Ecology of the Réserve Sylvo-Pastorale de Mbégué and cutting rates in its recently cleared Western half.

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Introduction

Incremental, almost imperceptable, change characterizes the process of desertification in the Senegal Sahel. Since 1960, mean rainfall has fallen at a rate of only 4 mm per year (Shaikh *et al.* 1988). Forested savanna decreases at a rate of only 1% per year (MDR 1982). Desertification in the Sahel starts on the scale of hectare-size pockets, not thousand-hectare tracts (NRC 1984).

This slow deliberate pace speeded up abruptly on April 28, 1991. For on that day, the Khalife-Général of the Mouride Islamic brotherhood called his followers to clear the 45 000 ha western half of the Forêt Classée de Mbégué for this season's peanut planting. Three weekends later, the zealous followers completed the task, leaving behind exposed tracts of sand and stumps.

After the fact, Eaux et Forêts officials stated that they had signed an agricultural contract with the Khalife and prepared a plan for a model agro-sylvo-pastoral project. Moreover, although people still commonly referred to the area as a forêt classée, the government had changed its status to Réserve Sylvo-Pastorale since 1952. This paper briefly describes the ecology of the area, analyzes field measurements of cutting rates, and compares Eaux et Forêts claims with the reality actually observed in the field.

Figure 1 shows the location of the Réserve Sylvo-Pastorale de Mbégue, commonly referred to as 'Khelkom'.

Ecology of the Forest

The area lies in the Sahelo-Sudanian bioclimatic zone, as defined by Aubreville (1950). Two ecosystems dominate: dry wooded savanna and dry stream beds. Table 1 lists the species observed within the cleared area. Interestingly, a comparison with the species composition of the Department of Mbacké (Table 2.), which lies just to the west of the forest, reveals that most of the species which have disappeared from Mbacké due to Mouride land expansion since 1912 are still found in Mbégué. The mean rainfall at Kaël, 20 km west of the forest, was 445 mm ± 124 mm for 1981-1990, down from 700 mm in the 1950s.

Over 14 000 ha of the forest lie in the floodplains of two dry branches, Diabel and Araldé, of the River Sine. The Sine today runs from Mayekor in the Region of Fatick to its confluence with the River Saloum at Foundioune. As recently as the 1920s, villagers report that the river extended upstream as far as Kaël in the Department of Mbacké. Today the Diabel and Araldé consist merely of dry stream beds up to 50 meters wide and 10 m lower in elevation than the upland plains. During the rainy season, small ponds form along their courses. In the dry season, the phreatic water table rests only 5 m from the surface.

The vegetation forms almost closed thickets arranged in three strata: trees at 3 m, shrubs at 1.5 m, and a herbaceous layer at ground level. Field data show an average of 35 trees of 100 mm diameter or greater per hectare. The soil dég dominates in the valleys. It is a vertisol, hydromorphic, with a substantial clay fraction in the first 20 cm, revealed by its sharp fissuring upon drying.

The remaining 31 000 ha consist of dry upland savanna undulated by the Harmattan wind into slight rills oriented NE-SW. During the rainy season, small ponds form in some low-lying depressions occasionally found between the rills. The soil joor dominates on these upland plains. It is an entisol characterized by low CEC, low field capacity, and a sand fraction of over 90% in all horizons. Joor consists of loose sand down to 30 cm, where a harder packed sand horizon begins.

Large tree species such as *Annogeissus leiocarpus* and *Cordyla pinnata* are found singly, gathering in small groves only in the low-lying depressions. Field data show an average of 10 trees of diameter 100 mm or greater per hectare. By far, the shrub *Guiera senegalensis* dominates the upland savanna, sometimes attaining heights of 2 m. Each root crown may send up as many as 10 trunks. Field data show an average of 150 shrubs of less than 100 mm diameter per hectare. In the Peanut Basin of Western Senegal, farmers use the shrub as their primary source of firewood. Farmers will customarily cut off all above-ground parts as they clear fields from March to May. An extensive root system insures regeneration of these parts, to be cut the following year.

The fauna of the forest includes the red monkey, skunk, hedgehog, rabbits, a variety of lizards, the Guinea Hen, and over 10 other bird species.

Before the clearing of the Western half, Peul herders used the area as pasture for large herds of cattle, sheep, and goats. The government had established a forage and watering station in the very heart of the forest at Khelkom. Other important watering points for the Western half include wells in the villages of Mbégué, Darou Salam Boki, Bondié, and Diabel outside the forest (Figure 2). Although no measurements of primary productivity have been taken, overgrazing only appears to occur adjacent to these watering points and along the main path for herds from the West to the forage of Khelkom. Herds have not yet subjected the rest of the forest to overgrazing.

Farmers from the four towns listed above cultivate a small area within the forest and extract a modest amount of firewood. Peul herders also harvest a limited amount of firewood and polewood. Deadwood is not plentiful; data collected show one dead tree per two hectares in the upland savannas.

Cutting Rates

On May 9 and June 9, 1991 the author surveyed seven one-hectare samples dispersed through the forest as shown in Figure 3. The author selected the sites at random on a map, placing dots in seven of the fifteen marabout concessions, and determined site locations relative to known landmarks. After locating a site in the field, the author established 500 m x 20 m plots oriented N-S when arriving from the South or E-W when arriving from the East or West. He collected the following data:

- numbers of trees and shrubs cut and diameters at ground level
- numbers of trees and shrubs alive and diameters at ground level
- number of trees dead before the cut
- species represented among cut trees and shrubs
- species represented among live trees and shrubs
- ecosystem type.

Table 3 shows this field data. For *Guiera senegalensis*, several trunks originating from one root crown were counted as one. The author did not identify the species of each individual cut, but instead recorded which species were represented.

Results

By any measure, the Mourides cut a significant fraction of the woody vegetation. Figure 4 shows a range of 88-99% of the trees cut at the 7 cutting survey sites. Figures 5 shows that the Mourides cut 96% of the trees and shrubs, over all diameter classes and sites. Even excluding the smallest diameter class (< 50 mm), comprised mainly of self-regenerating *G. senegalensis*, the Mourides cut over 94%. Still, because many workers removed even the *G. senegalensis* root crowns, a large proportion will not regenerate. Finally, Figure 6 estimates the total cut in the entire reserve at over 5 million trees and shrubs.

The Mourides cut irrespective of species, even felling such rare and highy valuable trees as Senegal Ebony (*Dalbergia melanoxylon*) and Kapok (*Bombax costatum*), as noted in Table 3. The author observed examples of all species listed in Table 1 cut, with the sole exception of the Baobab (*Adansonia digitata*). This is all the more surprising because the Wolof ethnic group to which most Mourides belong treasure a myriad of species for their wood, fiber, food, and medicinale values (Pousset 1989, von Maydell 1983).

The Mourides did not respect conditions which Eaux et Forêts promulgated to restrict environmental damage. Eaux et Forêts demanded that workers leave at east 20 trees per hectare. Figure 6 shows that they left an average of 4 trees per hectare at savanna sites, 7 per hectare at valley sites. Eaux et Forêts had even stipulated that no cutting take place in the valley areas. Furthermore, although plans called for 50 m hedgerows around each of the 15 marabout concessions, the author noted no hedgerows during 3 separate trips through all 15 concessions.

Environmental Effects

The adverse effects which follow any clearcutting of a wooded area have begun to manifest themselves at Khelkom. These include:

- increased soil erosion by wind and water
- decrease in soil organic matter and base nutrients
- decrease in potential primary productivity

- lower agricultural productivity than under wooded conditions
- disappearance of valuable tree species.

By converting the area from pasture to peanut cultivation, the Mourides have also put in place a system which will produce the following effects in the long term:

- overgrazing of the Eastern half of the forest
- further disruption of soil structure by tree stump removal
- increased risk of brush fires set as farmers burn their fields to clear weeds
- destruction of soil structure from tractors, commonly used by Mouride marabouts
- replacement of valuable herbaceous species such as *Aristida stipoides* by trash species such as burrs (*Cenchrus biflorus*) favored by infertile soils.
- increased tree felling in the Peanut Basin as farmers return home 'fired up' by the activity at Khelkom
- susceptibility and disrespect of remaining Forêts Classées and Réserves Sylvo-Pastorales.

Conclusion

The field data indicate that, under any criteria, the Mourides have drastically decreased the woody vegetative cover in an ecosystem already rendered precarious by decades of decreasing rainfall and increasing aridity. This paper has only treated the ecological dimension of the Khelkom issue in order to complement other work on the politics, sociology, economics, and land tenure aspects.

Yet, years of field experience in Senegal combined with with supplemental information can offer tentative answers to the question 'Why did the Mourides do this?'

1. Need for new agricultural land. In order to fulfil their food security needs as well as maintain peanut revenues to support a lifestyle marked by terraced villas and Mercedes Benz, Mouride marabouts must continually expand their land holdings. Table 4 presents an balance sheet between agricultural production and food needs for the Department of Mbacké, home of the Mouride brotherhood.

The clearing of Khelkom follows exactly the Mouride system of agricultural production described by Cruise O'Brien (1971). After setting a claim on a tract of uncultivated wooded land, a marabout sends his disciples to clear it. The disciples set up a camp (daara in Wolof), working, learning religious chants, and living under difficult conditions. After clearing the woody vegetation and planting peanuts for a couple years, the disciples' families arrive and establish a regular village. In this way, the Mourides established 325 of the 340 villages in the Department of Mbacké as well as the 150 000 person city of Touba.

2. Immediate revenues from wood product sales. Soon after the clearing began, tractors started plying the streets of the Mouride capital Touba selling firewood. Large stacks over 20 m in height

were a common sight. Returning workers also sold poles and roots. People needed money to buy peanut seeds for this year's planting.

3. History of declassifying national forest lands. In 1962 and 1969, the government declassified 27 000 ha of the Forêt Classée de Déali for the Mourides. In 1957, the government declassified for the Mourides the only Forêt Classée in the Department of Mbacké, itself only classified 9 years earlier.

4. Political vote haggling. Ironically, the April 8, 1991 widening of the already advanced state of democracy in Senegal only encourages acts of political favoratism. The Mouride brotherhood consists of a bloc of perhaps 1 million votes out of 2 million voters. During the one-party period of the 1970s, the government refused the Mourides' request for Khelkom several times. The current situation harks back to the overt political maneuvering during the democracy of the 1960s, described by Cruise O'Brien (1971).

During the clearing of Khelkom, the government even brought in all its support services, including water trucks, paramedics, and police. The government is also digging 3 deep-bore wells in the area using government funds (see Figure 3).

5. Ineptitude of Eaux et Forêts. Eaux et Forêts officials privately admit that the Mourides entered and cleared the forest before signing any agricultural contract. In a after-the fact attempt at damage control, officials hastily drafted the plan reconstructed in Figure 3. This demonstrates the impotence of Eaux et Forêts and its inability to effectively manage the country's natural resources.

6. Mouride attitude of total submission. Mouride disciples revere their marabouts to the point of submission and unquestioning obeiance to marabout commands (Diop 1981, Diouf 1990). This facilitated the mobilization of tens of thousands of disciples for the clearing of Khelkom, accomplished at a rate of 2 000 ha per day.

7. Assertion of Mouride uniqueness. A tendancy to draw attention to itself in large activities characterizes the brotherhood. Recently, Senegal's other four Islamic brotherhoods as well as a majority of the Arab world observed the fast of Ramadan from March 17 to April 14, while the Mourides decided to start the fast one day later and end it one day later.

8. Tax benefit for the government. May 28, 1991, the Khalife-Général made an unprecedented call to the merchants of Touba to pay the commercial tax and set up a tax collection center at his residence. The government expects a windfall from this, in light of Touba's commercial predominance in the region due to smuggling of merchandise from the Gambia.

Table 1.

Woody species of the Forêt Classée de Mbégué.

Dominant Savanna Species	Wolof names
Anogeissus leiocarpus	ngejan
Balanites ægyptiaca	sump
Guiera senegalensis	nger

Dominant Valley Species	Wolof names
Acacia seyal	surur
Combretum glutinosum	rat
Mitragyna inermis	xos

Other Species Present	Wolof names
Acacia ataxacantha	ded
Acacia macrostachya	sam
Acacia nilotica	neb neb
Acacia raddiana	seng
Acacia senegal	verek
Adansonia digitata	guy
Annona senegalensis	dugor
Balanites ægyptiaca	sump
Bauhinia rufescens	rand
Bombax costatum	garabu lawbe
Boscia angustifolia	nus
Calotropis procera	paftan
Capparis tomentosa	xareñ
Cassia occidentalis	mbanta
Cassia sieberiana	senjen
Combretum aculeatum	sawet
Combretum glutinosum	rat
Combretum micranthum	sexaw
Combretum nigricans	tap
Cordyla pinnata	dimb
Crateva adansonii	kulel
Dalbergia melanoxylon	jalamban
Detarium microcarpum	daank
Dichrostachys cinerea	sinc
Euphorbia balsamifera	salan
Feretia apodanthera	sinceer
Ficus iteophylla	loro
Gardenia erubescens	dibuton
Grewia bicolor	kel
Lannea acida	son
Maytenus senegalensis	ndori
Mitragyna inermis	xos
Piliostigma reticulatum	ngiigiis
Prosopis africana	yir
Pterocarpus erinaceus	wen
Sclerocarya birrea	bér
Securidaca longipedunculata	fuuf
Sterculia setigera	mbép
Tamarindus indica	ndakkar
Terminalia avicennioides	rob rob
Vitex doniana	lëng
Ximenia americana	ngoloñ
Zizyphus mauritiana	sidéem

Table 2.
Flore du Département de Mbacké
Sénégal
1991

Arbres Dominants

Acacia albida	kadd
Anogeissus leiocarpus	ngejan
Balanites ægyptiaca	sump
Guiera senegalensis	nger

Autres Espèces Présentes

Acacia ataxacantha	ded
Acacia macrostachya	sam
Acacia nilotica	neb neb
Acacia raddiana	seng
Acacia senegal	verek
Adansonia digitata	guy
Anacardium occidentale	darkase
Bauhinia rufescens	rand
Borassus æthiopium	ron
Calotropis procera	paftan
Capparis tomentosa	xareñ
Cassia occidentalis	mbanta
Combretum aculeatum	sawet
Combretum glutinosum	rat
Combretum micranthum	sexaw
Cordyla pinnata	dimb
Euphorbia balsamifera	salan
Feretia apodanthera	sinceer
Ficus iteophylla	loro
Gardenia erubescens	dibuton
Hexalobus monopetalus	xasaw
Mangifera indica	màngo
Maytenus senegalensis	ndori
Parinari macrophylla	new
Piliostigma reticulatum	ngiigiis
Prosopis africana	yir
Pterocarpus erinaceus	wen
Scerocarya birrea	bèr
Sterculia setigera	mbép
Tamarindus indica	ndakkar
Terminalia avicennioides	rob rob
Zizyphus mauritiana	sidéem

Arbres des bas-fonds

Acacia seyal	surur
Balanites ægyptiaca	sump
Combretum nigricans	tap
Dichrostachys cinerea	sinc
Mitragyna inermis	xos

Herbes Dominantes

Cenchrus biflorus	xaaxaam
Eragrostis tremula	selguuf

Espèces Disparues

Annona senegalensis	dugor
Bombax costatum	garabu lawbe
Dalbergia melanoxylon	jalamban
Detarium microcarpum	dàank
Diospyros mespiliformis	alom
Ficus platyphylla	mbap
Grewia bicolor	kel
Lannea acida	son
Newbouldia lævis	waswasor
Securidaca longipedunculata	fuuf
Vitex doniana	lëng
Ximenia americana	ngoloñ

Espèces en Diminution

Acacia macrostachya	ded
Acacia seyal	surur
Anacardium occidentale	darkase
Combretum nigricans	tap
Cordyla pinnata	dimb
Mangifera indica	mango
Prosopis africana	yir
Sclerocarya birrea	ber
Sterculia setigera	mbép
Terminalia avicennioides	rob rob

Arbres Plantes ou Régeneres Traditionnelement

Acacia albida	kadd
Adansonia digitata	guy
Borassus æthiopium	ron
Ceiba pentandra	benteñe
Ficus thonningii	dobale

Reboisement depuis 1980

Acacia holosericea	
Acacia linarœdes	
Anacardium occidentale	darkase
Azadirachta indica	niim
Cassia siamea	
Eucalyptus camaludensis	xotti buteel
Leucæna leucocephala	
Moringa oleifera	sop sop
Parkinsonia aculeata	
Prosopis julifora	neb neb tubaab
Phœnix dactylifera	tàndarma

Herbes Disparues

Aristida stipoides	mpal jinax
Cochlospermum tinctorium	feyar

Table 3. Data and Results.

Site	Mbégué			1	Wendou			2	Araldé			3	Diabel S			4	Diabel N.			5	Diabel Va			6	Khelkom S			7	Totals		
tree or shrub diameter ground level	alive	cut	%		live	cut	%		live	cut	%		live	cut	%		live	cut	%		live	cut	%		live	cut	%		live	cut	%
0-50mm	2	201	99		4	103	96		2	4	67		0	84	100		0	82	100		1	7	88		3	73	96		12	554	98
50-100mm	0	14	100		0	39	100		2	30	94		0	36	100		0	28	100		0	4	100		1	65	98		3	216	99
100-200mm	0	3	100		2	4	67		4	37	90		4	19	82.6		1	4	80		1	13	93		0	5	100		12	85	88
200mm+	2	3	60		0	2	100		3	7	70		0	0			0	0			1	5	83		0	0			6	17	74
totals	**4**	**221**	**98**		**6**	**148**	**96**		**11**	**78**	**88**		**4**	**139**	**97.2**		**1**	**114**	**99**		**3**	**29**	**91**		**4**	**143**	**97**		**33**	**872**	**96**
already dead		2				1				0				0				0				6				0				9	
ecosystem		savanna				savanna				valley				savanna				savanna				valley				savanna					
species cut	Cordyla pinnata G. senegalensis				B. ægyptiaca G. senegalens				Acacia senegal Acacia seyal B. ægyptiaca B. costatum S. setigera T. macroptera				Acacia seyal A. leiocarpus G. senegalensis				C. glutinosum G. senegalensis				Acacia raddiana Acacia seyal A. leiocarpus B. ægyptiaca C. glutinosum D. melanoxylon				A. leiocarpus G. senegalensis					
species alive	A. leiocarpus Cordya pinnata G. senegaensis				B. ægyptiaca				Acacia senegal B. angustifoia S. setigera				A. leiocarpus Z. mauritiana				A. leiocarpus				A. leiocarpus G. senegalensis				G. senegalensis					

Table 4.
Agricultural Production and Cereals Requirements
Département de Mbacké, Sénégal
1989

	Area (sq. km)	Population	Density (pers./sq km)	Millet Requirement (1000 kg)	Millet Production (1000 kg)	Rice Requirement (million CFA)	Peanut Production (million CFA)
Ville de Touba	19,80	131 169	6 625	6 558	0	3 542	0
Commune de Mbacke	4,70	32 131	6 836	1 607	0	868	0
Arrondissement de Ndame, Communautés Rurales de:							
Dalla	99,00	5 054	51	758	1 984	68	177
Missirah	135,00	3 552	26	533	2 785	48	259
Nghaye	86,00	3 925	46	589	1 700	53	149
Touba Fall	166,00	4 634	28	695	3 453	63	318
Touba Mosquée	533,20	34 834	65	5 225	11 498	470	1 093
Arrondissement de Kaël Communautés Rurales de:							
Darou Salam Typ	108,25	3 403	31	510	2 168	46	162
Dé N'Déye	91,70	3 318	36	498	2 001	45	153
Kaël	161,20	6 248	39	937	3 278	84	262
Madina	149,50	4 153	28	623	3 026	56	241
Ndioumane	130,72	4 539	35	681	2 835	61	217
Touba Mboul	152,60	3 864	25	580	3 369	52	243
Totals	**1 837,67**	**240 824**		**19 794**	**38 097**	**5 456**	**3 274**

Conclusions

In 1989, millet production met the needs of the population
However, peanut sales did not cover required rice purchases
Therefore, the Mouride population survived on income originating out of the Département.
That year's agricultural production was even above average
Therefore, in order to meet their ever-increasing needs, the Mourides must clear more land

Statistics Sources:

Area	Secteur Agricole de Mbacke
Population	Centres d'Expansion Rurales (CER) at Ndame and Kael
Departmental Agricultural Production	Secteur Agricole de Mbacké
Agr. Production in the Communautes Rurales	Centres d'Expansion Rurales (CER) at Ndame and Kael

Calculation Parameters:

Touba/Mbacke Millet Requirements	50 kg/person/year
Touba/Mbacké Rice Requirements	200 kg/person/year
Millet Requirements in the Communautés Rurales	150 kg/person/year
Rice Requirements in the Communautés Rurales	100 kg/person/year
Price of Rice	135 CFA/kg
Price of Peanuts	70 CFA/kg

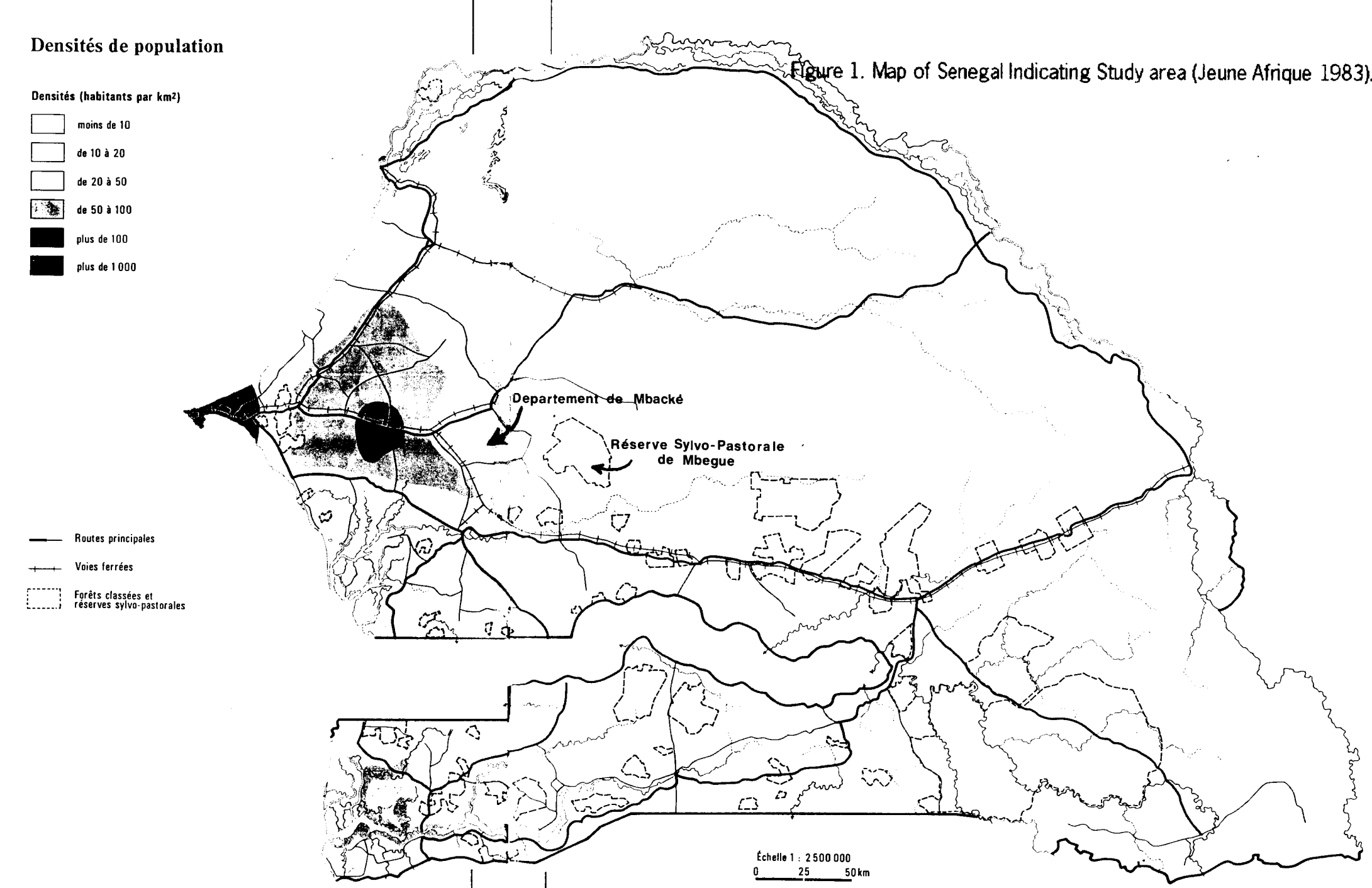


Figure 1. Map of Senegal Indicating Study area (Jeune Afrique 1983).

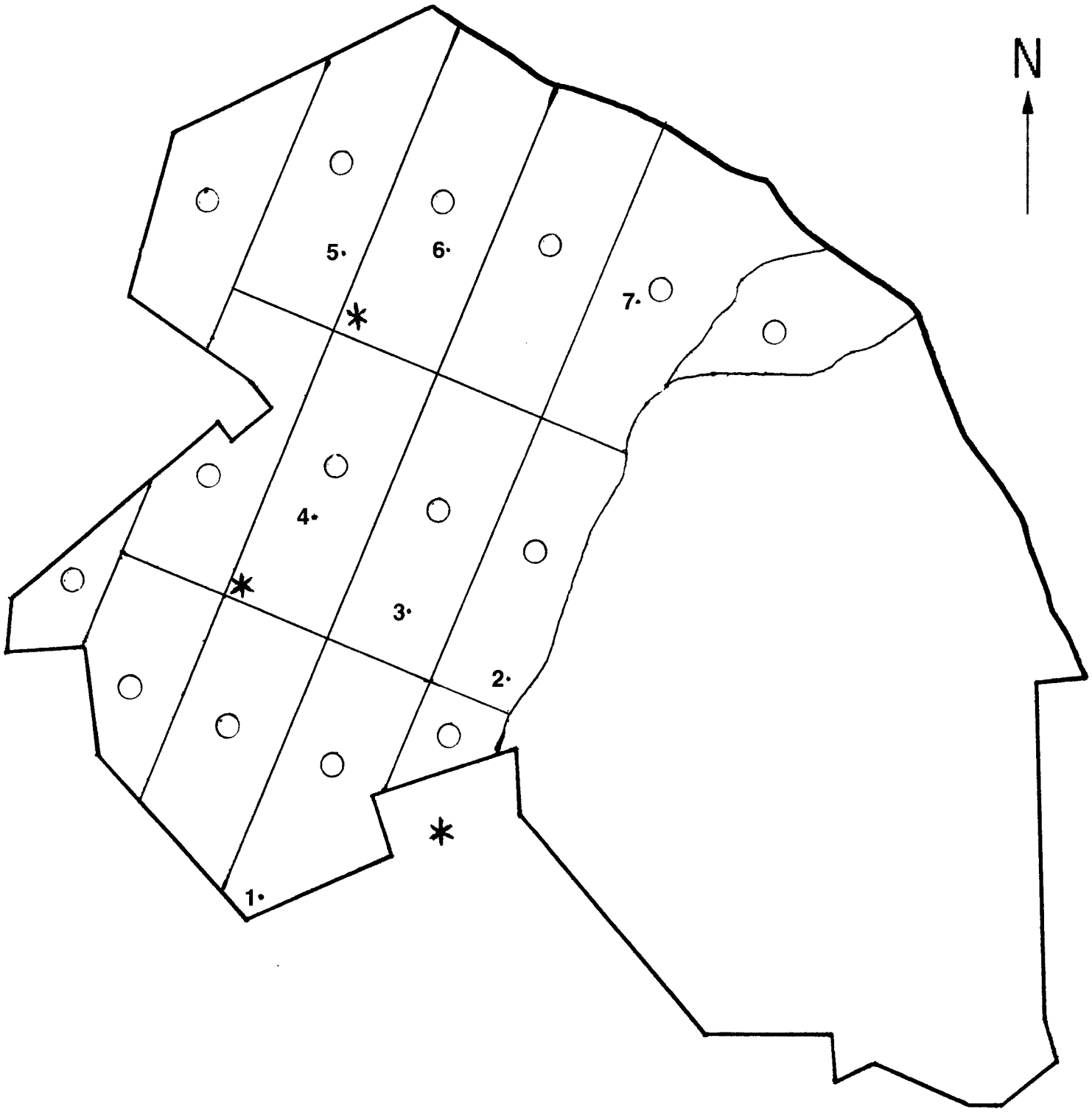


Figure 3. Reconstruction of Eaux et Forêts Plan for Khelkom, from interview with Inspecteur Régional de Kaolack.

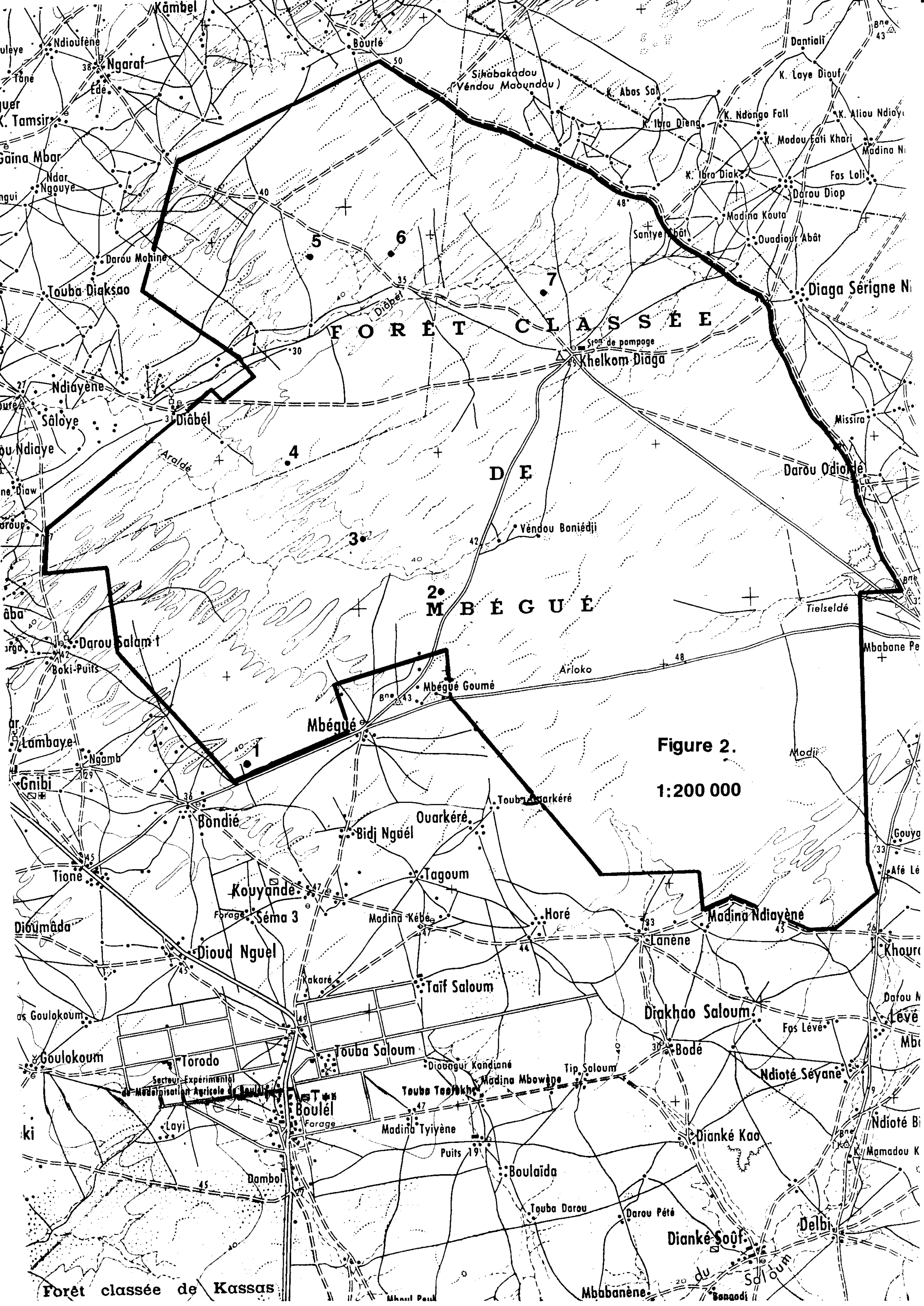


Figure 2.

1:200 000

Fig. 4. Trees and Shrubs Cut, by Site

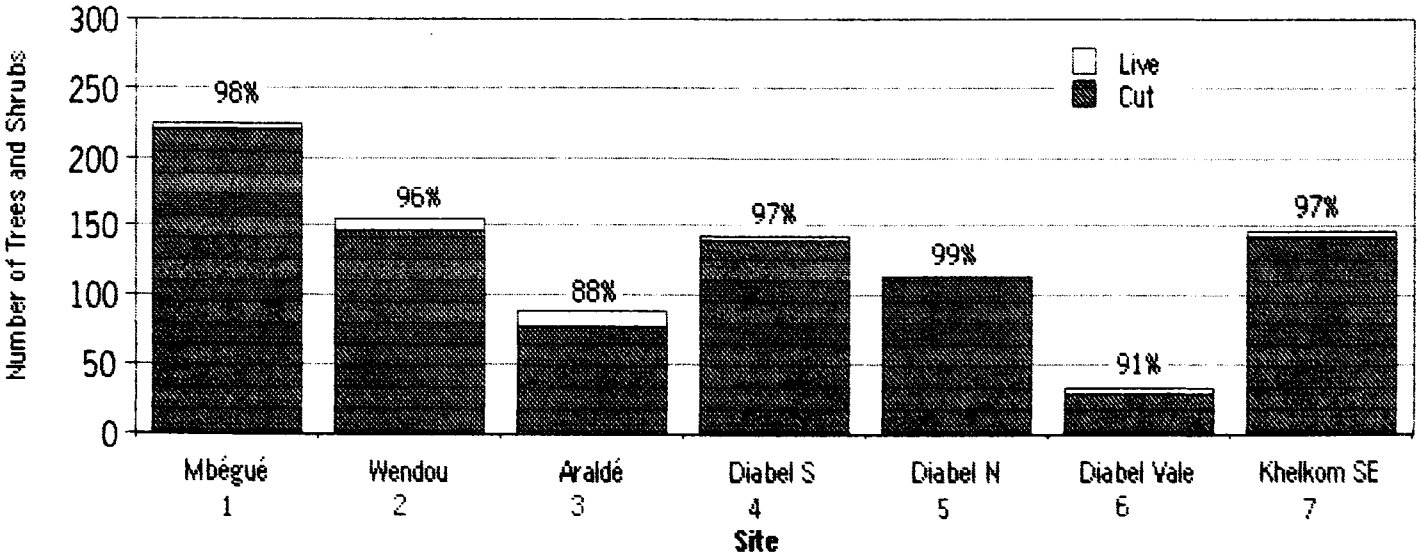


Fig. 5. Trees and Shrubs Cut as percent of Total

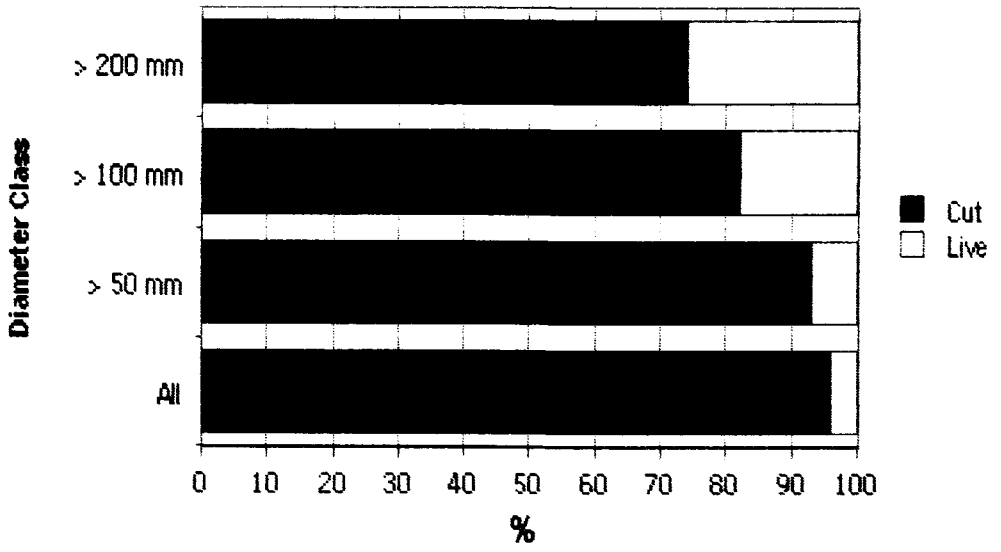
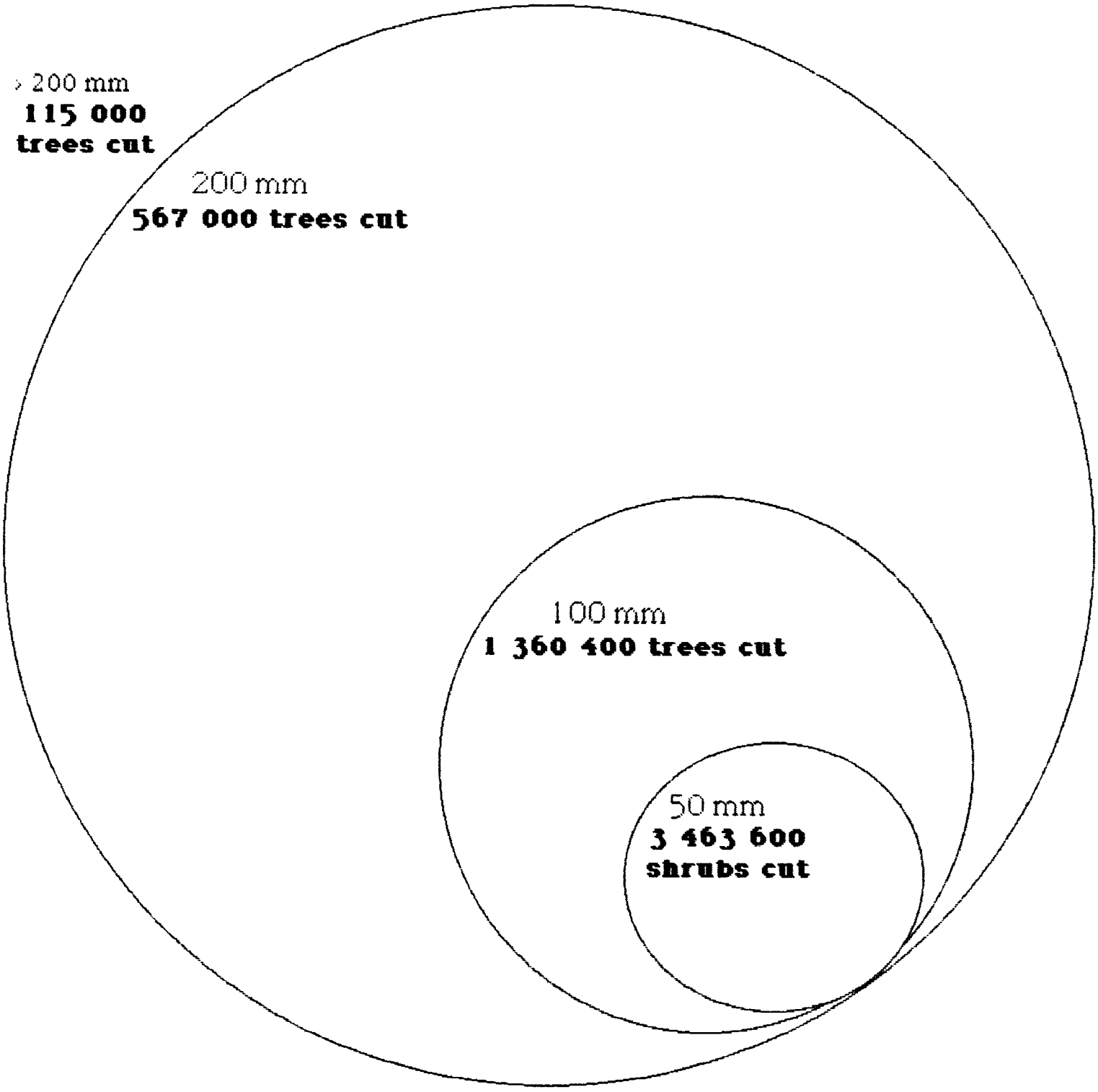


Figure 6. Estimation of total numbers of trees cut.

diameter classes	Savanna 31 000 ha			Valleys 14 000 ha			**Total cut**
	trees/ha		total trees cut	trees/ha		total trees cut	
	before	after		before	after		
0-50 mm	110	1.8	3 366 600	7	1.5	77 000	**3 463 600**
50-100 mm	37	0.2	1 128 400	18	1.0	238 000	**1 360 400**
100-200 mm	8	1.4	217 000	28	2.5	350 000	**567 000**
› 200 mm	1	0.4	31 000	8	2.0	84 000	**115 000**
all			4 743 000			749 000	**5 492 000**



Literature Cited

Aubréville, A. 1950. Flore Forestière Sudano-Guinéene. Réimprimé par COUESNON, Champagne-sur-Seine, France.

Copans, J. 1988. Les Marabouts de l'Arachide. L'Harmattan, Paris, France.

Cruise O'Brian, D. 1971. The Mourides of Sénégal. Oxford University Press, Oxford, United Kingdom.

Diop, Abdoulaye-Bara. 1981. La Societé Wolof. Editions, Karthala, Paris France.

Diouf, M. 1990. Le Kajoor dans le XIX^{e} Siècle. Editions, Karthala, Paris France.

Jeune Afrique. 1983. Atlas du Sénégal, 2^{e} Ed. Editions Jeune Afrique, Paris, France.

Ministère du Développement Rurale (MDR). 1982. Plan Directeur de Développement Forestier. Dakar, Sénégal.

National Research Council (NRC) 1984. Environmental Change in the West African Sahel. National Academy Press, Washington, D.C.

Pousset J.-L. 1989. Plantes Médicinales Africaines. Agence Française de Coopération Culturelle et Technique, Paris, France.

Shaikh, A., E. Arnold, K. Christophersen, R. Hagen, J. Tabor, P. Warshall. 1989. Opportunities for Sustained Development. Successful Natural Resources Management in the Sahel. Club du Sahel RC(89)03, Paris, France.

von Maydell, H.-J. 1983. Arbres et Arbustes du Sahel. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany.