Significance of sacred sites for riparian forest conservation in Central Benin

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Photograph 1.
Ceiba pentandra exploitation by migrant woodcutters.
Photograph N. Ceperley.

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RÉSUMÉ

IMPORTANCE DES SITES SACRÉS POUR LA CONSERVATION DES FORÊTS-GALERIES AU CENTRE-BÉNIN

Les mares, bassins ou sites sacrés de forêts-galeries le long des cours d'eau, encore appelés *Íbú ódó* en langue Tchabè, sont respectés par les communautés Tchabè le long des fleuves Ouémé et Okpara au Centre-Bénin (Afrique de l'Ouest). Le caractère sacré de ces sites et points d'eau a un impact évident sur la conservation de la biodiversité, à travers la prohibition de l'utilisation des poisons pour la pêche, de la pollution des eaux, l'interdiction de l'élevage, les défrichements dans leur voisinage immédiat, etc. La structure et la diversité des forêts-galeries et *Íbú ódó* ont été examinées dans trois sites différents (Djabata, Idadjo et Monka) de forêts-galeries adjacents à des sites et points d'eau sacrés. En outre, les caractéristiques des forêts-galeries ont été analysées du point de vue des différents modes d'utilisation et de gestion des terres, en zones agricole, domaines utilisés par les villages et sites sacrés des religions traditionnelles. La diversité des ligneux (dbh ≥ 10 cm) est plus élevée dans les sites des forêts sacrées, tandis que la surface terrière est plus grande dans les sites à forte emprise humaine ou adjacents aux *Íbú ódó*. Sur le plan floristique, les forêts-galeries les plus éloignées des villages sont les plus diversifiées, avec les plus grandes surfaces terrières. L'enquête ethnobotanique auprès des anciens et des chefs chasseurs a révélé l'importance culturelle et la diversité des ressources des sites de forêts-galeries sacrés. Les *Íbú ódó* sont respectés par tous les villageois y compris les immigrants et colons agricoles non Tchabè. Les fonctions des écosystèmes riverains (telles que brise-vent, fertilité des sols, sites privilégiés de chasse) sont reconnues et valorisées par les populations riveraines. La présente étude recommande d'inclure les sites sacrés de forêts-galeries dans une stratégie de gestion durable du bassin du fleuve Ouémé, afin d'inverser la destruction de la végétation et de préserver la diversité des forêts-galeries. C'est une nécessité pour un contrôle efficace des inondations et la conservation de la biodiversité au Centre-Bénin.

Mots-clés : forêt sacrée, forêt-galerie, services d'écosystèmes, mode d'utilisation des terres, Bénin.

ABSTRACT

SIGNIFICANCE OF SACRED SITES FOR RIPARIAN FOREST CONSERVATION IN CENTRAL BENIN

Íbú ódó, or sacred pools or points in the river, are generally respected by Tchabè communities along the Ouèmé and Okpara Rivers of Central Benin (West Africa). *Íbú ódó* are governed by rules that may influence conservation practices, including bans on fish poisoning, over-fishing and pollution and discouragement of cattle grazing and cultivation in their vicinity. Riparian forest structure and diversity was examined in three sites adjacent to sacred pools as well as in riparian areas adjacent to various land uses in the region. Diversity in riparian forest tree species was highest in areas adjacent to sacred forests, while tree basal area was larger in areas adjacent to village uses or to sacred lands. The most remote site had the most diverse riparian forest with the largest basal area. Concurrent interviews with elders and hunting chiefs revealed the significant cultural importance of sacred pools and riparian resources. *Íbú ódó* were respected not only by resident populations but also by migrants to the area. Riparian forests were valued for their many ecosystem services including soil fertility and their functions as windbreaks and hunting grounds. *Íbú ódó* should be incorporated into a long-term management strategy for the Ouémé River basin that will prevent the destruction of vegetation while conserving riparian forests. This would be crucial to flood control and biodiversity conservation in central Benin.

Keywords: sacred forest, riparian buffer, ecosystem services, land-use change, Benin.

RESUMEN

IMPORTANCIA DE LOS SITIOS SAGRADOS PARA LA CONSERVACIÓN DE LOS BOSQUES DE GALERÍA EN EL CENTRO DE BENÍN

Los Íbú ódó, charcas, lagunas o sitios sagrados en los ríos, suelen ser respetados por las comunidades Tchabè que habitan a lo largo de los ríos Ouèmé y Okpara del centro de Benín (África occidental). La presencia de los Íbú ódó está acompañada por reglas que pueden influir en las prácticas de conservación, tales como la prohibición del uso de venenos para peces, la sobrepesca o la contaminación de las aguas; al igual que la veda del pastoreo y los cultivos agrícolas cerca de estos sitios sagrados. Se examinó la estructura y la diversidad de tres sitios con bosques de galería o ribereños adyacentes a sitios sagrados, así como adyacentes a otros usos de la tierra predominantes en la región. La diversidad de especies de los bosques de galería fue mayor en las áreas adyacentes a bosques sagrados, mientras que el área basal arbórea fue mayor en bosques ribereños adyacentes a sitios de uso humano intenso, o en bosques ribereños adyacentes a bosques sagrados. El sitio de estudio más alejado presentó el bosque ribereño más diverso y con mayor área basal. Los resultados de entrevistas a ancianos y jefes de caza revelaron la significativa importancia cultural de los sitios sagrados y de los recursos de los bosques ribereños para estas poblaciones. Los Íbú ódó son respetados no solamente por las poblaciones residentes, sino también por inmigrantes y colonos agrícolas que no son Tchabè. Los bosques ribereños son apreciados por sus numerosos servicios, que incluyen su función de cortina rompevientos, la fertilidad de sus suelos, sus excepcionales cazaderos, etc. Se recomienda que los Íbú ódó sean incorporados en una estrategia de manejo a largo plazo de la cuenca del río Ouémé que prevenga la destrucción de la vegetación y conserve los bosques ribereños. Esto sería de importancia crucial para el control de las inundaciones y la conservación de la biodiversidad en la región central de Benín.

Palabras clave: bosque sagrado, bosque ribereño, servicios ambientales, cambios de uso de la tierra, Benín.

The degradation of tropical forests as a result of human activities is the major cause of decline in global biodiversity and ecosystem services. Conservation of ecosystems is therefore a priority to preserve both biodiversity and landscape functions (Solbrig, 1991). Benin has a rapidly growing population that is putting increasing pressure on natural resources while also relying more on their ecosystem services. Dense and increasing human populations now surround remnants of once intact natural forest in Benin. Conservation is especially critical in central Benin, which lies in the transition zone between southern Guinean forests and northern Sudanian savannas (White, 1983). This area's patchwork of savannas, agriculture and forest corridors perform valuable ecological functions and its degradation will mean a lower quality of rural life and increased migration to cities.

Riparian vegetation is of particular importance in Benin because of the pervasiveness of the anthropogenic savanna (Dupont, Weinelt, 1996). Central Benin is liable to flooding, leading to loss of lives, homes, infrastructure, cropland and food (Undha, 1985-2006). Conservation of riparian forest corridors in the central savanna zone is an opportunity to improve rural life due to their important ecosystem functions and may be instrumental in preventing potential disasters (Wang, Eltaher, 2002). Recognizing the local ecosystem services of riparian forests in Africa could improve their conservation status (McClain, Cossio, 2003).

Riparian vegetation, found on the borders of rivers and streams, filters nutrients and sediment, preventing them from entering waterways, and decreases flood damage (Darby, 1999). Vegetation also contributes to groundwater recharge, particularly in semi-arid areas affected by flash floods (Sandstrom, 1995; Nepstad *et al.*, 1994). Such ecological functions are dependent on the width of the riparian forest, its structure and its composition (Piegay & Bravard, 1997; Tabacchi *et al.*, 1998). Climate change is expected to make West Africa's already irregular precipitation even less regular, which will result in even more unpredictable floods and more frequent droughts (Ledger, 1961). Riparian ecosystem services are therefore expected to become even more important.

Photograph 2.
Expansion of millet fields adjacent to riparian forest, Idadjo.
Photograph N. Ceperley.

Riparian forests are under constant threat from human activities such as settlement, cultivation and harvesting of timber resources (Natta, 2003). Although perhaps more resilient than other forests thanks to their productivity and diversity (Naiman *et al.*, 2005), riparian forests face significant threats including timber extraction (photograph 1), fires and farm encroachment (photograph 2) (Goetz *et al.*, 2006). Degradation damages their ecological functions, with negative consequences for the people who benefit from their services. In Benin, riparian forests have economic and social values in addition to their ecosystem services. For example, *Pentadesma butyracea* (tallow tree) produces a marketable butter similar to that of *Vitellaria paradoxa* (shea nut tree) (Natta, 2003; Tchobo *et al.*, 2007).

Previous work concerning riparian forests in Benin has focused on their botanical composition and distribution (Natta, 2003), and in Africa, overall, on their diversity and function as wildlife habitats (Malanson, 1993). Natta (2003) found that the riparian forest near Idadjo was one of the most diverse forests in the region, containing several rare species, and that it was highly valued by the village for this reason. However, little or no work has been done in the Oueme River Basin in Benin on the social or hydro-ecological functions of these forests.

Sacred sites are found throughout Benin. The Adja plateau in southwestern Benin has over 82 distinct sacred forests (Sokpon *et al.*, 1998). Through botanical inventories, Kokou and Kokutse (2007) found sacred forests in coastal Benin and Togo to be island vestiges of biodiversity. The role of sacred forests and groves in conservation has long been recognized, since each site is culturally and ecologically unique. Local communities establish rules that vary between regions, including prohibition of reckless timber and game harvesting (although these rules may allow collection of firewood, fodder, and medicinal plants), thus tempering natural resource exploitation and preserving sites and their biodiversity over many generations. Kokou and Sokpon (2006) warned that the erosion of traditions would diminish the conservation value of these forests. Garcia *et al.* (2006) witnessed the dangers of degradation of sacred forests in India, which have been reduced in size and invaded by ubiquitous tropical species.

The International Union for Conservation of Nature formed a task force in 1998 to assess the cultural and spiritual values of protected areas (Iucn, 2008), and case studies from around the world have shown that these areas can be effectively incorporated into conservation agendas. Conservation of a landscape's ecological functions calls for a reorientation of strategies to incorporate cultural traditions also (Ramakrishnan *et al.*, 1998).

This article explores the coexistence of functions in forests that are both riparian and sacred in central Benin. This is the first time that the ecosystem function, as opposed to the biodiversity, of sacred spaces in Benin has been highlighted. It is not an exhaustive inventory of sacred sites, but rather an examination of the exchange between conservation and social values in three communities in central Benin. Kokou and Sokpon (2006) showed that sacred forests in southern Benin are well-defined islands within a severely disturbed landscape. This is not the case in central Benin, where specific points along the river surrounded by a general forest buffer are respected; however we believe that they offer grounds for a conservation alliance between traditional and modern approaches.

To show the impact of the sacred forests on parameters indicative of the ecological function of riparian forests, we compared forest structure and diversity across a gradient of human use from sacred to agricultural, and across three sites with varying perceptions of sacred and riparian importance. This is not an inventory of biodiversity, but rather a survey of forest composition. One goal of this research was to integrate the natural and social sciences approaches into a single rapid assessment. This study will provide the motivation for an in-depth examination of the hydrological buffering capacity of central Benin's sacred forests.

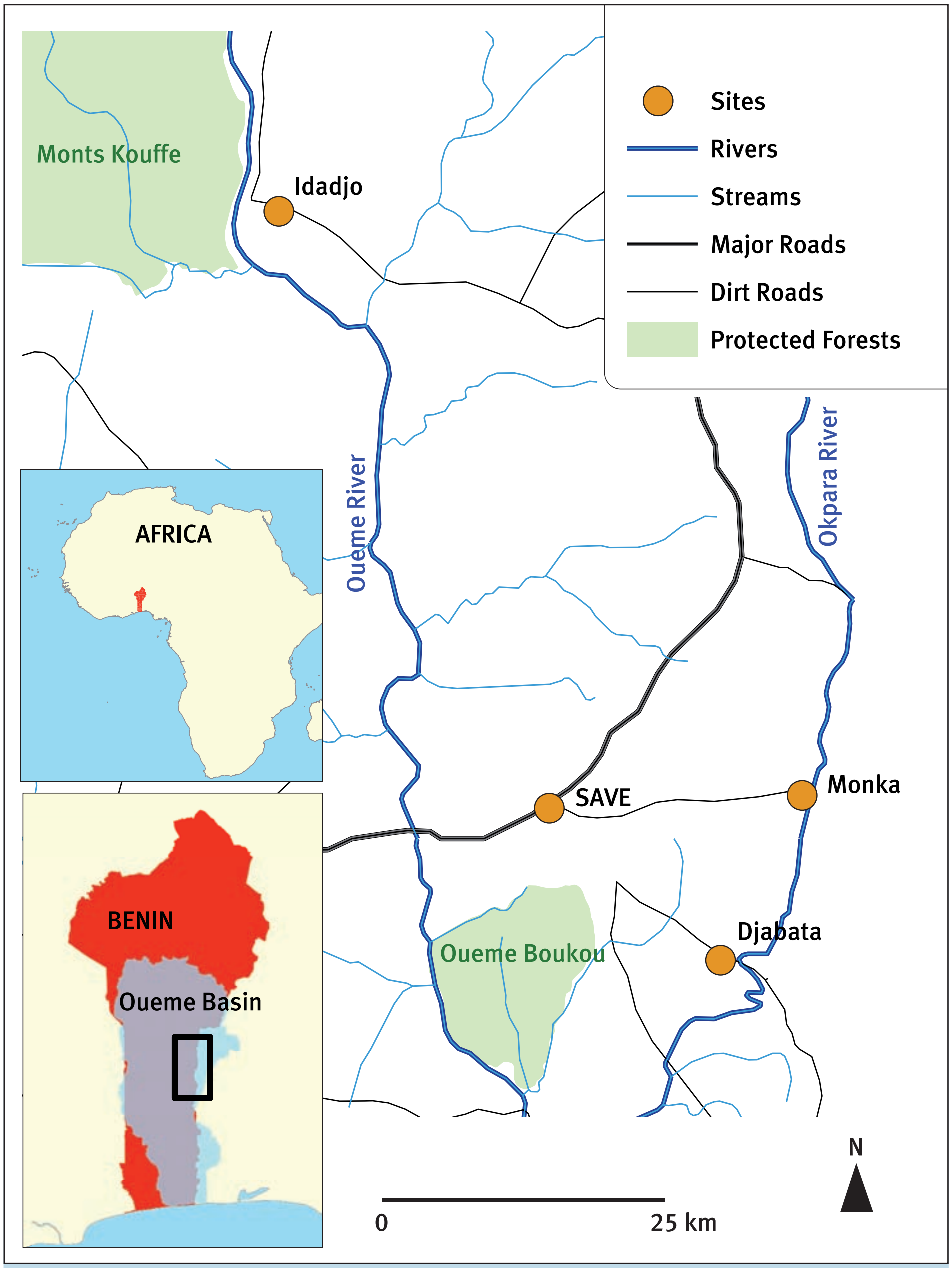

Figure 1.
Map of study area in the Republic of Benin showing the three sites and the regional capital.

Methods

Site Description

The study was conducted near three villages in the Oueme Basin in Central Benin: Idadjo, Monka, and Djabata, chosen because of their shared ecology and culture, and the presence of significant riparian forest and sacred sites. The Oueme Basin covers 59,500 km², the majority of which is in Benin (83 %), but the Basin is also shared with Togo (1 %) and Nigeria (16 %) (International River Basins of the World, 2002). The Oueme River stretches 523 km running in a general North to South direction and discharges into Lake Nokoué, a coastal lagoon in Cotonou before emptying into the Atlantic Ocean (Unesco, 2004; Bain, 2001). The central Oueme Basin is in the Sudano-Guinean transition zone receiving 1,100-1,200 mm in annual precipitation during two rainy seasons that peak in June and September (Adomou, 2005). The Oueme Basin is mostly composed of red, sandy-argillaceous, tropical ferruginous soil. Historically, the Oueme River was used to trade palm oil and slaves at the time of early contact with Europeans (Bain, 2001). Today, river traffic is limited to canoes and small craft for crossing, fishing and travel to neighbouring villages. However the river still is economically active for trade with Nigeria (Flynn, 1997).

Idadjo is located along the Oueme River, 72 km Northwest of Savé (figure 1). Opposite the village is the State "*Forêt des Monts Kouffé*", managed by the *Projet d'Aménagement des Massifs Forestiers* (PAMF). Monka is on the border of Benin and Nigeria, on the Okpara River, 23 km east of Savé. Monka has similar vegetation to Idadjo, although it is further south (Adomou, 2005). Djabata was chosen as the third site because it is more isolated than the other two. It is along the Okpara River, south of Monka and can only be reached by a narrow, frequently flooded path from Savé, or by overgrown footpaths from Monka and Igboja. Speakers of the Nagot or Tchabe dialects of Yoruba are the main residents of all three sites.

Rapid Forest Assessment

In each of the three villages, riparian forests along a gradient of human use were surveyed. Adjacent land use was used to classify human uses into three categories (from less to more intensive): sacred, village uses, and agricultural. Sacred includes riparian forest in areas immediately adjacent to sacred pools in the river, as well as dry-land forest maintained for spiritual reasons. Sites of general village use were adjacent to fire-maintained savanna with an abundance of human trails or other signs of use including fishing, herding and gathering of medicinal plants. Agricultural land had active farming of millet, corn, yam, vegetables, and groundnuts, or the first year of fallow.

A total of 152 transects of approximately 25 metres each were laid perpendicular to the channel from the river to the adjacent savannah (figure 2). At least 10 transects were adjacent to each of the three land use classes as defined above: sacred sites, village used lands, and agricultural lands (table I). Transects were spaced semi-randomly 50–100 m apart as determined by a random number generator. The large number of transects compensated for the wide variation in the vegetation. Natta (2003) characterized riparian buffers as having three zones according to their distance from the river – immediately adjacent to the river (RS), in the middle of the buffer (MS) and on the edge next to the savanna (ES). All trees and lianas with a diameter at breast height greater than 10 centimetres in three circular plots with a 4m radius, placed regularly along the transect to be representative of vegetation in the 3 zones, were measured and identified by species. Lianas were included because they contribute significantly to the woody vegetative mass in riparian forests and fulfil important ecological, hydrological and social roles. Herbarium samples of all tree species were taken for identification at the National Herbarium of Benin.

Analysis of Vegetation Characteristics

Tree species were categorized based on their life form and endemic zone (Adomou, 2005; Akoegninou *et al.*, 2006). Life forms of heights greater than 30 m, 8-30 m and 2-8 m were divided into mega-, meso-, and micro-phanerophytes, respectively. Liana species were considered a separate category and were summed to include all lengths and heights. Endemic zones were specified as Sudanian, Sudanian-Guinean, Guinean-Congolese, Sudanian-Zambezian, Tropical African, PanTropical, and PaleoTropical, which correspond, respectively, to plants of the dry savannas found throughout northern Benin, those present in the northern border areas of the dense Guinean forest, those present on the southern border areas of

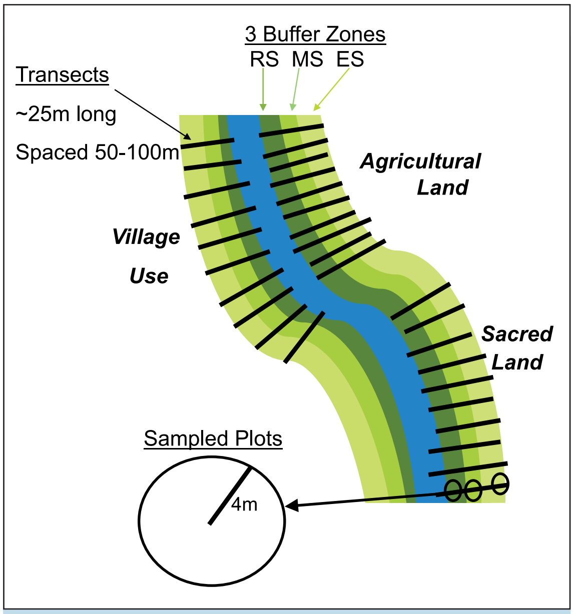

Figure 2.
Sampling design repeated in each of 3 sites. Plots were replicated on the Riverside (RS), Middle (MS), and Edge (ES) of each transect. Transects ran adjacent to agricultural land, sacred forests and/or pools, and to areas with signs of heavy human traffic for burning, hunting, and plant gathering for example. At each plot, all trees with a diameter at breast height (dbh) of 10 cm or more were measured by dbh and identified by species. The centre line represents the river, bordered on either side by the three layers of buffer vegetation. The dark lines running perpendicular to the river represent the transects. Inside the plot (magnified circle to the left) are circles with small circles representing the species of woody vegetation that were sampled.

Table I.
Distribution of transects surveyed, by land use type and village.

Plots	Djabata	Idadjo	Monka
Agricultural	7	8	3
Village Use	40	34	32
Sacred	10	1	17

the dense Guinean forest, species widely distributed across tropical Africa, species distributed across the tropics, and species of ancient origin (White, 1983).

Importance values were calculated separately for all species for each adjacent land use classification and site, by taking an average of the relative density (number of trees per hectare over total density), relative frequency (number of plots containing species over total number of

Table II.
Demographic breakdown of interview subjects by gender, age, profession, ethnic group, and birthplace.

	N	Gender		Age		Profession				Ethnic group			Birthplace		
		Men	Women	Min	Max	Farmer	NR expl	Commercial	Other (low expl)	Nagot	Fulani	Other	Village	Nearby (< 100 km)	Distant (> 100 km)
Idadjo	31	27	4	30	120	29	0	2	2	30	1	0	28	1	2
Djabata	32	22	10	22	100	18	5	6	4	31	1	0	25	4	3
Monka	39	31	8	22	80	21	10	6	7	36	1	2	29	4	6

Table III.
Importance values (IV) of tree species pooled by habitat, life form and endemic zone.
Bold face shows importance values greater than 15.

		IV by land use intensity (%)			IV by site (%)		
		Agricultural	Village Use	Sacred	Djabata	Idadjo	Monka
Habitat	Dry	6.58	9.28	16.00	14.75	6.86	6.18
	Moist	3.04	7.49	0.95	6.80	7.37	5.32
	Riparian	90.38	83.23	82.67	78.45	85.78	88.50
Life Form	Megaphanerophyte (>30 m)	2.70	6.07	4.38	6.20	8.32	3.72
	Mesophanerophyte (8-30 m)	44.30	41.46	43.50	47.23	32.69	44.37
	Microphanerophyte (2-8 m)	45.76	47.16	46.49	39.80	53.42	48.40
	Liana (all lengths)	4.91	3.36	3.75	3.83	2.86	3.51
Endemic Zone	Sudanian	0.98	4.61	0.48	4.08	2.75	2.72
	Sudan-Guinean	22.96	26.03	32.03	31.25	22.78	26.99
	Guinean-Congolese	42.81	27.12	34.05	34.17	20.85	28.16
	Sudanian Zambezian	23.68	35.44	30.11	24.35	42.45	38.42
	Tropical African	1.42	1.36	2.33	2.02	3.23	0.00
	Pan Tropical	0.00	5.16	0.46	4.13	6.08	3.72
	Paleo Tropical	8.15	0.29	0.52	0.00	1.86	0.00

plots) and relative dominance (basal area of the species over total basal area). Diversity was calculated using species richness (R) divided by the area sampled. Species richness was compared between sites using the Jacquard index of similarity (*J*)

J=a+b+c

where *a* is the number of species in common between two plots being compared, *b* is the number of species present in the first but absent in the second plot, and *c* is the number of species present in the second but absent in the first plot (Magurran, 1988).

Statistical Analysis

The data from measurements of all vegetation variables for the three plots along each transect were pooled so that the transect samples included vegetation from the three zones (savanna edge, middle, and river side) and all replications. A two-way analysis of variance (ANOVA) was used to compare the effects of adjacent land use (sacred, village used, agricultural), and site (Idadjo, Monka, and Djabata) on the average buffer width, overall vegetation density, basal area, and species richness.

Ethnographic Surveys

In each site, at least 30 interviews based on a questionnaire were completed concerning cultural values of riparian forests, sacred sites along the river, land use practices and ethnobotanical uses of riparian forest. Interviewees included men, women, experts (such as village chiefs, hunters, and healers), long-term village residents and some recent immigrants (table II). Interviewees were selected semi-randomly by walking through the village and identifying different families and neighborhoods (Cunningham, 2001). Responses to interviews were used to perform a principal component analysis characterizing differences between the villagers' perceived values and uses of riparian forests, sacred areas and the species within them.

Results

Tree Species Composition

In total, fifty-four species were found from twenty-six different families (appendix 1). *Pterocarpus santalinoides* had the highest importance values (IV), with IV of 18-34 % in all sites except for the sacred forests, where *Cola laurifolia* had a higher IV, and in agricultural lands, where *Cynometra megalophylla* had the highest IV, although these IVs were relatively low. The majority of species were micro- or mesophanerophytes (2-10 m in height) typical of riparian habitats, and were from the Guinean-Congolese, Sudanian-Guinean or Sudanian-Zambezian endemic zones (table III). In riparian buffers adjacent to sacred forests, species preferring dry areas had a higher IV than they did in other sites, but these were still low compared to the riparian species. Sacred forests had significantly more Sudanian-Guinean species ($p < 0.05$) than other sites (table III).

Vegetation Structure and Diversity

Riparian forests adjacent to agricultural lands and to sacred forests had a more even tree diameter distribution, and those adjacent to village lands were the most evenly distributed (figure 3). ANOVA revealed that village use had a significant effect on buffer width and density (figure 4). Idadjo has the densest and widest riparian forests. Finally, sacred forests seem to have a higher level of tree species richness. The Jacquard index of similarity shows that diversity varies more by site than by land use, and that Monka and Djabata differ more from one another than either from Idadjo (table IV).

Ethnographic Survey

Hunting was the most valued use of the riparian forest, followed by soil richness for farming, collecting medicinal plants and a variety of plants unique to the riparian forest and fish-

Photograph 3.
Hunting Association & Chief at Monka in front of a sacred tree.
Photograph N. Ceperley.

Photograph 4.
Main Okpara river crossing point to Nigeria, at Monka.
Photograph N. Ceperley.

Table IV.
Jacquard index of similarity for the 3 sites and 3 land use classes.

	Djabata	Idadjo		Agricultural	Village
Monka	0.32	0.41	Sacred	0.50	0.49
Idadjo	0.41	-	Village	0.43	-

ing (table V, photograph 3). A total of 89 % of the respondents agreed that riparian forests were important sacred sites. A large number of respondents agreed to some of the less obvious but important benefits of the riparian forest as well, for example that it preserves water quality, prevents droughts and floods and contributes to climate regulation (rain and temperature). Respondents mentioned other benefits and uses of riparian forests including timber, windbreak functions and the importance of its river for transporting goods to Nigeria (in Monka, photograph 4).

The principal component analysis of the responses to our questionnaire regarding the importance of the riparian forests separates the two villages along two axes (figure 5). We grouped the values of the riparian forest into those concerning resource use, those revealing a sacred value and those concerning ecological functions. The first component primarily divides Idadjo from Monka. Residents of Monka value the ecological benefits of the riparian forests, particularly erosion control, fire break function, drought buffering and flood protection, in addition to the abstract notion of the sacred, whereas residents of Idadjo value many of the exploitative uses, particularly herding, hunting and medicinal plants, as well as rainfall and water quality regulation, and the diversity of vegeta-

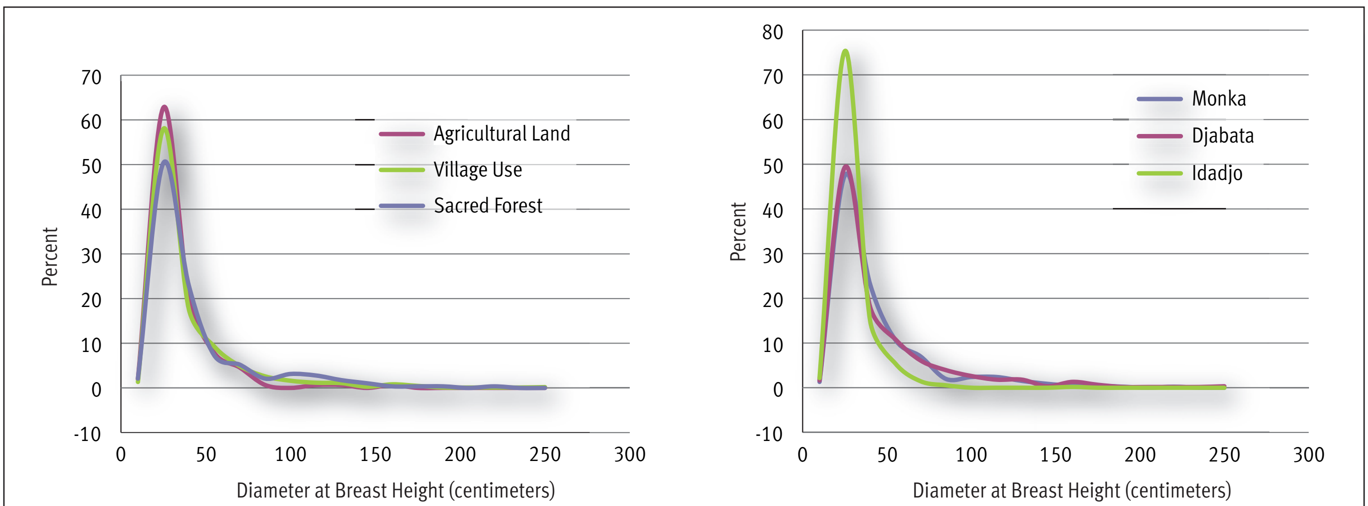

Figure 3.
Normal fit of the histogram of the dbh measurements across the 3 land use classes (left) and the 3 sites (right).

Table V.
Perceived importance of riparian forests in the 3 sites.

		Idadjo	Djabata	Monka	Total
	N	31	32	39	102
Ecological benefits	Diversity of vegetation	87	50	77	73
	Drought prevention	55	50	87	67
	Regulation of rain	84	16	90	66
	Maintaining water quality	77	22	85	64
	Erosion control	55	34	79	59
	Flood prevention	52	34	82	59
	Fire break	52	16	67	47
Exploitative uses	Hunting	97	84	95	94
	Soil fertility	97	97	82	93
	Medicinal plants	87	56	85	78
	Fishing	74	63	77	73
	Herding	87	38	67	65
Sacred use	Sacred sites	58	44	82	64
	Total sites	6	41	23	70
	Average sites mentioned	3	5	3	4
	St. dev. sites mentioned	1	7	3	4
	Max sites mentioned	5	41	14	41

Photograph 5a.
Dikotcha Sacred Point on the Okpara River at Djabata, which people cannot reach.
Photograph N. Ceperley.

Photograph 5b.
The sacred pool at Idadjo where the water is reportedly of immeasurable depths and no fish poisons are permitted.
Photograph N. Ceperley.

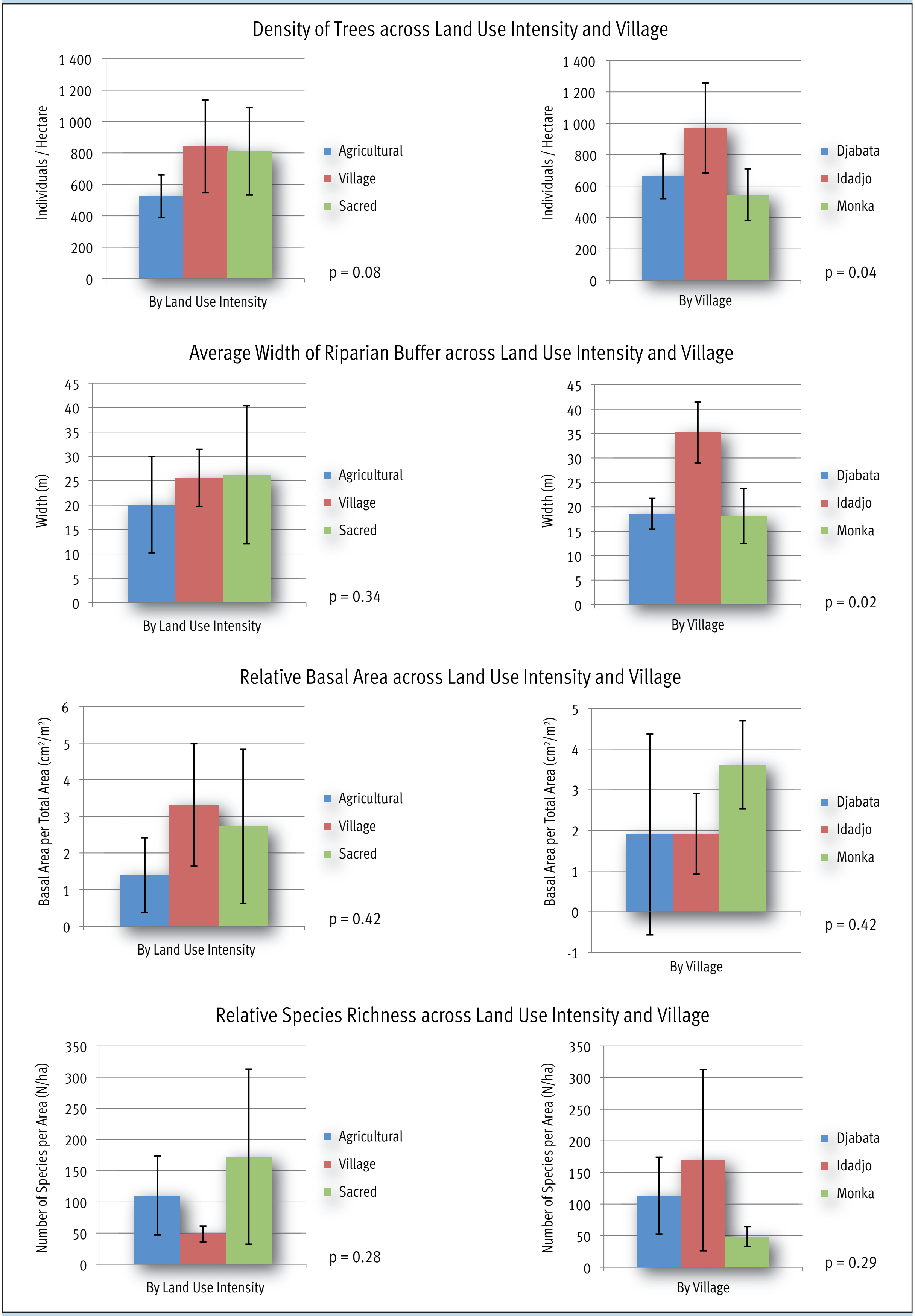

Figure 4.
Comparison of structural characteristics across 3 land use classes (left) and 3 sites (right). The bar shows the mean with a 95 % confidence interval around the mean. P-values of p ‹ 005 significance are shown on the graphs.

Table VI.
List of Sacred Sites in each village.

Sacred sites mentioned by multiple informants by research site (Mentioned by % respondents)		
Djabata (24)	Monka (23)	Idadjo (6)
Okpara (72)	Ojutu (82)	Kunfa (100)
Dikotcha (69)	Asoukou (79)	Atcha (90)
Ojubo (59)	Igbo (28)	Alo (84)
Omiboubou (53)	Agemo (10)	Wasa (29)
Yakpa (31)	Awoni (10)	Ooaa (10)
Ojule (19)	Akpamanzin (10)	Atena (3)
Ega (16)	Apasi (8)	
Oloukeou (13)	Obu (8)	
Agbo (9)	Gbegbe (5)	
Ainfa (6)	Amosi (5)	
Agbale (6)	Sokpo (5)	
Akpans.oya (6)	Omi Kotu (3)	
Otere (6)	Agemo 2 (3)	
Omodueko (6)	Atchibwin (3)	
Ububagi (3)	Oyin (3)	
Gogo (3)	Fimon (3)	
Atchin (3)	Aka (3)	
Omiouya (3)	Ilelaku (3)	
Oniyii (3)	Awa (3)	
Tchoungbe (3)	Koko (3)	
Omoduegu (3)	Adjinki (3)	
Atouyaya (3)	Igbola (3)	
Afaimon (3)	Agbo (3)	
Otchess (3)		

tion. The second component separates Djabata from the other two sites, as more sacred sites were mentioned in Djabata. Soil fertility is more valued in Djabata and Idadjo.

Residents of Djabata named between 2 and 41 sacred sites, Monka between 0 and 14 sacred sites, and Idadjo between 1 and 5 sacred sites (table VI). Knowledge of rules surrounding the sacred sites, the rituals associated with the sites, the location of the sites, and the individuals responsible for each site was greater in Djabata than in Monka and Idadjo. The sacred pools occurred in spiritual sites that combine one or more of the following characteristics: deep water, gurgling sounds, good fishing, occurrence of a historical event, or an outstanding landscape feature such as a suspended rock (photograph 5). Pools were believed to be home to spirits, and community members believed that upsetting them could have direct consequences for them, including floods, drought, disease and infertility. Most were surrounded by taboos ranging from the manner one must behave or dress near the fetish to specific rules regarding what one can or cannot do.

Village elders believe that people can make requests to the spirit, for example to improve business, conceive a child, or bring a good harvest. There is usually an elder who is responsible for organizing the sacrifices and communicating with each particular spirit (photograph 6). Sacred trees are actively maintained and may be replaced if the wind destroys them, in order to preserve the means of communication with the spiritual world (photograph 7). Ethnobotanical knowledge of plants and their names also varied between the three sites (appendix 2). Uses varied between ritual and supernatural uses, such as carving of symbolic twin statues (photograph 8) to very practical uses such as attaching roofing thatch. Medicinal uses dominated the reported values of most species.

Environmental change was described both specifically and generally. Small trees have grown larger and there is less rain and more drought. Changes are attributed to the increasing population and the diminishing respect for sacred sites, and to developments, such as hand pumps, which separate people from the landscape. The river used to be cleaner and had more water. Pollution in the water was overwhelmingly blamed on the arrival of cattle and their herders in the last 10-20 years, who degrade the banks and destroy riparian vegetation, burn, spread invasive species, and scare away wild animals – as confirmed in Monka by the royal registry – driven to the area by conflicts and shortages of pasture elsewhere (photograph 9). Other migrants contribute to the riparian degradation by farming land by the river granted to them by the king.

Discussion

Riparian forest structure and diversity

In 40 phytosociological plots, Natta (2003) found the forest near Idadjo to contain 183-195 tree species at a density of 748-785 trees per hectare, with a diameter at breast height (dbh) strictly above 10 cm, a basal area of 45.6 m^2 per hectare (± 15.8) and a width of 41.12 m (± 19.5). This study shows 48 species near Idadjo, much less than the number found by Natta (2003), although our site had similar density (1,050 trees/ha) and similar basal area (44.29 m^2/ha). Idadjo also contained the most tropical generalist species and riparian-specialists, suggesting that its forest was more controlled by hydrology because of a history of more severe floods (Naiman *et al.*, 2005).

The lower diversity compared with previous studies can be attributed in part to errors inherent to our rapid assessment method. However, our method did capture the structure of the riparian buffer, which is a more important factor determining riparian forests in flood buffering. Our method is therefore adequate for evaluating the structure of riparian buffers, but not for species diversity.

Idadjo also had a diameter class distribution dominated by small trees, which could be explained by the recent conservation initiatives that have resulted in a decrease in the use of fire and tree cutting, and have therefore stimulated natural tree regeneration and sprouting from certain species such as *Pterocarpus santalinoïdes*, *Cola laurifolia*, *Cynometra megalophylla*, and *Syzygium guineense*. In contrast, riparian forests in Djabata had the largest diameter trees and were the most species diverse. Djabata's forests may be the oldest, and provide some flood buffering, but Idadjo's forests were the densest and widest. Thus Djabata and Idadjo's riparian forests are better than Monka's for flood buffering.

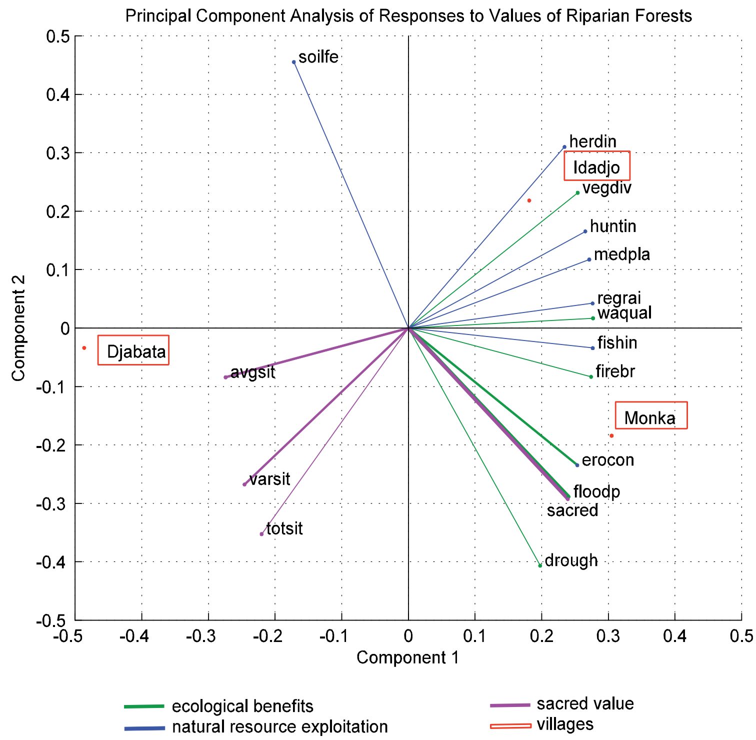

Figure 5.
Principal component analysis of responses to ranking of values of riparian forests. The components are shown on the two axes. Values are grouped into ecological benefits (in green: vegetation diversity, regulation of rain, water quality, fire breaks, flood control, drought prevention, erosion control), benefits arising from natural resource exploitation (in blue: herding, hunting, medicinal plants, fishing, soil fertility), and sacred values (in purple: sacred sites, total sites, variation of sites, average sites).

Comparison of environmental management in three villages with contrasting perceptions of the importance of sacred and riparian forest

Those three study sites represent three different trajectories of environmental management; traditionally-led, externally-led and economically-led. This was evident from results of the principal component analysis. The traditional knowledge system, reflected in knowledge of sacred sites, was strongest in Djabata, compared to Monka and Idadjo, which are much more accessible from large cities and thus experience more cultural change. The population of Idadjo, in contrast to Djabata, has maintained botanical knowledge but without much of a connection to sacred sites. This is a reflection of conservation driven by an external organization, PAMF. Monka's position on the main Nigerian transport route makes it more accessible to economic activities, resulting in lower levels of traditional and botanical knowledge among its people.

Photograph 6.
The King of Djabata.
Photograph N. Ceperley.

In all three sites, taboos were identified that specifically addressed the need to conserve riparian forests. However, these cultural and spiritual motivations for conservation need to stand up to the economic and demographic changes that are driving land use change. Major drivers of change in riparian vegetation include the expansion of agricultural fields adjacent to riparian forest, timber harvests and cattle grazing. Migrants who come from northern Benin to farm in the central Oueme Basin are responsible for the majority of agricultural expansion. The village king designates land far from the village for their use, often in the more fragile but more fertile floodplain. Valuable species such as *Ceiba pentandra*, *Diospyros mespiliformis* and the vulnerable *Khaya senegalensis*, and *Albizia ferruginea* are harvested for timber to be sold elsewhere in the region by outsiders who pay a nominal fee to the local king. But perhaps the most severe threat to the landscape and to water quality, especially from local communities, is cattle grazing, which has increased in the last decade as Fulani herders have been driven into the area by regional droughts (Basset, Turner, 2007).

Comparison with sacred areas found in other African countries

The Tchabe Kingdom lies in the centre of the Oueme River Basin. The legends of the origin of this Kingdom and the communities that comprise it are many, but some tell of people emerging from the waters of the Oueme and Okpara rivers. Even those who say that the people arrived overland refer to historical events around specific places in the river, which may be "*Ibu odo*", i.e., sacred pools or points in the river. These sacred pools are subject to rules that may influence conservation practices, including the prohibition of fish poison use, overfishing, polluting the site and discouragement of nearby cattle grazing. Respected not only by resident populations but also by migrants to the area, these sacred sites are valuable for riparian forest and water conservation. Yoruba religious beliefs and practices in general influence natural resource management (Adekunle, 2005) and sacred forests among the Yoruba throughout Benin and Nigeria reinforce community cohesion (Ojo, 1967). Similar to the description by Garcia *et al.* (2006), there are taboos and rules governing the use of natural resources in these sacred sites; however, the sacred forests that we identified in central Benin were not isolated islands, nor is it likely that they are residual elements of an earlier landscape. The local communities largely take responsibility for land use, apart from a few state-protected forests. This has the disadvantage that there is a lack of overarching vision and understanding for land use and water management across the entire basin, often a necessity for effective management (Dudgeon, 2000). Local control is advantageous because it allows for more local innovation and freedom, and the knowledge of West African farmers should not be underestimated (Richards, 1985).

Photograph 7.
Sacred site at Monka where a blown-down tree was replanted.
Photograph N. Ceperley.

Photograph 8.
Twin boy, with twin statue made from odo wood (*Diospyros mespiliformis*).
Photograph N. Ceperley.

Across Africa, sacred forests are important for conservation and some are also valued for their ecosystem functions. The sacred forest of Nyangkpe on the border of Nigeria and Cameroon has survived because of a strict initiation process that gives value to the forest by persuading initiates that maintaining this patch of forest amidst the pressures of agricultural expansion is crucial because of its spiritual, ancestral and magical worth. The result is that these forests harbour the largest and rarest trees in the region (Komanda *et al.*, 2003). Rain-shrine communities in Tongo in present-day Zambia found shrines around sites where it was forbidden to dig roots, cut wood, or burn because of the power they held over rainfall (Lebbie, Freudenberger, 1996). Kikuyu forests on mountain ridges in Kenya were conserved for generations before the government turned them into plantations. The ecological and climatological services of these forests were clear to both local people and scientists, who witnessed dramatic changes in local rainfall, infiltration, and erosion when they were destroyed. Researchers have argued that Poro forests in Sierra Leone should not only be incorporated into institutional co-management agreements but also expanded (Lebbie, Freudenberger, 1996).

The matrix of marshes, riverbeds and dry lands and, correspondingly, forests and savannas in central Benin has allowed for a diversity of crops and livelihoods such as fishing and hunting, and has sheltered immigrants fleeing from enemies. Yoruba migrants came to this region in search of safety that they found in the rugged terrain, hills and marshes (Adediran, 1994). The kingdom of Tchabe was a pre-colonial state, separate from both the Oyan State to the east and the Kingdom of Dahomey to the west, which were both powerful at the time of European contact. Most interestingly, there is evidence that the people of Djabata, along with those of Savé and Kabua, left their homeland, the Egbado regions of central Yorubaland, in the 15th and 16th centuries, perhaps when the Oyo state was raiding its neighbours in the early 16th century, and were later conquered by the first king of Savé. Similarly, Idadjo was founded at the time of the wars as a hiding place that brought people from different parts together.

Conclusion

Residents of Idadjo, Djabata, and Monka almost universally agreed that in recent years, the exploitation of both animal and forest resources had gone beyond a reasonable level. They warned that if exploitation was not controlled, it was likely to deplete them entirely.

The maintenance of *Ibu odo*, sacred points respected by Tchabe communities along the Oueme and Okpara Rivers, tends to conserve riparian forest structure and diversity. *Ibu odo* are governed by rules that influence conservation practices, including the prohibition of fish poison use, overfishing, pollution and the discouragement of grazing cattle, and which are respected not only by locals but also by migrants to the area.

When combined with the social assessment of the importance of sacred pools, this study offers an argument for respecting and reinforcing the conservation of sacred forests. Encouraging respect for sacred sites is particularly crucial among younger generations and migrants to the area. A dense and diverse riparian area will lessen the regional severity of droughts and floods. Incorporating sacred sites into a long-lasting local conservation strategy could be instrumental in conserving the important riparian forest and hence the watershed.

From the results of our study, it is not clear which land use is optimal for flood buffering, as each of the buffers studied have attributes that provide some flood buffering potential. However, those results suggest that the landscape produced by traditional beliefs and conservation programs both function, although differently, as a way of preserving riparian forests from economic drivers of forest change in the Oueme Basin. Although we did not find the sacred forest to have better riparian buffers than those in other lands used by humans, the sacred forests are riparian areas that can add to the existing buffer zones.

Photograph 9.
Fulani cattle along the riverbank, Monka.
Photograph N. Ceperley.

Future work should focus on understanding the specific cattle–induced changes in the last decade, define and map the successional stages of riparian forests in this region and quantify the ecosystem services, specifically the buffering potential, offered by each stage of forest succession. Social studies need to access the traditional cosmologies and ethics that result in greater respect for riparian buffers and the river. These need to be compared with the beliefs of the migrant groups. Future studies should also assess the conservation potential of these forests by determining the percentage of riparian forest which is sacred and its abundance throughout the country.

By working with local groups, specific beliefs and values can be emphasized in future government-led conservation that can result in efforts that strengthen, instead of erasing, the local knowledge systems. When this collaboration is done well, the forests as well as the culture will remain for generations to come.

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Appendix 1.
List of all identified species with their importance values (IV). Botanical family, life form (LF), endemic zone (EZ), and habitat (H) are also given. Life forms are grouped as megaphanerophyte (mega, > 30 m), mesophanerophyte (meso, 8-10m), microphanerophytes (micro, 2-8m), and lianas (li-). Nanophanerophytes (0.5-2m) are not included in the analysis. The classification is derived from: RAUNKAIER (1934), SCHNELL (1971), KEAY & HEPPER (1954-1972), KEAY *et al.* (1964), ARBONNIER (2004), and AKOEGNINOU *et al.* (2006). Endemic zones are grouped as Sudanian (S), Sudanian Guinean (SG), Guinean-Congolese (GC), Sudanian Zambezian (SZ), Tropical African (TA), PanTropical (Pt), and PaleoTropical (Pal). Habitats are grouped as riparian specific (R), preferring moist soil (M), or preferring dry land (D). "." Indicates the species was not found in that site or land-use class. Boldface indicates IV > 15.

Scientific name	Family	IV by Land Use Class (%)			IV by Site (%)			LF	EZ	H
		Agricult.	Heavy Use	Sacred	Djabata	Idadjo	Monka			
Acacia sieberiana	Fabaceae	.	0.15	.	.	0.32	.	meso	SZ	R
Alafia benthamii	Apocynaceae	2.95	2.07	3.75	3.14	0.12	3.51	li - meso	GC	R
Albizia ferruginea	Fabaceae	.	0.14	0.08	.	.	0.35	meso	GC	D
Albizia glaberrima	Fabaceae	.	0.55	.	0.33	0.83	.	micro	GC	D
Anogeissus leiocarpa	Combretaceae	.	1.5	0.48	0.7	1.24	1.61	meso	S	M
Antidesma venosum	Euphorbiaceae	0.92	3.27	0.95	4.98	0.71	0.89	micro	SG	R
Aphania senegalensis	Sapindaceae	0.94	1.51	.	2.63	0.12	.	micro	SG	R
Cassipourea congoense	Rhizophoraceae	0.89	1.72	4.09	0.52	1.3	4.71	meso	SG	R
Ceiba pentandra	Bombacaceae	.	5.16	0.46	4.13	6.08	3.72	mega	Pt	M
Celtis zenkeri	Celtidaceae	.	0.15	2.93	1.38	0.35	.	mega	GC	D
Cola laurifolia	Sterculiaceae	9.16	14.34	11.55	15.41	14.17	13.8	meso	SG	R
Cola millenii	Sterculiaceae	.	0.16	.	.	0.33	.	micro	GC	R
Crateva adansonii	Capparaceae	8.15	0.29	0.52	.	1.86	.	micro	Pal	R
Cynometra megalophylla	Fabaceae	13.05	11.33	14.08	13.71	8.42	12.35	meso	GC	R
Daniellia oliveri	Fabaceae	0.88	.	.	0.22	.	.	meso	SZ	D
Dialium guineense	Fabaceae	10.14	5.62	10.75	6.64	1.68	10.37	meso	GC	R
Diospyros mespiliformis	Ebenaceae	8	3.69	4.93	4.47	4.26	4.52	meso	SZ	R
Diospyros monbuttensis	Ebenaceae	.	0.42	.	0.67	0	.	micro	GC	R
Drypetes floribunda	Euphorbiaceae	10.73	0.14	.	.	4.26	.	micro	GC	R
Ekebergia capensis	Meliaceae	.	0.75	1.17	0.45	0.3	1.38	meso	SZ	D
Elaeis guineensis	Arecaceae	1.04	0.26	.	0.6	.	.	meso	GC	M
Ficus ovata	Moraceae	.	2.15	.	2.77	0.12	.	micro	GC	D
Ficus sycomorus.subsp. gnaphalocarpa.	Moraceae	.	0.15	.	.	.	0.32	micro	SZ	R
Ficus vallis-choudae	Moraceae	.	0.15	.	0.24	.	.	micro	SZ	D
Flacourtia flavescens	Flacourtiaceae	0.89	.	.	.	0.3	.	micro	GC	D
Holarrhena floribunda	Apocynaceae	0.88	1.47	4.13	1.33	0.52	4.06	meso	SG	R
Kigelia africana	Bignoniaceae	1.91	.	0.47	0.22	0.42	.	meso	SG	R
Lannea barteri	Anacardiaceae	.	0.28	.	.	0.6	.	meso	S	D
Lannea nigritana	Anacardiaceae	0.98	2.24	.	3.38	0.61	.	meso	S	D
Lecaniodiscus cupanioides	Sapindaceae	.	0.49	1.3	.	0.32	1.58	micro	GC	D
Lonchocarpus sericeus	Fabaceae	1.34	0.14	0.56	.	0.72	0.36	meso	SG	R
Malacantha alnifolia	Sapotaceae	.	.	0.46	.	0.89	.	micro	At	D
Manilkara multinervis	Sapotaceae	0.89	1.45	3.96	4.03	0.55	.	meso	SG	D
Milletia thonningii	Fabaceae	.	0.35	.	.	1.06	.	meso	GC	D
Mimusops kummel	Sapotaceae	.	0.28	0.02	0.46	0.02	.	micro	SZ	R
Mitragyna inermis	Rubiaceae	.	0.45	.	.	.	1.11	meso	S	R
Morelia senegalensis	Rubiaceae	0.1	0.15	.	.	0.32	.	micro	SG	R
Motandra guineensis	Apocynaceae	0.87	0.59	.	.	1.54	.	li - meso	SG	R
Napoleonaea vogelii	Lecythidaceae	.	0.84	0.7	1.66	0.09	.	micro	GC	R
Oncoba spinosa	Flacourtiaceae	.	.	0.47	0.22	0	.	micro	SZ	D
Pancovia bijuga	Sapindaceae	0.95	.	.	.	0.3	.	micro	GC	R
Parinari congensis	Chrysobalanaceae	2.7	0.76	0.99	0.69	1.89	.	mega	SG	R
Piliostigma thonningii	Fabaceae	.	0.14	0.46	0.22	0.3	.	micro	SG	D
Premna angolensis	Verbenaceae	.	0.15	.	.	0.32	.	li - micro	GC	D
Pterocarpus santalinoides	Fabaceae	8.8	29.6	18.2	18.08	34.32	28.76	meso	SZ	R
Strychnos nigritana	Loganaceae	.	0.42	.	.	1.19	.	li - meso	GC	R
Synsepalum brevipes	Sapotaceae	1.06	1.17	0.46	1.67	1.1	.	meso	GC	R
Syzygium guineensis	Myrtaceae	1.42	1.36	1.87	2.02	2.34	.	meso	At	R
Tricalysia okelensis	Rubiaceae	0.88	0	4.44	0.23	0	2.87	micro	SZ	D
Uvaria chamae	Annonaceae	1.09	0.14	.	0.46	.	.	li-micro	GC	M
Vitellaria paradoxa	Sapotaceae	.	0.14	.	.	0.3	.	meso	S	D
Vitex chrysocarpa	Verbenaceae	5.13	0.65	0.89	.	3.22	0.57	micro	SZ	R
Xylopia parviflora	Annonaceae	0.3	0.48	3.77	0.17	0.22	3.17	meso	SG	R
Zanthoxylum xanthoxyloides	Rutaceae	2.06	.	1.1	1.05	.	.	meso	SG	D

Appendix 2.
Local names and uses of species found in riparian forests. $ indicates that more than 15 % of respondents considered this an income generating tree (14). This is not an exhaustive list of uses, but rather a sampling of most common responses.

Scientific name	Local names (Idadjo, Monka, Djabata)	Uses
Acacia sieberiana	(igi ede)	tooth & mouth pain, malaria
Alafia benthamii	(efou adja, itacoun, pakuko, kpakoukou)	roofing, ropes, houses
Albizia ferruginea	(ayore dudu,)	$, construction, food
Albizia glaberrima	(ayoyi, ayoé, ayowe)	construction
Anogeissus leiocarpa	(igi agni, igi agni, igi agni, ayín)	$, soap, construction, malaria, children, toothpicks
Annona senegalensis	(embo, ambo)	magic, snakes, bees, soap, pimples, mouth pain, malaria, food
Antidesma venosum	(oadu, migniro,)	mouth pain, children, toothpicks
Aphania senegalensis	(ayinka)	soap, malaria, children
Blighia sapida	(oosín)	$, food, in sauces
Borassus aethiopum	(agbon egede, agonte)	$, construction, food
Cassipourea congoense	(oko si ni igbo, igon awodudu, ijoko aya funfun)	construction, malaria
Ceiba pentandra	(agù, aba, rini, araba, aaba)	$, construction, sauces, boats
Celtis zenkeri	(igi upín, upen,)	magic
Cola laurifolia	(ofakí, afakí, afakí)	$ roofs, bows & arrows, construction
Cola millenii	(igi allassa)	construction, pirogue
Crateva adansonii	(ose odo)	yams, magic, malaria, child, sauce
Cynometra megalophylla	(guimguimdo, igi agé, binbindu, kèga, agè, agé dudu)	food
Daniellia oliveri	(ooya)	$, construction, malaria
Dialium guineense	(mososo, djetin ndoe, agé funfun)	malaria, food
Diospyros mespiliformis	(igin, igi odu, igi odu)	$, construction, food
Diospyros monbuttensis	(igi wowo)	construction, firewood
Drypetes floribunda	(gongo igbo, ,)	malaria, children, food
Ekebergia capensis	(igi iyeye igbo, iyeye, iyéyé)	malaria, food
Elaeis guineensis	(ope)	$, soap, alcohol, brooms, oil
Ficus ovate	(upin odo)	magic, drum
Ficus sycomorous subsp. gnaphalocarpa	(opolipo, igi akpolikpo)	magic, food
Ficus vallis-choudae	(igi okpota, opoto, upín odé)	magic, firewood
Flacourtia flavescens	(opoto)	magic, malaria, children
Holarrhena floribunda	(koloo, seunseun, igi igbo, sanka, igi ire, ié iyé)	$, construction, hats, swellings
Khaya senegalensis	(igi igbo, sanka)	pimples, mouth pain, antibiotic, construction, sauce
Kigelia africana	(agin ho, aikpe)	magic, stomach, yams, malaria, children
Lannea barteri	(pando, pando, mouyin)	mouth, children
Lannea nigritana	(akù)	$, sauce, food
Lecaniodiscus cupanioides	(aponpon, orobedje ketou)	malaria, firewood
Lonchocarpus sericeus	(wáwá igbo, oosi igbo or oochin igbo,)	laxative, sauce
Malacantha alnifolia	(apapo, apapo,)	construction
Manilkara multinervis	(igi aka)	construction
Millettia thonningii	(emindo, emedo, thehagigi)	handles (gun, machetes, hoe)
Mimusops kummel	(igi itó)	diarrhea, children, firewood
Mitragyna inermis	(kankansa, kakanja)	malaria, children
Morelia senegalensis	(aíkpon)	bows & arrows, malaria
Motandra guineensis	(agbasa abo)	$, roofs, malaria
Oncoba spinosa	(antohín igbo)	construction
Pancovia bijuga	(-)	bows & arrows,
Parinari congensis	(kinda)	children, toothpicks
Piliostigma thonningii	(igi igonowo)	children, toothpicks
Premna angolensis	(iyáfo odo, akopa, tchowowoko, igi omi)	pimples, malaria
Pterocarpus santalinoides	(panumu, , panumu)	malaria, food
Salacia longipes	(igi amòn)	$, hunt
Strychnos nigritana	(ofefedù, sessédo, sesedo)	magic, malaria, children
Synsepalum brevipes	(igon awo funfun,)	construction
Syzygium guineensis	(ogbon)	malaria, toothbrush
Tricalysia okelensis	(emedò, , igi agingin)	$, magic, craziness
Uvaria chamae	(sasa boto, aíkpon odo, sansamboto)	$, soap, swellings, pain, pimples, malaria, construction
Vitex chrysocarpa	(igi iagaga)	roofs
Vitex doniana	(aounju)	malaria, children, sauce, food
Xylopia parviflora	(aime)	hunting
Zanthoxylum xanthoxyloides	(igi iyáwo marunun, aíkpon omi,)	stamps, toothpicks

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