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Authors: Schmidt, Marco, Mbayngone, Elisée, Bachmann, Yvonne, Hahn, Karen, Zizka, Georg, et al.

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The impact of land use on species composition and habitat structure in Sudanian savannas – A modelling study in protected areas and agricultural lands of southeastern Burkina Faso

Marco Schmidt, Elisée Mbayngone, Yvonne Bachmann, Karen Hahn, Georg Zizka & Adjima Thiombiano

Abstract

SCHMIDT, M., E. MBAYNGONE, Y. BACHMANN, K. HAHN, G. ZIZKA & A. THIOMBIANO (2016). The impact of land use on species composition and habitat structure in Sudanian savannas – A modelling study in protected areas and agricultural lands of southeastern Burkina Faso. *Candollea* 71: 265–274. In English, English abstract. DOI: <http://dx.doi.org/10.15553/c2016v712a11>

Sudanian Savannas are under high agricultural pressure and are therefore changing rapidly. Due to high population densities and an increasing need for food and cash crops, the mosaic of traditional agroforestry systems, fallows and savanna is being transformed into intensively used croplands and savannas only remain in protected areas. The focus of this study is to characterize the differences in plant diversity and composition between protected areas and surrounding agricultural lands and to identify areas most important for plant conservation. Building on observation and collection records, we modelled distributions of individual plant species and summarized these. We mapped the species richness of vascular plants in general, of woody plants, graminoids and forbs, the share of weeds and the average size of grasses and trees and calculated means for the reserves and outside areas. Distinct differences between protected areas and agricultural lands have been found in the richness of herbs (both forbs and graminoids) and weeds as well as in the size of grasses: Woody species seem to be less affected by human impact in the agricultural lands concerning both species richness and plant size. Weeds are playing an important role in the higher species richness of the agricultural lands.

Keywords

Growth form composition – Plant size – Protected areas – Sudanian savannas – Species richness – West Africa

Addresses of the authors:

MS: Senckenberg Biodiversity and Climate Research Centre (BiK-F), Data and Modelling Centre, Senckenberganlage 25 60325 Frankfurt am Main, Germany.
E-mail: mschmidt@senckenberg.de

EM: University of N'Djaména, Laboratory of Systematic Botany and Vegetation Ecology, BP 1027, N'Djaména, Tchad.

YB: Technical University Darmstadt, Center for Teacher Education, Alexanderstrasse, 664283 Darmstadt, Germany.

KH, GZ, YB: J.W. Goethe University, Institute for Ecology, Evolution and Diversity Max-von-Laue-Straße 13, 60438 Frankfurt am Main, Germany.

GZ, MS: Senckenberg Research Institute and Natural History Museum Frankfurt, Department of Botany and molecular Evolution, Senckenberganlage 25, 60325 Frankfurt am Main, Germany.

AT, EM : University of Ouagadougou, Laboratory of Biology and Vegetation Ecology, BP 848, Ouagadougou 09, Burkina Faso.

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Introduction

Tropical grassy biomes, long neglected, are increasingly moving into the focus of research and conservation, especially in Africa, where they cover a third of the continental land surface (PARR et al., 2014). Sudanian savannas, located in West Africa between the Sahelian drylands and the Guinean rainforests, are a biome characterized by high grasses of the Andropogoneae (BOCKSBERGER et al., 2016). They are particularly under threat by expanding agriculture with one of the highest human population densities on the continent. Due to the increasing need for food and cash crops, vast areas have been transformed into croplands and only few larger patches of close-to-natural savanna remain in protected areas (PAs). On the other hand the economic importance of wild plant products for the population is high, as many species are regularly used for food, medicine and crafts (MBAYNGONE & THIOMBIANO, 2011; ZIZKA et al., 2015).

The partial faunal reserve of Pama is the westernmost part of the so-called WAPO (W-Arly-Pendjari-Oti) complex of PAs in the border region of Burkina Faso, Niger, Benin and Togo. With an area of 223,500 ha it is one of the largest PAs in Burkina Faso and belongs to the category IV of the IUCN. Different Sudanian savannas and woodlands (HAHN, 1996), gallery forests along the Singou and Pendjari rivers and rocky habitats of the Gobnangou hills (OUÉDRAOGO & SCHMIDT, 2010) are included in the reserve. The local population mainly consists of Gourmantché, followed by Mossi and Peulh, the largest town in the study area is Pama, but the closeby regional capital Fada N’Gourma (c. 45 km to the north of the reserve) certainly also has an influence. During the last decades, areas outside the reserves experienced large scale conversions of savannas and woodlands to mosaics of fields and fallows and even larger areas of bare soil (SOULAMA et al., 2015).

Although the large reserves of the area have mainly been installed for the protection of fauna and particularly large mammals (see, e.g., HENSCHER et al., 2014), they contribute also to the protection of Burkina Faso’s flora, even more so with expanding and intensified land use, pushing the agricultural frontier to the very borders of the PAs (UNEP, 2008; GNOUMOU, 2013) and in some cases even beyond. With the growing importance of PAs for plant conservation, it becomes important to identify the key areas for the conservation of plant diversity. Pama reserve is home to 450 species of vascular plants (MBAYNGONE et al., 2008), for Arly National Park 490 species have been documented (OUÉDRAOGO et al., 2011), a large proportion of the 2067 species documented for Burkina Faso (THIOMBIANO et al., 2012). The purpose of this study is to identify areas of high diversity and areas important for the conservation of rare species.

Methods

We are building on extensive vegetation surveys in the area of the Pama reserve (SCHMIDT, 2006; MBAYNGONE, 2008), inventories of the BIOTA biodiversity observatories (JÜRGENS et al., 2012), records from georeferenced photo records (DRESSLER et al., 2014) and collection data from the herbaria of Senckenberg (FR) and the University of Ouagadougou (OUA), combining these data types in order to account for their specific strengths and weaknesses (SCHMIDT et al., 2010). The vast majority of coordinates was recorded using a GPS with a spatial accuracy of c. 10 m, in the case of vegetation plot data, the center point location has been assigned to all species occurring within the plot, thereby additionally reducing the accuracy by a few meters (herb layer relevés usually on 10 m × 10 m, woody layer relevés on 30 m × 30 m). In order to avoid the influence of the roads on species composition and the satellite signals corresponding to their localities, records were usually taken > 500 m from the road. After data cleaning, removing doubles, resolving synonymies and assigning infraspecific taxa to the respective species rank using the Vascular Plant Catalogue of Burkina Faso (THIOMBIANO et al., 2012) as a nomenclatural reference, we had an occurrence dataset of 10878 records for 648 species of vascular plants, more species than known from the two checklists of Pama and Arly (see above). Measures of plant size for grasses and trees have been taken from POILECOT (1995, 1999), SCHMIDT et al. (2011) and SCHMIDT et al. (2013), classification as weeds is based on LE BOURGEOIS & MERLIER (1995) and ATAHOLO (2001).

Due to limited accessibility within the reserve, especially towards the end of the rainy season, when the majority of plant species can be identified, most data have been taken close to roads and close to the enclaves around villages. To close the resulting gaps in species occurrence data we modelled species distributions using Maxent v. 3.3.3 and environmental predictors consisting of a set of topographic and remote sensing (RS) variables closely linked to environmental factors and with sufficient spatial resolution for the task.

For an optimal choice of environmental data and botanical occurrence data as well as full coverage of the Pama reserve we restricted our study to the area between 0.5°E–1.5°E and 11°N–12°N (Fig. 1). The area is covered by a single Landsat 8 scene. Therefore no edge effects occur within the RS data. The Landsat 8 scene from the 13th of October 2013, WRS path 193/row 52, was downloaded from the US Geological Survey website [<http://earthexplorer.usgs.gov>]. After rescaling the values of the Top of the Atmosphere (TOA) spectral radiance and the Thermal Infrared Sensor data to at-satellite brightness temperature [http://landsat.usgs.gov/Landsat8_Using_Product.php], the following ecologically important predictor variables were calculated from the RS data: NDVI, MSI, SAVI, ferrous minerals, iron oxide, clay minerals and at-satellite brightness temperature (KRIEGLER et al., 1969;

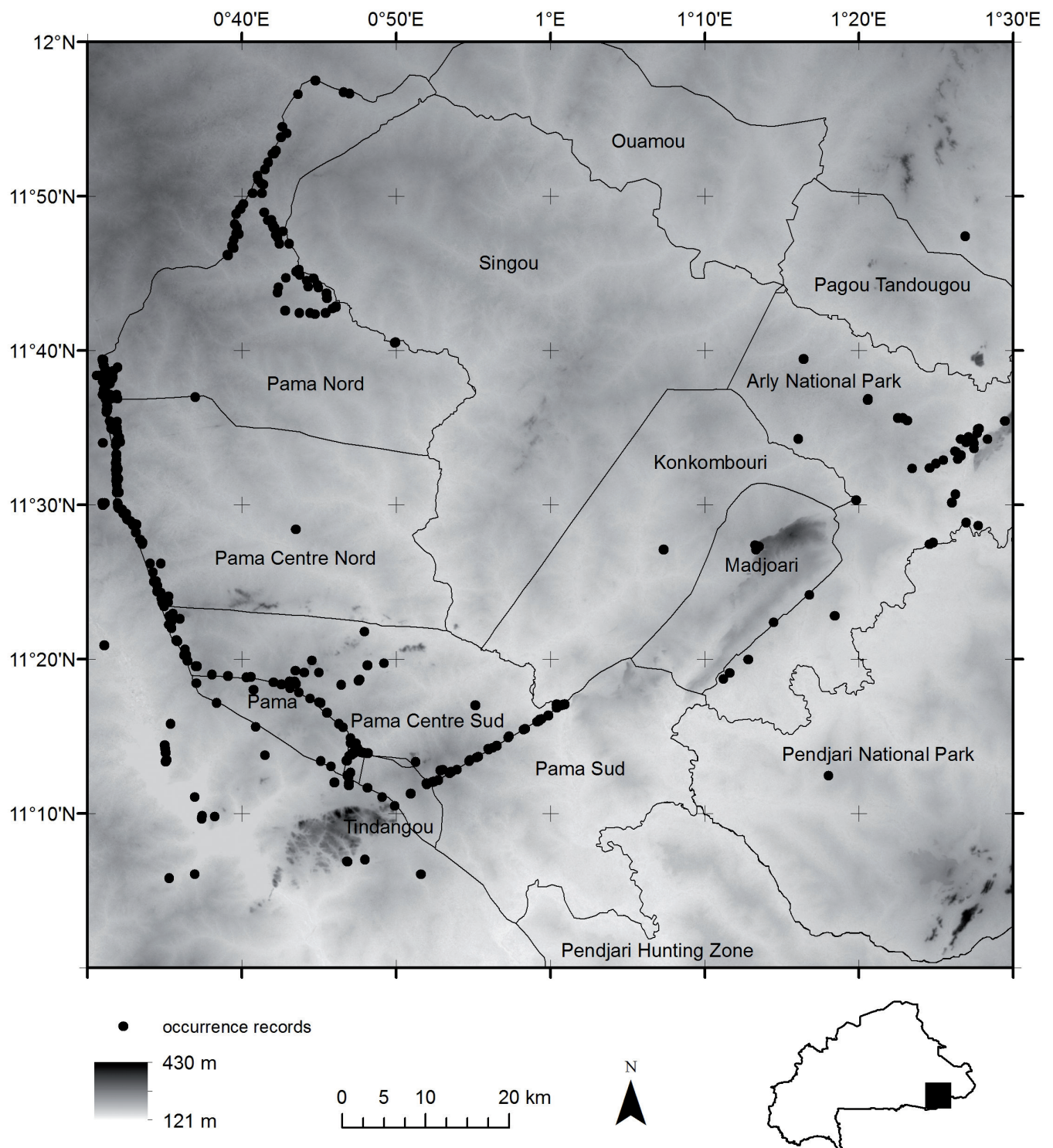


Fig. 1. – Study area including the Pama reserve and neighbouring PAs of the western WAPO complex. The Pama, Tindangou and Madjoari areas are enclaves where agriculture is allowed. The small country map in the lower right shows the position of the study area within Burkina Faso.

HUETE, 1988). Furthermore slope and the Topographic Wetness Index (TWI, BEVEN & KIRKBY, 1979) were calculated from the ASTER GDEM V2. To avoid problems with multicollinearity we excluded the RS layers highly correlated with the NDVI (SAVI, MSI, ferrous minerals, iron oxide), resulting in five final predictor variables: NDVI, at-satellite brightness temperature, clay minerals, slope and TWI. All datasets were clipped to the extent of the study area. Analysis was conducted at the spatial resolution of 30 m. Processing was done with ERDAS Imagine 13 (Intergraph Corporation), SAGA-GIS 2.0 (SAGA Development Team) and ArcGIS 10 (ESRI Inc.).

Only the 209 species with 10 or more spatially unique occurrence points have been considered for the modelling approach. SDMs of 21 species with an AUC < 0.7 have also been excluded from the further analysis. Probabilities of occurrence have been transformed into presence/absence using the Equal sensitivity and sensibility threshold (LIU et al., 2005) and stacked to produce maps of species richness for all species and specific groups. The calculation of average values for the different areas concerned has been done in R (v. 3.2.2), using the 'raster' library. The southernmost areas (Pama-Sud, Pendjari Hunting zone and Pendjari National Park) have been excluded from this analysis, because of their low sampling density.

Results

We modelled distributions of 188 species of vascular plants. The average AUC was 0.78, the predictor variable with the largest contribution to the models was at-satellite brightness temperature (with an average contribution of 44%), followed by NDVI (19%), clay minerals (17%), slope (12%) and TWI (8%).

The stacked SDM maps of species richness (Fig. 2) and plant size (Fig. 3) show clear differences between the PAs and the agricultural areas (see also Table 1 for average values). Although the species richness map of all vascular plants (Fig. 2A) doesn't show clear-cut differences between reserve and surroundings, the averaged values are distinctly higher for outside areas. Within the reserve larger differences between high and low diversity areas exist. Especially Pama Centre Nord and the northern parts of Pama Nord seem to be more diverse. Growth forms react differently (Fig. 2): while the diversity patterns of grass-like species (Fig. 2B) are very similar to the general patterns of species richness, forbs are comparatively more diverse in the agricultural land (Fig. 2C) and woody species are rather evenly distributed among land use types but with highest values in Pama centre Nord and Pama Nord (Fig. 2D). Distinctly higher diversities in the agricultural land are shown for weedy species (Fig. 2E) and only slightly higher values for non-weedy species (Fig. 2F).

The maps of maximum plant size (Fig. 3) and average values in Table 1) show very clear patterns of higher grasses (Fig. 3A) within the reserve, while size patterns of woody plants are quite indifferent to protection status (Fig. 3B).

Discussion

Our approach clearly showed differences in species diversity patterns and structural parameters between the reserve and the agricultural areas. These are in line with the findings of HAHN-HADJALI et al. (2006) from the BIOTA observatories of the same area: The higher species richness found there in Kikidéni (communal lands/cattle grazing) as compared to Natiabouani (Pama Nord) is mainly attributed to lower size annual species, a group largely overlapping with the weedy species set of the present study. DEVINEAU et al. (2009) also found higher numbers of weeds and annuals outside and more perennial herbs inside the reserves in western central Burkina Faso. The effective protection of tall grass species within the reserve (Fig. 3a) is contributing to wildlife conservation in the PAs concerning both food and habitat requirements.

Woody species in our study area seem to be generally less affected by human impact in the agricultural lands, concerning both species richness and plant size, a result also found in Sissili (South Central Burkina Faso) by PARÉ et al. (2009) and in the closeby W-National Park by NACOLMA et al. (2011), but contrary to the findings of TRAORÉ et al. (2012) from SW Burkina Faso. With the growing intensification of agriculture linked to cotton cultivation, replacing the traditional agro-forestry systems with their mosaics of fields and fallows, the woody species are expected to be more heavily impacted in the future.

The use of high resolution remote sensing and topographic variables representing factors known to have a direct impact on the organisms (temperature, soil, water availability) made it possible to reach a high spatial resolution and a good distinction between protected area and agricultural lands. The results show clearly the importance of these variables for small-scale distribution studies, where the interpolated climate grids often used on larger scales reach the limits of their predictive power.

Recent works on grass traits (PASTUREL et al., 2016) in African savanna biomes stressed the importance of plant size in defining functional types of grasses especially in their response to climate. Our results show that such types would also be useful for the study of different land use systems.

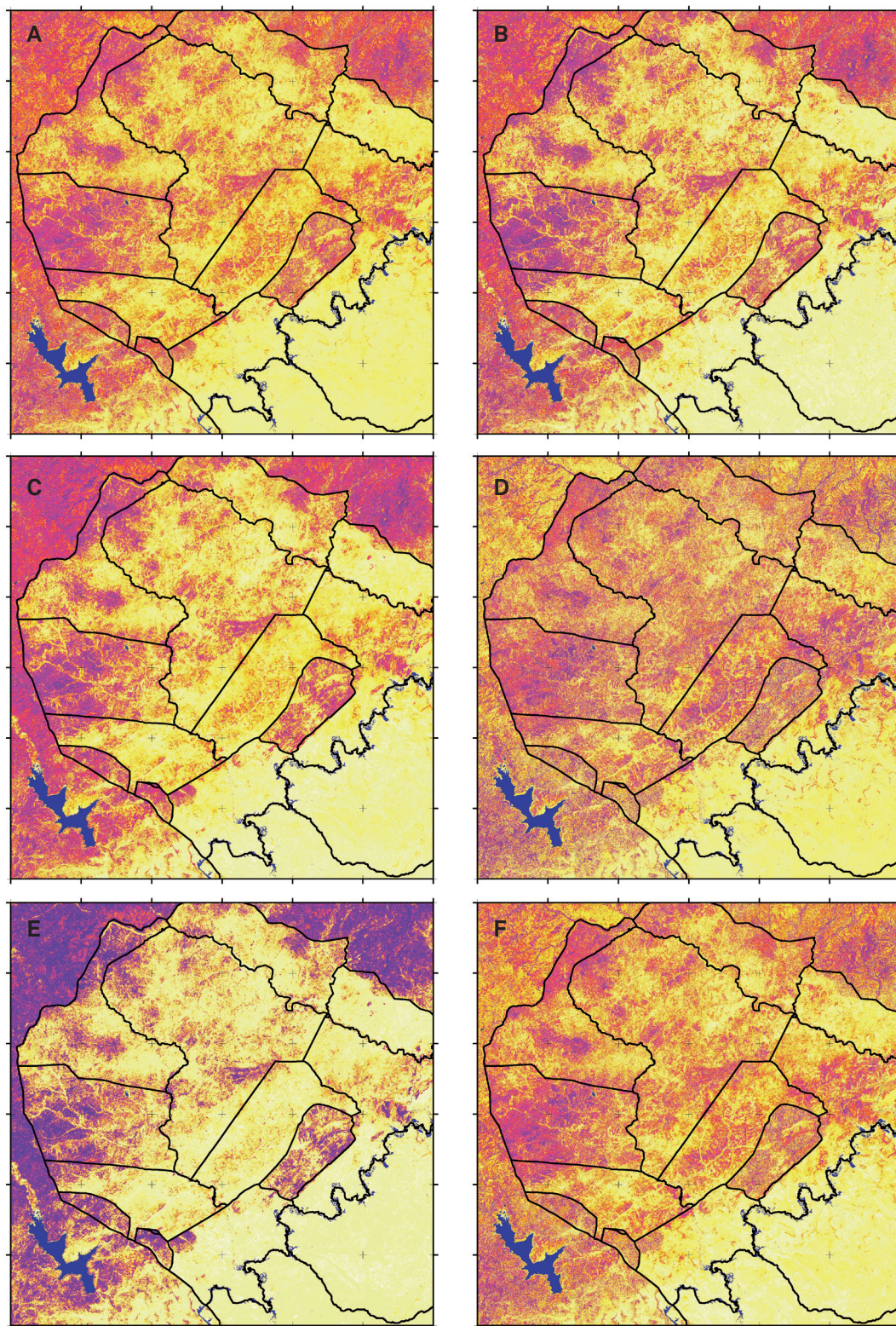


Fig. 2. – Maps of species richness. **A.** All plant species (2-211 spp.); **B.** Graminoids (0-50 spp.); **C.** Forbs (0-86 spp.); **D.** Woody species (0-52 spp.); **E.** Weedy species (0-48 spp.); **F.** Non-weedy species (0-140 spp.). The color coding stretches from light yellow for the lowest values via orange and red to violet for the highest values.

Table 1. – Average values of species richness of plants in general, groups of growth form and weeds/non-weeds summarized from the stacked SDM models for the different PAs in the western WAP complex and cultivated lands in the enclaves and outside the PAs. The last two columns give average values of plant height for grasses and trees.

	All species	Forbs	Graminoid	Woody	Non weeds	Weeds	Grass height [cm]	Tree height [cm]
Enclaves/outside								
Madjoari	78.11	31.80	17.57	19.12	51.40	18.08	157.22	9.43
Tindangou	84.16	37.29	19.59	17.69	51.18	24.13	140.54	9.75
Pama	90.36	39.98	21.43	19.52	56.56	24.71	139.85	9.75
outside PAs	94.13	42.69	22.59	19.18	56.83	28.47	135.68	9.10
Protected Areas								
Konkombouri	59.50	18.89	11.54	18.86	44.19	5.95	186.29	9.09
Pama Centre Nord	91.33	36.50	22.18	23.21	62.67	20.16	166.98	8.83
Pama Centre Sud	60.16	20.67	13.17	17.09	42.76	9.42	177.37	9.22
Pama Nord	75.56	28.81	18.05	19.92	52.10	15.79	173.01	8.96
Singou	60.24	21.10	13.72	16.99	42.50	10.48	178.59	9.08
Pagou Tandougou	39.90	12.00	7.23	12.43	27.83	5.05	172.92	9.06
Arly	55.37	18.43	11.06	16.47	39.64	8.11	172.24	9.00
Ouamou	61.83	22.40	14.72	16.73	43.45	11.51	177.14	9.22
meanOut	92.42	41.54	22.06	19.16	56.24	27.36	137.81	9.15
meanPA	64.51	23.16	14.54	17.94	45.33	11.51	175.30	9.04

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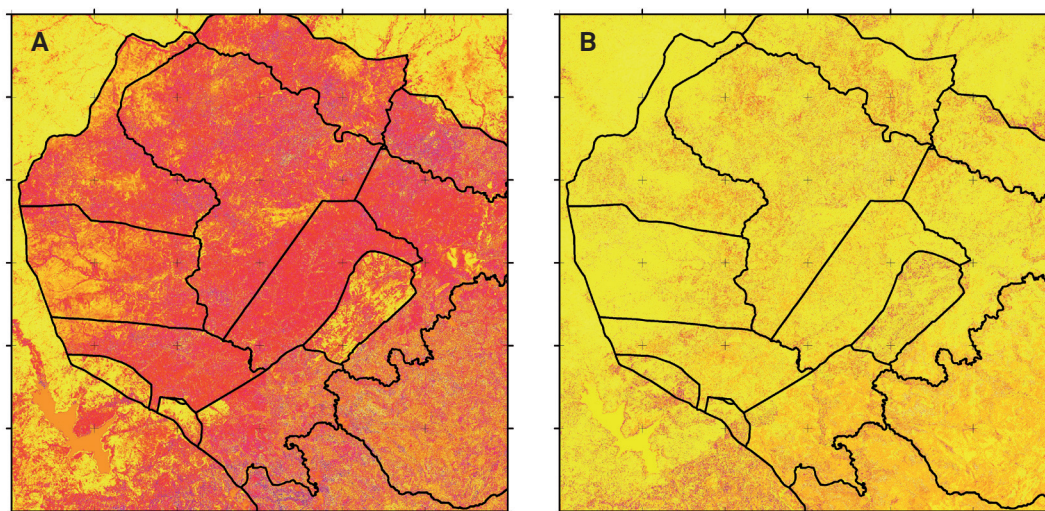


Fig. 3. – Maps of mean maximum plant size (calculated as average of maximum plant size of all species predicted as present within a grid cell). **A.** Grasses (Poaceae) (30–360 cm); **B.** Woody species (3–25 m). The color coding stretches from light yellow for the lowest values via orange and red to violet for the highest values.

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Appendix 1. – List of species with 10 or more spatially unique occurrences in the study area. For each species the number of samples, the AUC of the species distribution models (mean value out of 100 runs), the growth form and the assignment to the weed categories are provided.

Species	#samples	AUC	Growth Form	Weed	Species	#samples	AUC	Growth Form	Weed
<i>Abildgaardia abortiva</i>	35	0.74	graminoid	N	<i>Combretum molle</i>	75	0.74	woody	N
<i>Abildgaardia coleotricha</i>	26	0.78	graminoid	N	<i>Combretum nigricans</i>	91	0.74	woody	N
<i>Abildgaardia filamentosa</i>	38	0.74	graminoid	N	<i>Commelina benghalensis</i>	12	0.79	forb	Y
<i>Abildgaardia hispidula</i>	61	0.75	graminoid	Y	<i>Commelina erecta</i>	15	0.72	forb	N
<i>Acacia dudgeonii</i>	126	0.77	woody	N	<i>Commiphora africana</i>	13	0.77	woody	N
<i>Acacia gourmaensis</i>	127	0.78	woody	N	<i>Corchorus olitorius</i>	22	0.77	forb	Y
<i>Acacia hockii</i>	91	0.79	woody	N	<i>Corchorus tridens</i>	29	0.90	forb	Y
<i>Achyranthes aspera</i>	22	0.79	forb	Y	<i>Crossopteryx febrifuga</i>	83	0.80	woody	N
<i>Alysicarpus ovalifolius</i>	60	0.78	forb	Y	<i>Crotalaria macrocalyx</i>	61	0.71	forb	N
<i>Alysicarpus rugosus</i>	18	0.71	forb	Y	<i>Crotalaria microcarpa</i>	53	0.73	forb	N
<i>Andropogon chinensis</i>	75	0.78	graminoid	N	<i>Crotalaria naragutensis</i>	10	0.82	forb	N
<i>Andropogon fastigiatus</i>	72	0.75	graminoid	Y	<i>Ctenium newtonii</i>	31	0.77	graminoid	N
<i>Andropogon gayanus</i>	175	0.72	graminoid	N	<i>Curculigo pilosa</i>	10	0.84	forb	N
<i>Andropogon pseudapricus</i>	161	0.74	graminoid	N	<i>Cyanotis longifolia</i>	19	0.88	forb	N
<i>Aneilema lanceolatum</i>	63	0.76	forb	N	<i>Cymbopogon caesius</i>	33	0.77	graminoid	N
<i>Annona senegalensis</i>	118	0.75	woody	N	<i>Dactyloctenium aegyptium</i>	17	0.96	graminoid	Y
<i>Anogeissus leiocarpa</i>	72	0.73	woody	N	<i>Desmodium gangeticum</i>	21	0.73	forb	N
<i>Aristida adscensionis</i>	15	0.88	graminoid	Y	<i>Desmodium velutinum</i>	22	0.76	forb	N
<i>Aristida kerstingii</i>	110	0.75	graminoid	Y	<i>Detarium microcarpum</i>	19	0.73	woody	N
<i>Aspilia bussei</i>	106	0.77	forb	N	<i>Dichrostachys cinerea</i>	40	0.73	woody	N
<i>Aspilia helianthoides</i>	26	0.75	forb	N	<i>Digitaria argillacea</i>	95	0.75	graminoid	Y
<i>Balanites aegyptiaca</i>	52	0.76	woody	N	<i>Diheteropogon amplexans</i>	59	0.76	graminoid	N
<i>Blepharis linariifolia</i>	26	0.81	forb	N	<i>Diospyros mespiliformis</i>	34	0.75	woody	N
<i>Bombax costatum</i>	22	0.72	woody	N	<i>Entada africana</i>	17	0.75	woody	N
<i>Brachiaria jubata</i>	44	0.80	graminoid	N	<i>Eragrostis turgida</i>	13	0.90	graminoid	Y
<i>Brachiaria lata</i>	37	0.85	graminoid	Y	<i>Euclasta condylotricha</i>	21	0.80	graminoid	N
<i>Brachiaria serrata</i>	25	0.75	graminoid	N	<i>Euphorbia convolvuloides</i>	100	0.78	forb	Y
<i>Brachiaria villosa</i>	75	0.81	graminoid	N	<i>Feretia apodanthera</i>	88	0.75	woody	N
<i>Brachystelma bingeri</i>	30	0.80	forb	N	<i>Flueggea virosa</i>	45	0.74	woody	N
<i>Bridelia scleroneura</i>	49	0.74	woody	N	<i>Gardenia erubescens</i>	24	0.77	woody	N
<i>Buchnera hispida</i>	11	0.77	forb	N	<i>Gardenia ternifolia</i>	90	0.76	woody	N
<i>Burkea africana</i>	11	0.72	woody	N	<i>Grewia bicolor</i>	16	0.82	woody	N
<i>Cassia mimosoides</i>	181	0.74	forb	Y	<i>Grewia cissoides</i>	68	0.76	forb	N
<i>Cassia obtusifolia</i>	13	0.85	forb	Y	<i>Grewia lasiodiscus</i>	45	0.76	woody	N
<i>Chasmopodium caudatum</i>	59	0.78	graminoid	N	<i>Grewia mollis</i>	44	0.74	woody	N
<i>Chloris pilosa</i>	27	0.82	graminoid	Y	<i>Gymnosporia senegalensis</i>	146	0.73	woody	N
<i>Chlorophytum limosum</i>	31	0.79	forb	N	<i>Hackelochloa granularis</i>	81	0.79	graminoid	Y
<i>Chrysopogon nigrifolius</i>	17	0.85	graminoid	N	<i>Heliotropium strigosum</i>	12	0.76	forb	N
<i>Cienfuegosia heteroclada</i>	16	0.86	forb	N	<i>Heteropogon contortus</i>	22	0.72	graminoid	N
<i>Cissus adenocaulis</i>	29	0.79	forb	N	<i>Hexalobus monopetalus</i>	16	0.78	woody	N
<i>Cissus flavicans</i>	37	0.82	forb	N	<i>Hibiscus cannabinus</i>	106	0.72	forb	N
<i>Cissus populnea</i>	24	0.71	forb	N	<i>Hyparrhenia glabriuscula</i>	15	0.74	graminoid	N
<i>Cleome viscosa</i>	10	0.89	forb	Y	<i>Hyparrhenia involucrata</i>	96	0.75	graminoid	N
<i>Cochlospermum planchonii</i>	51	0.75	forb	N	<i>Hyparrhenia smithiana</i>	25	0.80	graminoid	N
<i>Cochlospermum tinctorium</i>	83	0.77	forb	N	<i>Hyparrhenia subplumosa</i>	28	0.76	graminoid	N
<i>Combretum adenogonium</i>	49	0.74	woody	N	<i>Hyperthelia dissoluta</i>	20	0.78	graminoid	N
<i>Combretum collinum</i>	116	0.75	woody	N	<i>Hyptis spicigera</i>	43	0.74	forb	Y
<i>Combretum glutinosum</i>	202	0.73	woody	N	<i>Hyptis suaveolens</i>	10	0.80	forb	Y

Species	#samples	AUC	Growth Form	Weed	Species	#samples	AUC	Growth Form	Weed
<i>Indigofera aspera</i>	14	0.90	forb	N	<i>Schizachyrium sanguineum</i>	40	0.77	graminoid	N
<i>Indigofera bracteolata</i>	113	0.76	forb	N	<i>Schoenefeldia gracilis</i>	52	0.86	graminoid	N
<i>Indigofera colutea</i>	14	0.79	forb	N	<i>Scleria pergracilis</i>	16	0.84	graminoid	N
<i>Indigofera dendroides</i>	87	0.76	forb	N	<i>Scleria sphaerocarpa</i>	25	0.72	graminoid	N
<i>Indigofera lepieurii</i>	58	0.73	forb	N	<i>Sclerocarya birrea</i>	25	0.78	woody	N
<i>Indigofera leptoclada</i>	22	0.81	forb	N	<i>Securidaca longipedunculata</i>	11	0.81	woody	N
<i>Indigofera microcarpa</i>	10	0.77	forb	N	<i>Setaria barbata</i>	17	0.78	graminoid	N
<i>Indigofera paniculata</i>	21	0.80	forb	N	<i>Setaria pumila</i>	69	0.86	graminoid	Y
<i>Indigofera stenophylla</i>	57	0.72	forb	Y	<i>Sida alba</i>	62	0.80	forb	N
<i>Ipomoea coscinosperma</i>	61	0.81	forb	N	<i>Sida rhombifolia</i>	14	0.96	forb	N
<i>Ipomoea eriocarpa</i>	45	0.80	forb	Y	<i>Sida urens</i>	15	0.88	forb	N
<i>Kohautia tenuis</i>	20	0.81	forb	Y	<i>Siphonochilus aethiopicus</i>	20	0.77	forb	N
<i>Lannea acida</i>	93	0.77	woody	N	<i>Spermacoce chaetocephala</i>	31	0.90	forb	Y
<i>Lantana ukambensis</i>	11	0.73	forb	N	<i>Spermacoce filifolia</i>	60	0.75	forb	N
<i>Lepidagathis anobrya</i>	107	0.77	forb	N	<i>Spermacoce radiata</i>	156	0.73	forb	Y
<i>Leucas martinicensis</i>	23	0.89	forb	Y	<i>Spermacoce stachydea</i>	163	0.73	forb	Y
<i>Lippia chevalieri</i>	10	0.73	forb	N	<i>Sporobolus festivus</i>	99	0.74	graminoid	Y
<i>Loudetia togoensis</i>	19	0.81	graminoid	N	<i>Sporobolus pyramidalis</i>	22	0.77	graminoid	Y
<i>Ludwigia hyssopifolia</i>	12	0.71	forb	Y	<i>Sterculia setigera</i>	17	0.82	woody	N
<i>Mariscus squarrosus</i>	10	0.88	graminoid	Y	<i>Stereospermum kunthianum</i>	156	0.75	woody	N
<i>Merremia kentrocaulos</i>	14	0.82	forb	N	<i>Striga asiatica</i>	18	0.77	forb	N
<i>Microchloa indica</i>	81	0.74	graminoid	Y	<i>Striga hermonthica</i>	29	0.84	forb	Y
<i>Mitracarpus hirtus</i>	11	0.86	forb	Y	<i>Strychnos spinosa</i>	53	0.78	woody	N
<i>Mitragyna inermis</i>	15	0.80	woody	N	<i>Stylochiton hypogaeus</i>	32	0.81	forb	N
<i>Monechma ciliatum</i>	46	0.77	forb	Y	<i>Stylochiton lancifolius</i>	21	0.77	forb	N
<i>Mukia maderaspatana</i>	46	0.73	forb	N	<i>Tacca leontopetaloides</i>	33	0.76	forb	N
<i>Pandiaka angustifolia</i>	183	0.73	forb	N	<i>Tamarindus indica</i>	29	0.72	woody	N
<i>Panicum pansum</i>	53	0.79	graminoid	Y	<i>Tephrosia bracteolata</i>	115	0.78	forb	N
<i>Paspalum scrobiculatum</i>	15	0.82	graminoid	Y	<i>Tephrosia linearis</i>	17	0.74	forb	Y
<i>Pennisetum pedicellatum</i>	116	0.78	graminoid	Y	<i>Tephrosia pedicellata</i>	58	0.79	forb	Y
<i>Pericopsis laxiflora</i>	10	0.84	woody	N	<i>Terminalia avicennioides</i>	144	0.73	woody	N
<i>Philenoptera laxiflora</i>	32	0.80	woody	N	<i>Tinnea barteri</i>	40	0.84	forb	N
<i>Phyllanthus amarus</i>	39	0.74	forb	Y	<i>Trichilia emetica</i>	11	0.71	woody	N
<i>Piliostigma reticulatum</i>	56	0.78	woody	N	<i>Tripogon minimus</i>	28	0.79	graminoid	N
<i>Piliostigma thonningii</i>	126	0.74	woody	N	<i>Triumfetta lepidota</i>	43	0.78	forb	N
<i>Polycarpaea eriantha</i>	18	0.75	forb	N	<i>Triumfetta pentandra</i>	13	0.75	forb	Y
<i>Polycarpaea linearifolia</i>	17	0.76	forb	N	<i>Vigna filicaulis</i>	12	0.76	forb	N
<i>Polygala arenaria</i>	64	0.73	forb	Y	<i>Vigna heterophylla</i>	10	0.78	forb	N
<i>Pseudocedrela kotschy</i>	35	0.73	woody	N	<i>Vigna racemosa</i>	56	0.71	forb	N
<i>Pteleopsis suberosa</i>	45	0.80	woody	N	<i>Vitellaria paradoxa</i>	119	0.74	woody	N
<i>Pterocarpus erinaceus</i>	59	0.77	woody	N	<i>Wissadula rostrata</i>	18	0.78	forb	N
<i>Rhynchosia minima</i>	11	0.79	forb	N	<i>Ximenia americana</i>	122	0.73	woody	N
<i>Rottboellia cochinchinensis</i>	38	0.76	graminoid	Y	<i>Ziziphus abyssinica</i>	38	0.78	woody	N
<i>Schizachyrium exile</i>	44	0.80	graminoid	N	<i>Ziziphus mauritiana</i>	18	0.87	woody	N
<i>Schizachyrium nodulosum</i>	29	0.81	graminoid	N	<i>Ziziphus mucronata</i>	31	0.78	woody	N
<i>Schizachyrium rupestre</i>	63	0.76	graminoid	N	<i>Zornia glochidiata</i>	11	0.90	forb	Y