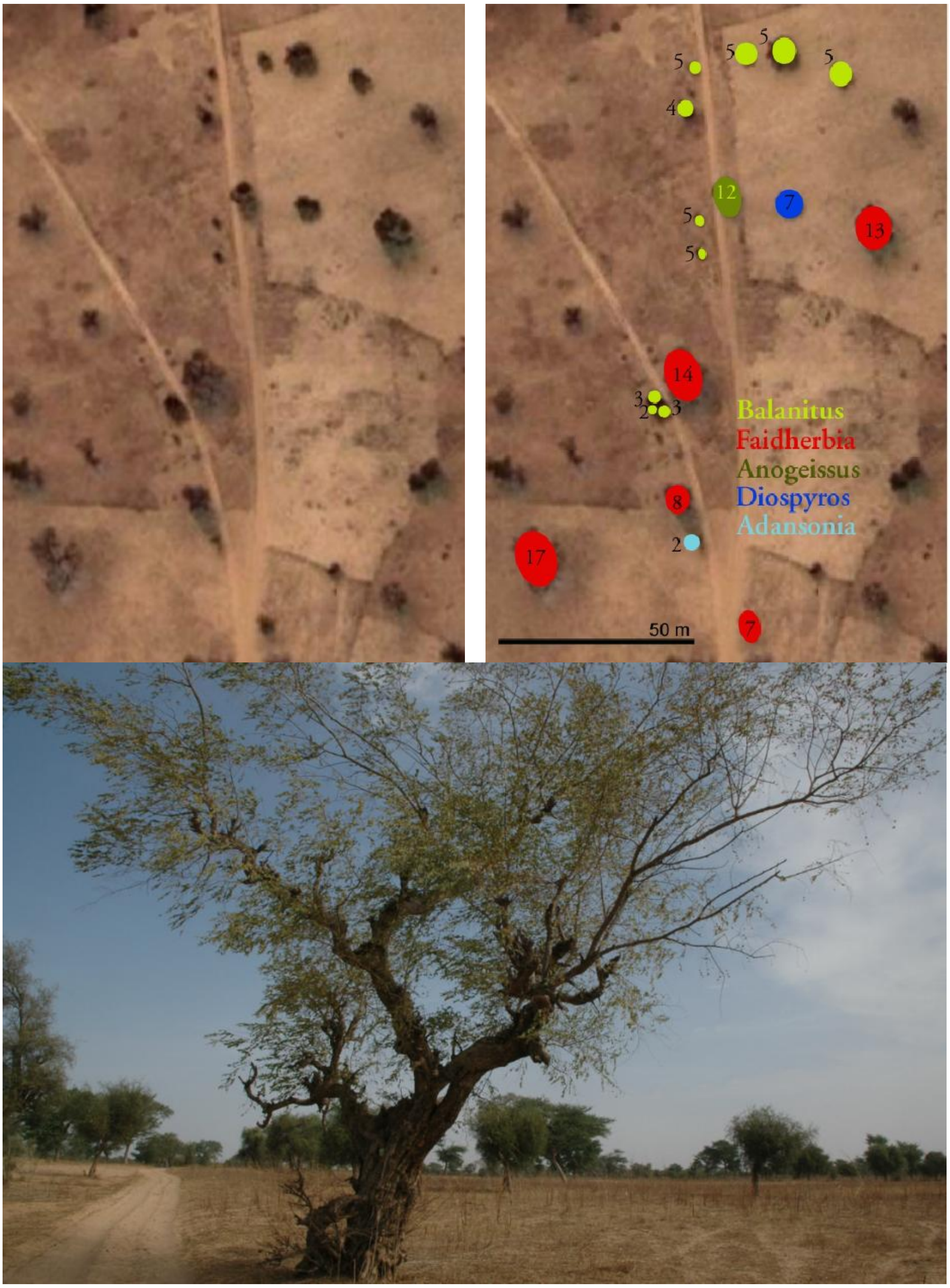

Fig. 15. *Google Earth image of plot "x03", arable land with millet fields and scattered trees, of which some large ones; total surface of the area shown is 120 x 200 m. The width of the 18 individual trees in 5 species were measured on 8 February 2011 (in m). Note that* Faidherbia *(open structure) can be distinguished from* Balanites *(dense crown). Obviously, this plot remained largely unchanged since 20 October 2004, when the image was taken. The photo shows the single* Anogeissus leiocarpa *(width 12 m) with some* Balanites *trees in the background.*

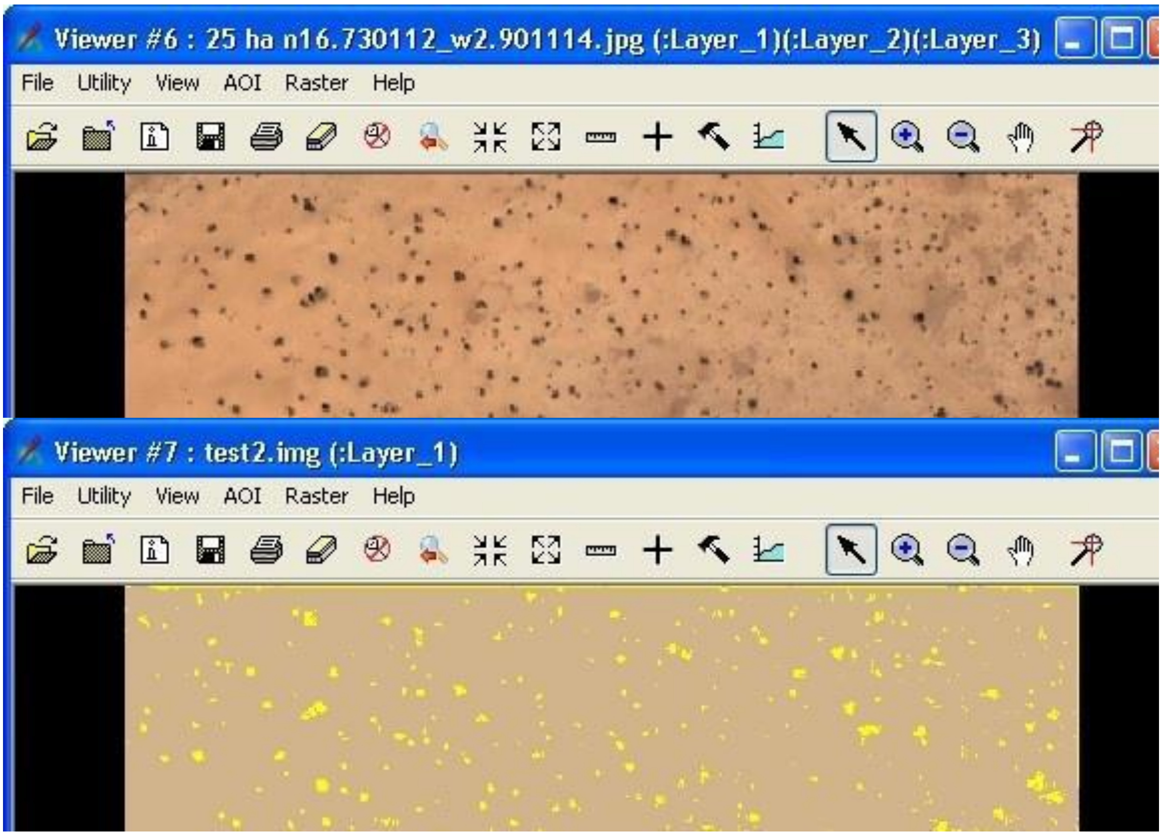

Fig. 16. *Google image (width 500 m) of an Acacia forest in northern Mali, converted into an ArcGis- shapefile, allowing us to quantify semi-automatically tree density and canopy.*

3.3 Status of the trees and shrubs

The initial idea was to record presence/absence of leaves, flowers and/or fruit for each tree. As this was highly synchronised per tree species, we usually refrained from doing so and just made a general note. Unfortunately, at first we did not make those notes each day, hence not anticipating differences in flowering in the same species according to latitude (e.g. *Balanites aegyptiaca*, *Faidherbia albida* flowered in the south, but not in the north). From halfway the field period, we started to systematically collect daily notes on flowering, fruiting and leafing of common tree species in use by Palearctic bird species

3.4 Lianas

Our initial plan to note the presence and status of lianas in a tree was aborted as it took too much time. Moreover, few lianas had flowers with (a lot of) nectar or edible fruit.

3.5 Peculiarities

Nearly all Sahelian tree are being clipped by the local people. For large trees, we made notes whether clipping had occurred in the past months. We also recorded whether large tree were nearly dead.

3.6 General circumstances per plot

The following information was initially meant to be recorded per plot:
(1) presence of cattle, sheep or goats,
(2) grazing as revealed by the presence of droppings,
(3) presence of locusts,
(4) agriculture in previous wet season (millet, peanut),
(5) ground being wet/moist/dry,
(6) ground being bare or covered by low (<5 cm) or high (10-40 cm) vegetation,
(7) ground being stony (laterite), sandy or loamy.

In fact, we recorded this information per site, and rarely for each separate plot. Each plot was also photographed, allowing a check on classifications made in the field.

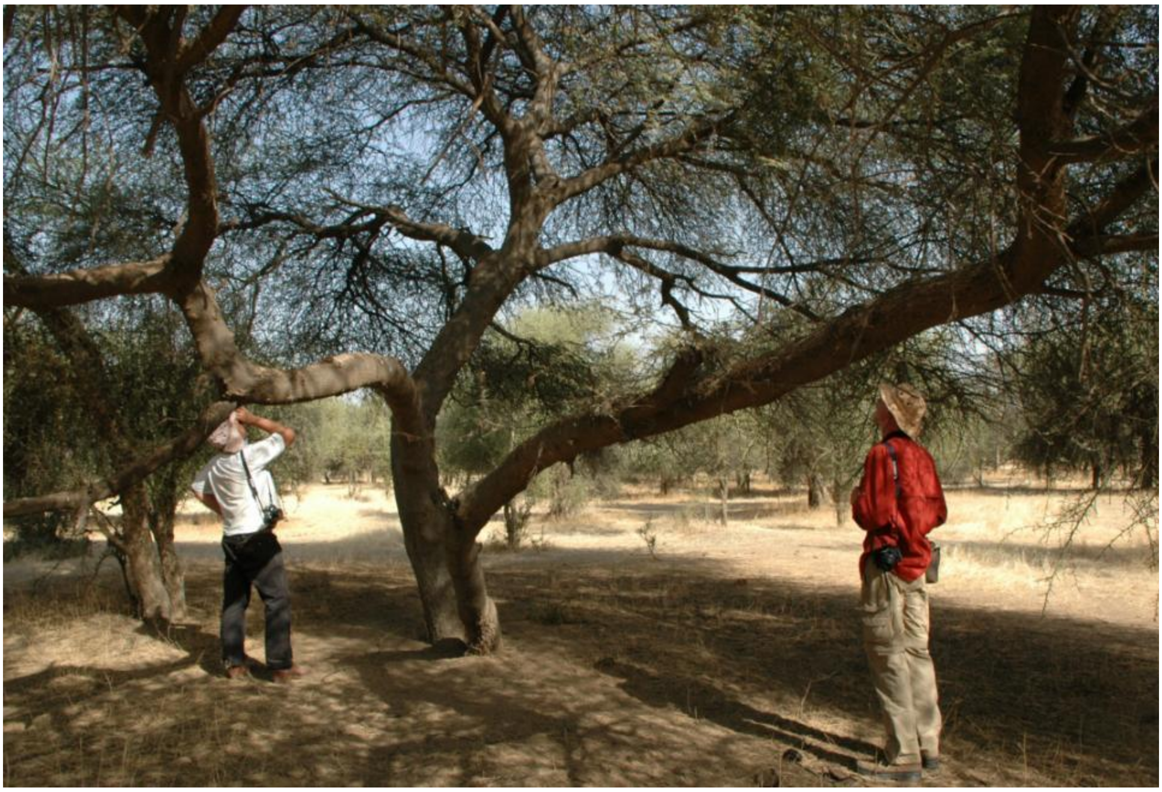

Fig. 17. *How long to wait to be sure that all birds present in this* Acacia tortilis *tree have been traced?*

4 Birds

4.1 Identification

All Palearctic species were recorded, not only woodland species, but also birds feeding on the ground (e.g. Yellow Wagtail) or in the air (House Martin). We also noted every Hoopoe Lark, Crested Lark, Great Grey Shrike, Rufous-tailed Scrub-robin but not, or in any case not systematically, other Afro-tropical species. If possible, we noted sex (Red-backed Shrike, Subalpine Warbler) and subspecies (Yellow Wagtail). Moreover, we noted the activity of the bird (feeding / non-feeding) and whether the bird under observation was silent, calling or singing.

When a bird was present in a tree, we recorded tree species, as well as tree height and width. When moving to another tree, notes were only taken from the initial tree.

4.2 Counts of birds moving in and out of the plot

We saw several Montagu's and Marsh Harriers while doing the counts. These birds passed the transect in less than a minute. These birds were recorded but obviously such observations cannot be used to calculate densities. Theoretically, densities of roaming birds might be calculated when the duration of their presence within a plot is known. For instance, a harrier hunting in the plot for one minute might be considered as 0.02 bird if the entire count took 50 minutes. The same is true, although to a much lesser degree, for Red-backed Shrike or Hoopoe, also birds moving around a lot.

During the field work, birds landing in the plot during the count were noted as "observed outside the plot", whereas birds being present but leaving the plot (for instance, chased away by us), were noted as "present in the plot". If this was unknown, birds present temporarily were considered as "outside the plot" and birds present most of the time as "present".

4.3 Effort to discover all birds

Our aim was to detect all birds in the plot. This was easy to accomplish in most sites, since trees and bushes were usually scattered and small (< 4 m). Finding birds in larger trees was not difficult if the crown was open. Fortunately, most Acacia trees and *Faidherbia albida* are rather "transparent". Dense-leaved *Balanites aegyptic*a and huge *Tamarindus indica* were more difficult to search adequately. Calling or singing facilitated sighting of the birds, but most were silent, even in the early morning. This necessitated searching by sight. Nearly 100% of the observed birds were feeding and moved around within the trees, also during the hottest hours around noon. Hence, we used the full day-light period for counting birds.

In open landscapes (desert and steppe with hardly any trees in the north, arable land with hardly any tree left further to the south) it took 7-10 min to cover a plot of 250 x 50 m. This effort increased to even more than an hour in plots with many high trees. The difference with open landscapes is also obvious from the walking speeds such as derived from the GPS-track. On average, we moved in a plot with 1.45 km/h or 0.4m/s, but this varied between 0.26 and 4.11 km/h (or 0.07-1.14 m/s). The observation time per plot is related to the total "tree volume" in the plot, where tree volume is based on the assumption that the volume of a tree may be described as

$\pi.h.r^2$,

where h=height and r= radius of the width.

The relationship between observation time and total tree volume can be described with a linear function, but the variation is large (Fig 18). Further analysis revealed that a part of this variation may be attributed to the presence of large trees. All scrubs and trees were subdivided in four height classes:

1: 0.5-2 m
2: 3-5 m
3: 6-9 m
4: 10-22 m

We calculated the total canopy as % relative to the total surface of the plot, separately for the four height classes. The effort was expressed as the time (min) needed to monitor 1 ha.

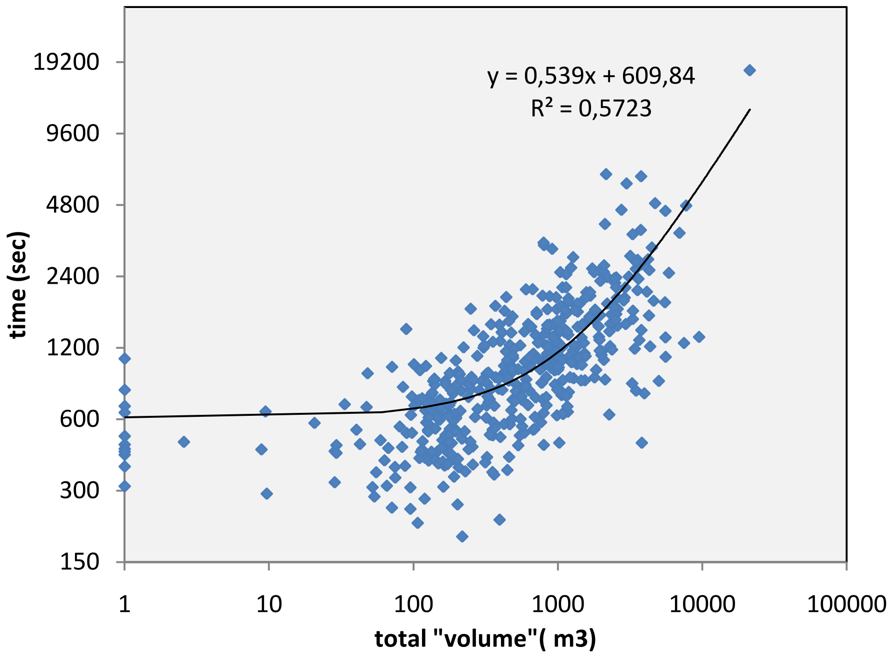

Fig. 18. *Time spent in a plot as a function of the total "tree volume" (m^3) of all scrubs and trees in the plot.*

Volume = $\sum \pi.h.r^2$, where h = height, m, and r = radius of tree width, m.

The linear relationship is shown, but the line is curved, since time and volume are plotted on a log-scale.

The time to monitor (min/ha) can be describes as a function of the canopy:

Dependent variable:	Unstandardized Coefficients		Standardized Coefficients		
min/ha	B	Std. Error	Beta	t	Sig.
(Constant)	10.367	.584		17.740	.000
canopy <3m	.,94	.389	.039	1.014	.311
canopy 3-5m	.527	.086	.235	6.124	.000
canopy 6-9m	2.238	.185	.463	12.076	.000
canopy >9m	1.572	.280	.213	5.615	.000

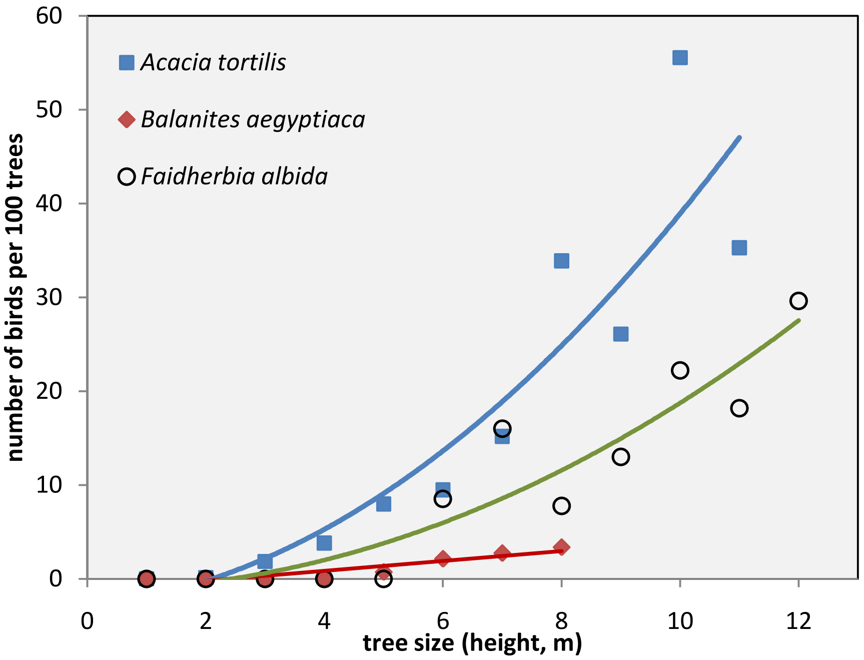

Fig. 19. *Number of Bonelli's Warblers per 100 trees in* Acacia tortilis *(n=6537),* Faidherbia albida *(n=740) and* Balanites aegyptiaca *(n=5301) as a function of tree height.*

The multiple regression equation is highly significant (R^2=0.785). It took 10 minutes to monitor 1 ha without trees. The observation time increased by 0.4 min per 1% canopy of trees+scrubs < 2 m, by 0.5 min for canopy 3-5 m high, but by about 2 min per 1% for larger trees. The contribution of canopy in low trees+scrubs is not significant. The analysis may be refined, by subdividing the canopy of different species with a more or less open crown. Most important is, however, that it is apparently possible to relate the time spent in searching for birds to total canopy of low and high trees. This offers the possibility to compare our results with future fieldwork as regards the effort spent in detecting birds.

Our conclusion that "nearly 100% of the observed birds were feeding and moved around " may be interpreted in two ways: (1) nearly all birds present were actually feeding, (2) inactive birds were not seen being too difficult to be detected, certainly in high, dense trees. The latter seems to be not likely. First, we actually saw inactive birds around sunrise and sunset. That was also the reason to start the observations 20-30 minutes after sunset and stop the field work already before sunset. Secondly, if resting birds have been overlooked, one may expect that relatively more birds were not seen around noon. The latter possibility may be examined. The recorded number of Bonelli's Warblers differed per tree species, but more were observed in higher trees (Fig. 19); the same was found in other tree species. The same data were split up for counts done during the morning (7-10 h), noon (11-15 h) and evening (16-19 h), but we found no differences in the number of birds detected during the morning, noon and evening in small and large trees. Apparently, the birds continued to feed the entire day-light period, due to the low food supply and/or the enhanced energy requirements in birds gaining weight before leaving north.

This analysis offers no actual proof, but it gives more confidence that (nearly) all birds present were detected, - also during the hot hours around noon. However, it remains worthwhile to count the same plot several times, for instance in the early morning and during noon. Another check is to count the same plot several times with a variable observation time.

It is not possible to give guidelines how much time is needed to detect all bird in a tree, since each tree is different, but some general remarks can be made. First, on 656 ha of plots, we observed 1003 birds in 57,899 trees and scrubs. Less than 2% of the trees had one or more birds. Hence, it requires strict discipline of the fieldworkers to scan tree after tree carefully, also tree species for which the probability of seeing a bird is close to zero.

Secondly, the effort to discover the woodland birds varies during the course of the season: many birds, still silent until mid-February, sing in the early morning later in the season, but birds feeding the entire day-light period in February might take a rest in the middle of the day earlier in the season.

Fig. 20. *Open landscape with* Adenium obesum *(Desert rose),*Acacia senegal *and* A. tortilis*, - birds at this site were easy to locate (top) . A large* Tamarindus indica *(left) and a dense flood forest with large* Acacia seyal *and* Ziziphus spina-cristii *(right) were more difficult and took more time*.

5 References

Arbonnier M – 2004. Trees, shrubs and lianas of West African dry zones. CIRAD / Margraf Publishers / MNHN.

Tappan GG, Sall M, Wood EC, Cushing M – 2004. Ecoregions and land cover trends in Senegal. J. Arid. Envirom. 59: 427-462.

Zwarts L, Bijlsma RG, van der Kamp J, Wymenga E – 2009. Living on the edge: wetlands and birds in a changing Sahel. KNNV Publishers.

Fig. 21. *One of the largest* Acacia tortilis *trees we have seen*.

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