ECOLOGICAL MONITORING PROGRAM

NDOKI-LIKOUALA LANDSCAPE

2006-2007

SUMMARY OF RESULTS

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OVERVIEW OF THE NDOKI-LIKOUALA MONITORING PROGRAM

Prior survey and field research conducted in northern Congo by the Wildlife Conservation Society (WCS) in the late 1980's and early 1990's identified important habitat for key wildlife species, including forest elephants, gorillas and chimpanzees. Subsequent to this WCS, in collaboration with government and international public and private-sector partners, established three major site-based conservation projects in the Ndoki-Likouala landscape, implementing three different, yet integrated, conservation and management strategies across contiguous, but spatially distinct, zones; 1) integral protection of wildlife and their habitat in a core protected area – the Nouabale-Ndoki National Park, 2) community-based conservation and management of wildlife and other natural resources in the Lac Tele Community Reserve, and 3) wildlife management and conservation in the surrounding commercial timber concessions. The result is that a total of 22,354km², or 78% of the entire landscape, is now under improved management. The combined objective of these programs is to conserve target populations of forest elephants, great apes and other key wildlife species and their habitat across the Ndoki-Likouala landscape. The Ndoki-Likouala monitoring program was established with the primary goal of evaluating the impact of our conservation actions in achieving this combined objective, and would accomplish this goal by estimating the density and abundance of a variety of mammal species in survey strata under different management regimes and impacted by varying degrees of human pressure.

Between January and August 2006, field data collection was undertaken for the first phase of the Ndoki-Likouala ecological monitoring program. This first phase of monitoring builds on baseline density estimates for all management strata that were obtained between 2001-2005 during MIKE-CITES surveys (Nouabalé-Ndoki National Park, Mokabi Forestry Management Unit), CIB forestry management surveys (in collaboration with WCS in the Kabo, Pokola, Loundougou and Toukoulaka Forestry Management Units), and WCS surveys (Lac Tele Community Reserve and Bailly swamps). The specific objectives of the landscape monitoring program are as follows:

1. Provide punctual information on trends in the abundance and distribution of elephants and great apes in the Ndoki Likouala Landscape

2. Provide punctual information on the trends in abundance indices of other large mammals, including bongo and buffalo in the Ndoki-Likouala Landscape

3. Provide punctual information on the presence and distribution of human activities, including poaching, in the Ndoki Likouala Landscape.

A total of ten survey teams were trained and equipped for the inventories and deployed across a total of 2.8 million hectares of contiguous forest that includes two protected areas, community-use areas and

commercial timber production forest. Management regimes in these forests range from integral protection (Nouabalé-Ndoki National Park), community-based natural resource management (Lac Tele Community Reserve), multiple-use forests managed for sustainable wildlife harvesting and commercial timber exploitation (CIB forestry concessions), and, in the case of Mokabi commercial timber exploitation with no formal wildlife or forestry management strategy associated. The Bailly swamps currently has no conferred land use status or management strategy, and represents a potentially important ecological corridor for elephants between the Likouala swamps and the *terra firme* forests to the west **(see Figure 1 and Table I).**

The surveys used standard line transect – recce methodology modified from the CITES-MIKE surveys in 2003-2004 **(see Table 2 and Figure 2).** Line transect distance sampling was used to estimate densities of great apes (gorillas and chimpanzees) and elephants using nest and dung counts respectively. Sampling effort represented a balance between the ability to detect change over time and the logistical, financial and personnel constraints imposed by such a large-scale program. We assumed a maximum coefficient of variation of 25% for elephant and great ape (combined) density estimates. All transects were 2km in length and the number of transects within each stratum varied between 15 and 24, giving a total transect length of 336 km across the landscape. Transects were connected by travel 'recces', which were used to collect data on the presence and distribution of illegal human activities. Full details of the study design and methodology are presented in the final report (Stokes 2007).

In total, 329.72km of line transect were completed across 166 transects. In between transects a total of 2,313.9 km of reconnaissance walks were completed. Spatial coverage of the zone by field teams, collected through field survey GPS tracklog itineraries is illustrated in **Figure 4.**

Preliminary analyses of line-transect data were completed during a 3-week workshop held in Bomassa, Nouabalé-Ndoki National Park in October 2006. This workshop included WCS field survey team leaders, MEFE conservators from the Nouabalé-Ndoki National Park and Lac Tele Community Reserve, and a representative from CNIAF (Centre Nationale des Inventaires d'Aménagement Faunique et Floristique). Full details of analytical methods used and results of spatial and statistical analyses are presented in the final report (Stokes 2007).

We present here a summary of the main results as follows: density estimates for elephants and apes in each of the seven management intervention zones **(Table III and IV)** and by habitat type **(Table V and VI).** We also present encounter rates of human sign from transects (**Table VII**) and encounter rates of other large mammals and duikers from transects (**Table VIII**). Data from travel recce walks on elephant and great ape carcasses (poaching and otherwise) and all camps (recces and transects) are presented in **Figure 5.** Distribution maps of elephants, gorillas, chimpanzees, human sign, buffalo, bongo, sitatunga and red river hog are presented in **Figure 6 - 14.**

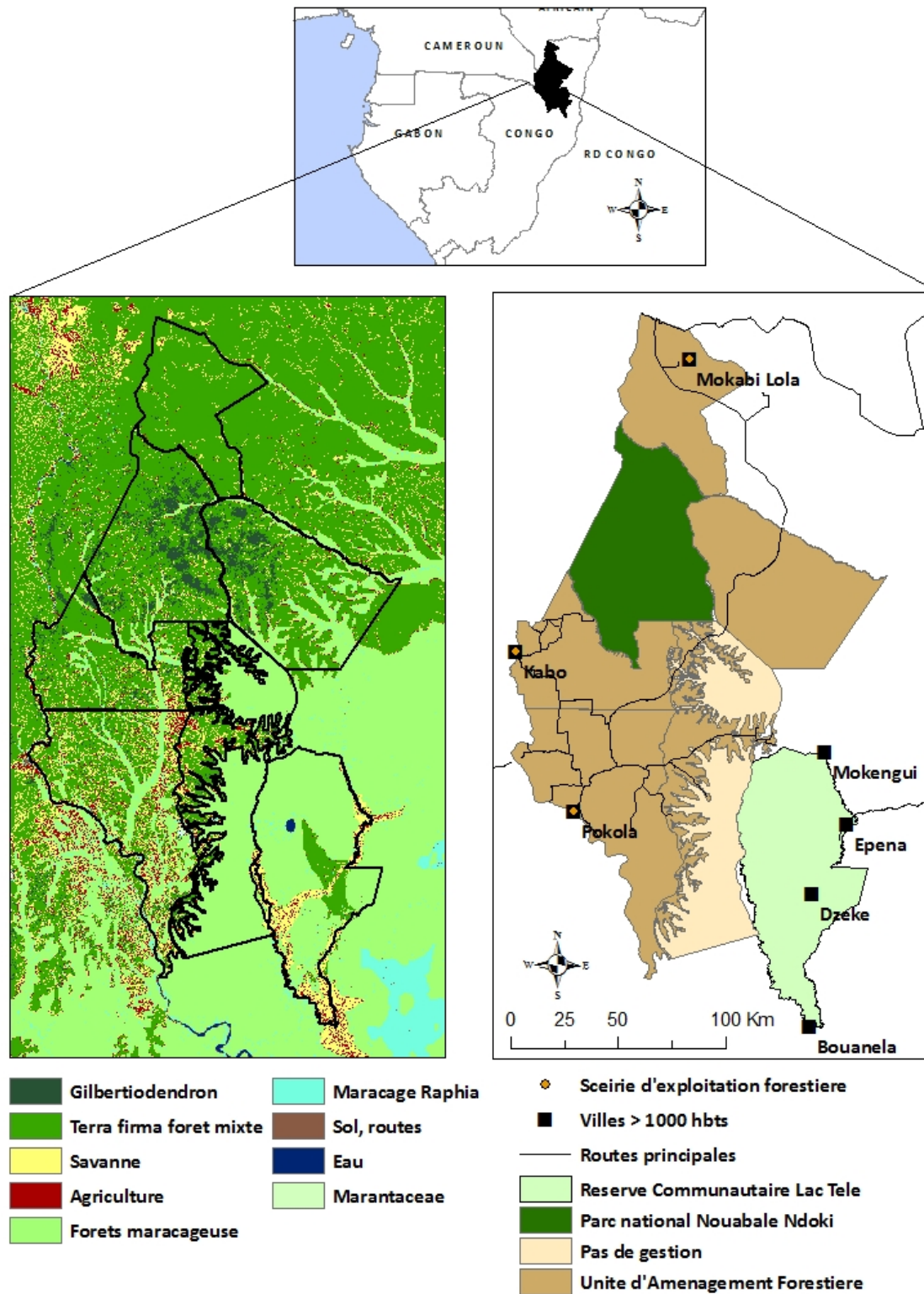**Figure 1. Presentation of landscape: major vegetation types and land use**

■ Gilbertiodendron	■ Maracage Raphia	◆ Sceirie d'exploitation forestiere	
■ Terra firma foret mixte	■ Sol, routes	■ Villes > 1000 hbts	
■ Savanne	■ Eau	— Routes principales	
■ Agriculture	■ Marantaceae	■ Reserve Communautaire Lac Tele	
■ Forets maracageuse		■ Parc national Nouabale Ndoki	
		■ Pas de gestion	
		■ Unite d'Amenagement Forestiere	

Table I. Socio-economic and management features of the landscape

Land Management unit	Area (km²)	Human pop. [1]	Road density (km/km²) [2]	Primary land use	Start of logging activities	Start of wildlife mangmt. activities	Primary actors [3]	Management plan status	Primary wildlife management activities
Nouabale-Ndoki National Park	4,190	0	0	Protection	Not logged	1991	WCS/MEF	Adopted	Law enforcement, ecotourism
Kabo FMU	2,870	4,222	1.07	Commercial logging	1968	1999	CIB/WCS /MEF [4]	Adopted[5]	Law enforcement, zoning, transport controls
Pokola FMU	4,510	16,299	1.08	Commercial logging	1975	2000	CIB/WCS /MEF [4]	Underway	Law enforcement, zoning, transport controls
Loundougou FMU	4,230	2,693	0.20	Commercial logging	2005	2001	CIB/WCS/MEF[4]	Underway	Law enforcement, zoning, transport controls
Toukoulaka FMU	2,080	1,357	1.72	Commercial logging	1992	2000	CIB/WCS/MEF[4]	Underway	Law enforcement, zoning, transport controls
Mokabi	2,670	1,984	0.12	Commercial logging	2003	None[6]	Rougier	Initiated	None[6]
Bailly and Bodingo swamps	3,770	0	0.02	No use	Not logged	None	None	N/A	N/A
Lac Tele Community Reserve	4,380	14,745	0	Community natural resource management	Not logged	2000	WCS/MEF	Underway	Law enforcement, community governance

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[1] Mavah GA, Auzel P (2004) WCS-PROGEPP; Mavah GA (2005) WCS-PROGEPP; WCS-LTCR unpub.. 2005

[2] WCS-Congo GIS database

[3] WCS (Wildlife Conservation Society); CIB (Congolaise Industrielle du Bois); MEF (Ministry of Forest Economy)

[4] The agreement between CIB, WCS and MEF was signed in 1999 with the purpose of integrating wildlife management and conservation into commercial logging concessions. This led to the creation of PROGEPP (Projet de Gestion des Ecosystèmes Périphériques au Parc National de Nouabale-Ndoki)

[5] The Kabo FMU is the only logging concession in the Republic of Congo to have been awarded FSC (Forest Stewardship Council) certification

[6] No formal wildlife management strategy or wildlife law enforcement is currently in place although WCS/MEFE are conducting anti-poaching patrols along the northern border of the NNNP (southern sector of Mokabi) as part of the NNNP surveillance program

Table II & Figure 2. Summary of survey design and sampling effort

| Survey stratum	Area (km2)	No. transects	Total transect length (Km)
Nouabale-Ndoki National Park	3,963	20	40.0
Kabo FMU	2,887	15	30.0
Pokola FMU	4,502	21	41.0
Loundougou FMU	4,229	20	40.0
Mokabi	2,669	15	30.00
Bailly/Bodingo/ Toukoulaka	5,793	24	48.00
Lac Tele Community Reserve :	3,927	53	106.00
Swamp forests	*2,107*	*17*	*34.00*
Terre-firma forests	*355*	*15*	*30.00*
Seasonally flooded forests	*1,465*	*21*	*42.00*
TOTAL	**27,970**	**168**	**336.0**
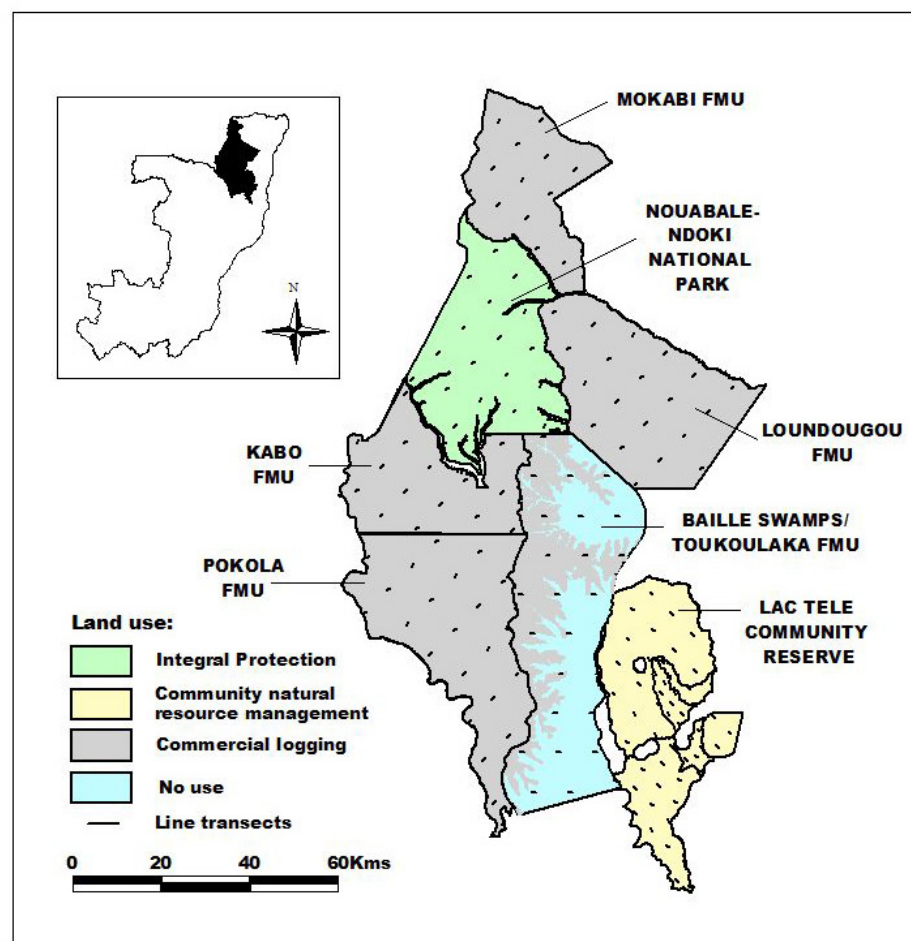
Figure 3. Percentage of major vegetation types found in the different survey strata (from line transect data extrapolated across stratum surface area)
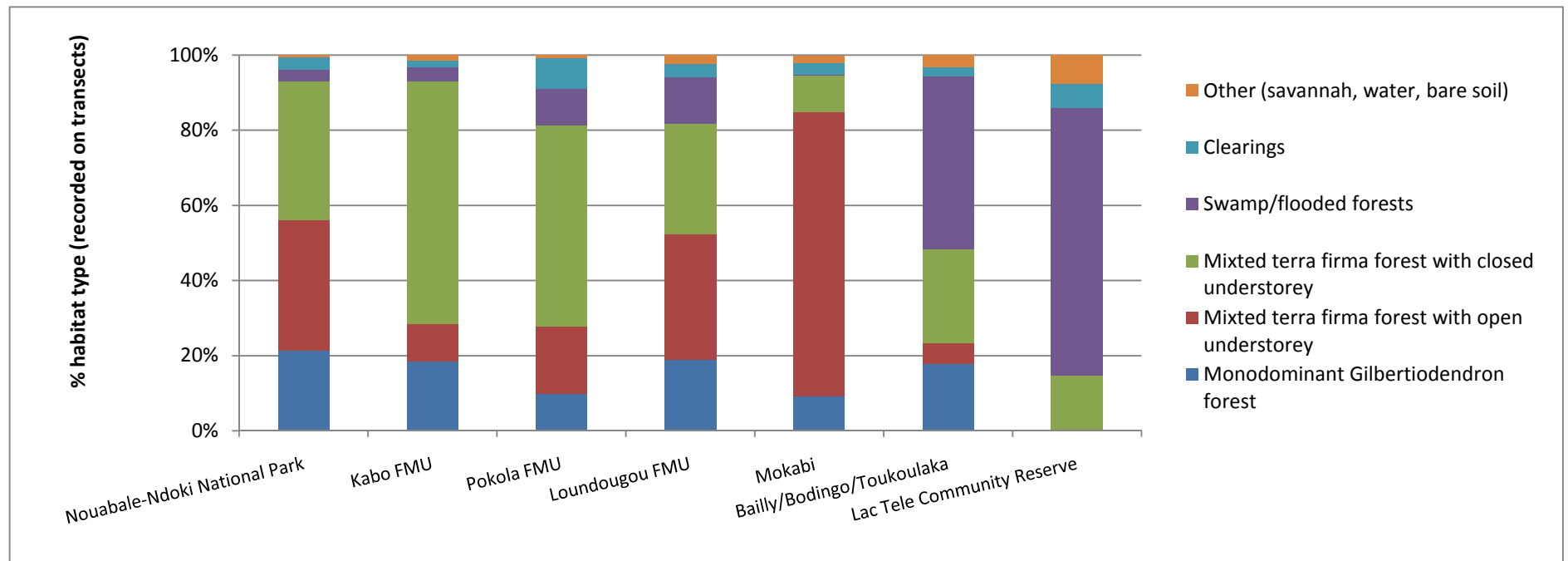
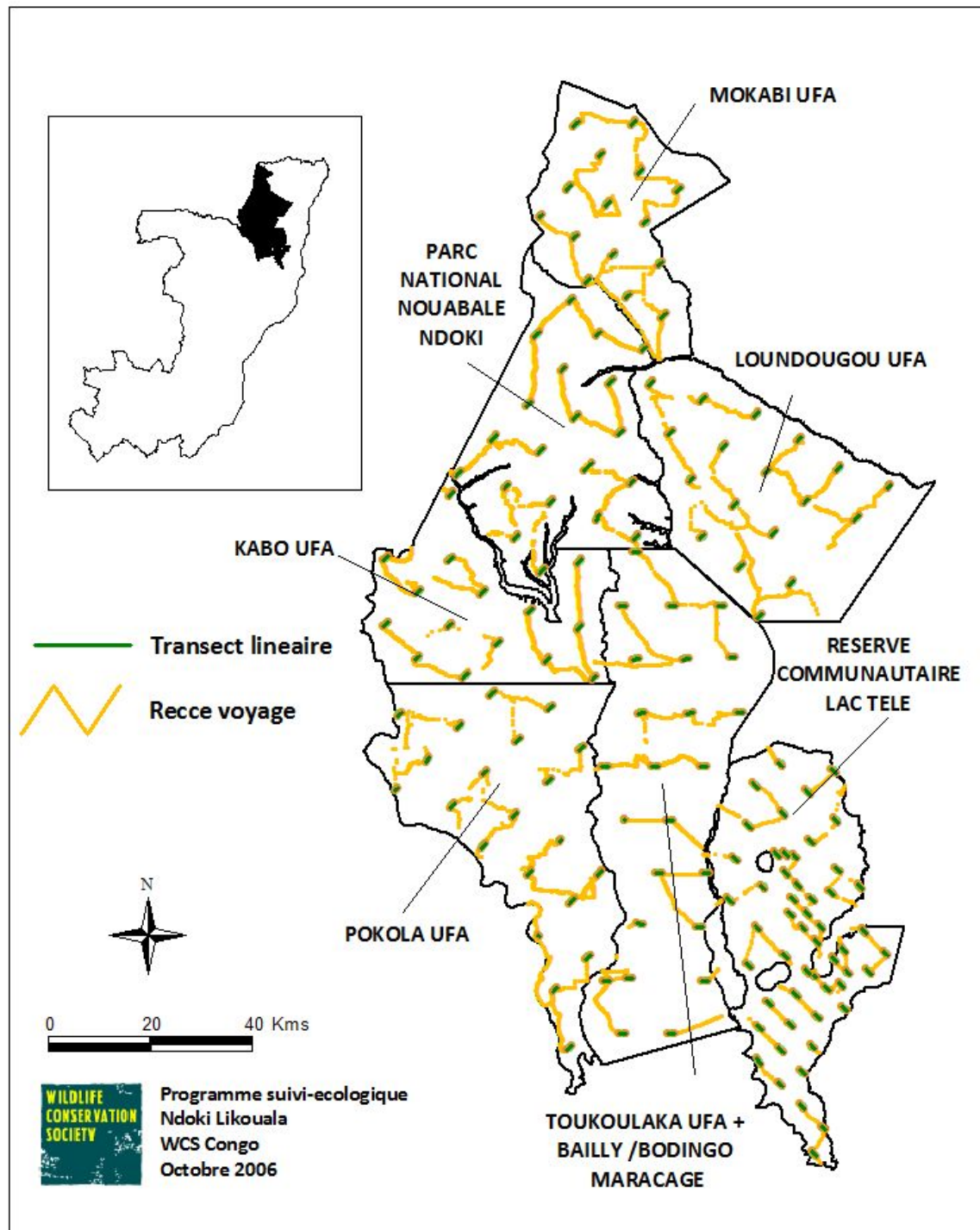**Figure 4. Transect and recce itineraries as recorded by field teams**

Table III. Great ape abundance estimates for management strata and for the landscape

Survey stratum	Km	Ape sp.	No nests	Inds/ km²	95% CI	CV %	N	95% CI
Nouabale-Ndoki National Park	40.0	*All apes*	*283*	*2.90*	*[1.90-4.44]*	*20.6*	*11,505*	*[7,526-17,590]*
		Gorillas	81	1.02	[0.59-1.77]	26.8	4,038	[2,331-6,994]
		Chimpanzee	202	1.03	[0.61-1.71]	25.1	4,066	[2,434-6,795]
Kabo FMU	30.0	*All apes*	*175*	*2.54*	*[1.47-4.39]*	*26.2*	*7,327*	*[4,234-12,678]*
		Gorillas	119	2.16	[1.02-4.56]	36.1	6,235	[2,950-13,178]
		Chimpanzee	56	0.39	[0.24-0.66]	24.5	1,138	[682-1,899]
Pokola FMU	41.0	*All apes*	*371*	*3.95*	*[2.35-6.64]*	*25.5*	*17,767*	*[10,564-29,882]*
		Gorillas	305	4.08	[2.27-7.36]	28.9	18,382	[10,198-33,132]
		Chimpanzee	66	0.34	[0.14-0.82]	44.2	1,533	[637-3,691]
Loundougou FMU	35.7	*All apes*	*131*	*1.61*	*[0.97-2.65]*	*24.3*	*6,796*	*[4,120-11,212]*
		Gorilla	51	0.78	[0.34-1.77]	40.7	3,292	[1,448-7,486]
		Chimpanzee	80	0.48	[0.25-0.90]	30.9	2,028	[1,078-3,813]
Mokabi	29.0	*All apes*	*15*	*0.23*	*[0.09-0.59]*	*47.0*	*607*	*[233-1,581]*
		Gorillas	8	0.15	[0.05-0.45]	53.5	411	[140-1,204]
		Chimpanzee	7	0.05	[0.02-0.13]	45.5	138	[55-350]
Bailly/Bodingo/ Toukoulaka	48.0	*All apes*	*157*	*1.44*	*[0.88-2.35]*	*24.2*	*8,338*	*[5,106-13,615]*
		Gorilla	75	0.86	[0.43-1.74]	35.1	4,988	[2,466-10,086]
		Chimpanzee	82	0.37	[0.2-0.69]	31.2	2,127	[1,134-3,989]
Lac Tele Community Reserve [7]	106.0	*All apes*	*521*	*2.08*	*[1.10-4.01]*	*35.2*	*8,152*	*[4,319-15,729]*
		Gorillas	451	2.27	[1.20-4.50]	41.1	8,918	[4,726-17,657]
		Chimpanzee	70	0.13	[0.04-0.39]	55.71	510	[169-1,543]
Ndoki-Likouala Landscape	**329.7**	***All apes***	***1653***	***2.16***	***[1.73-2.70]***	***11.3***	***60,492***	***[48,374-75,647]***
		Gorillas	**1090**	**1.65**	**[1.24-2.21]**	**14.5**	**46,264**	**[34,607-61,849]**
		Chimpanzees	**563**	**0.41**	**[0.31-0.55]**	**14.6**	**11,541**	**[8,651-15,396]**

Table IV. Elephant abundance estimates for management strata and for the landscape

Survey stratum	Km	No. dungpiles	Inds/ km²	95% CI	CV %	N	95% CI
Nouabale-Ndoki National Park	40.0	165	0.64	[0.47-0.91]	17.2	2,555	[1,813-3,600]
Kabo FMU	30.0	182	0.72	[0.46-1.13]	21.8	2,084	[1,333-3,258]
Pokola FMU	41.0	211	0.82	[0.47-1.42]	27.6	3,677	[2,109-6,411]
Loundougou FMU	35.7	96	0.39	[0.19-0.82]	36.5	1,652	[789-3,457]
Mokabi	29.0	22	0.03	[0.002-0.08]	57.2	69	[22-216]
Bailly/Bodingo/ Toukoulaka	48.0	161	0.51	[0.21-1.2]	44.1	2,931	[1,231-6,977]
Lac Tele Community Reserve [7]	106.0	5	0.01	[0.002-0.05]	74.6	43	[10-200]
Ndoki-Likouala Landscape	**329.7**	**842**	**0.47**	**[0.33-0.65]**	**16.9**	**13,011**	**[9,305-18,195]**

[7] Global estimate calculated from the total (weighted by area) of the three vegetation survey strata

Table V. Great ape abundance by habitat type

Habitat type	Ndoki-Likouala Landscape	NNNP	Kabo FMU	Pokola FMU	Loundougou FMU	Mokabi	Bailly	LTCR
Gilbertiodendron **forest (km)**	**36.7**	8.6	5.6	4.0	6.8	2.7	8.6	0.5
Gorilla[8]		-	-	-	-	-	-	-
Chimpanzee[8]		2.13 [1.13-3.99]	0.97 [0.33-2.8]	1.14 [0.35-3.74]	0.58 [0.3-1.13]	0	0.57 [0.32-1.03]	0
Mixed *terra firma* forest with open understory (km)	**60.9**	14	3.0	7.4	12.0	22	2.5	0.04
Gorilla[8]		0.64 [0.21-1.96]	1.38 [0.28-6.80]	0.47 [0.16-1.37]	0.63 [0.17-2.41]	0.09 [0.03-0.32]	1.37 [0.40-4.69]	0
Chimpanzee[8]		1.35 [0.74-2.46]	0.52 [0.15-1.76]	1.05 [0.51-2.15]	1.28 [0.61-2.67]	0.01 [0.004-0.24]	1.48 [0.43-5.1]	0
Mixed *terra firma* forest with closed understory (km)	**116.1**	14.7	19.4	21.9	10.5	2.8	12.2	34.6
Gorilla[8]		0.93 [0.44-1.96]	3.41 [1.70-6.83]	6.81 [3.72-12.49]	1.92 [0.96-3.83]	0.23 [0.006-0.97]	1.67 [0.64-4.32]	0.45 [0.22-1.15]
Chimpanzee[8]		0.21 [0.007-0.69]	0.11 [0.003-0.38]	0.01 [0.004-0.22]	0.02 [0.005-0.39]	0	0.1 [0.009-1.04]	0.03 [0.01-0.21]
Swamp/flooded forest (km)	**88.3**	1.2	1.2	4.0	4.5	0.07	22.1	55.3
Gorilla[8]		3.47 [1.81-6.65]	0	1.14 [0.23-5.64]	0.40 [0.18-1.44]	0	0.62 [0.29-1.32]	1.19 [0.56-2.68]
Chimpanzee[8]		0	0.82 [0.12-5.88]	0.20 [0.03-1.20]	0	0	0.29 [0.12-0.71]	0.15 [0.05-0.47]
Clearings (km)	**13.77**	1.4	0.5	3.4	1.2	0.9	1.2	5.2
Gorilla[8]		2.00 [0.34-11.88]	9.06 [3.70-22.2]	9.20 [4.61-18.39]	4.67 [0.67-32.42]	3.12 [0.67-14.53]	1.77 [0.24-13.30]	7.54 [3.63-17.82]
Chimpanzee[8]		-	-	-	-	-	-	

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[8] Inds/km ² [95% Confidence Intervals]

Table VI. Elephant abundance by habitat type

Habitat type	Ndoki-Likouala Landscape	NNNP	Kabo FMU	Pokola FMU	Loundougou FMU	Mokabi	Bailly	LTCR
Gilbertiodendron forest (km)	**36.7**	8.6	5.6	4.0	6.8	2.7	8.6	0.5
Inds/km^2 [95% CI]		0.35 [0.16-0.79]	0.36 [0.16-0.84]	0.13 [0.02-0.79]	0.22 [0.09-0.55]	0.13 [0.008-2.06]	0.31 [0.16-0.61]	0
Mixed *terra firma* forest with open understory (km)	**60.9**	14	3.0	7.4	12.0	22	2.5	0.04
Inds/km^2 [95% CI]		0.54 [0.39-0.75]	0.44 [0.16-1.21]	0.47 [0.22-1.01]	0.41 [0.25-0.69]	0.03 [0.005-0.14]	1.04 [0.27-3.93]	0
Mixed *terra firma* forest with closed understory (km)	**116.1**	14.7	19.4	21.9	10.5	2.8	12.2	34.6
Inds/km^2 [95% CI]		0.68 [0.44-1.06]	0.89 [0.57-1.36]	1.09 [0.67-1.76]	0.37 [0.12-1.14]	0	0.62 [0.21-1.8]	0
Swamp/flooded forest (km)	**88.3**	1.2	1.2	4.0	4.5	0.07	22.1	55.3
Inds/km^2 [95% CI]		2.34 [1.33-4.11]	0.34 [0.06-1.91]	0.10 [0.009-1.11]	0.53 [0.06-4.73]	0	0.60 [0.13-2.7]	0.03 [0.006-0.12]
Clearings (km)	**13.77**	1.4	0.5	3.4	1.2	0.9	1.2	5.2
Inds/km^2 [95% CI]		1.04 [0.51-2.1]	1.79 [0.77-4.15]	1.49 [0.66-3.34]	0.69 [0.24-1.97]	0	0.52 [0.07-3.76]	0

Table VII: Encounter rate of human sign by survey stratum.

	Dist. (km)	N	No. signs (all)	ER All signs (km^{-1})	Standard error (signs km^{-1})	No signs cartridges	ER gun cartridges (km^{-1})	No camps	ER camp (km^{-1})
Nouabale-Ndoki National Park	40,01	20	11	**0,28**	0,09	**0**	**0,00**	**0**	**0,00**
Mokabi	29,00	15	110	**3,93**	0,92	**7**	**0,23**	**3**	**0,10**
Kabo FMU	30,00	15	48	**1,60**	0,53	**0**	**0,03**	**3**	**0,10**
Pokola FMU	41,04	21	93	**2,21**	0,60	**3**	**0,07**	**2**	**0,05**
Loundougou FMU	35,67	18	42	**1,26**	0,33	**0**	**0,00**	**0**	**0,00**
Bailly/Bodingo/Toukoulaka	48,00	24	36	**0,75**	0,27	**0**	**0,00**	**0**	**0,00**
Lac Tele CR (Swamp)	34,00	17	24	**0,71**	0,41	**0**	**0,00**	**1**	**0,03**
Lac Tele CR (Terra Firma)	30,00	15	15	**0,50**	0,21	**1**	**0,00**	**0**	**0,03**
Lac Tele CR (Mixed habitats)	42,00	21	45	**1,07**	0,38	**0**	**0,00**	**2**	**0,05**

Table VIII: Encounter rates of other large mammals by survey stratum.

	Dist. (km)	N	Blue duiker (dung)		Red duikers[9] (dung)		Bongo (dung)		Yellow-backed duiker (dung)		Sitatunga (dung)		Buffalo (dung)		Red river hog (dung)	
			No.	ER (SE km^{-1})	No.	ER (SE km^{-1})	No.	ER (SE km^{-1})	No.	ER (SE km^{-1})	No.	ER (SE km^{-1})	No.	ER (SE km^{-1})	No.	ER (SE km^{-1})
Nouabale-Ndoki National Park	40.01	20	23	0.57 (0.13)	115	2.90 (0.41)	0	0 (0)	28	0.70 (0.14)	0	0 (0)	1	0.03 (0.03)	5	0.13 (0.10)
Mokabi	29.00	15	61	2.03 (0.54)	294	9.97 (1.27)	4	0.13 (0.09)	27	0.90 (0.27)	0	0 (0)	0	0 (0)	10	0.33 (0.21)
Kabo FMU	30.00	15	29	0.97 (0.36)	68	2.27 (0.41)	1	0.03 (0.03)	15	0.50 (0.12)	0	0 (0)	2	0.07 (0.41)	0	0 (0)
Pokola FMU	41.04	21	30	0.71 (0.20)	164	3.90 (1.05)	2	0.05 (0.03)	31	0.76 (0.20)	0	0 (0)	10	0.24 (0.11)	14	0.33 (0.08)
Loundougou FMU	35.67	18	103	2.86 (0.52)	316	8.79 (1.79(	1	0.03 (0.03)	54	1.51 (0.28)	0	0 (0)	1	0.03 (0.03)	13	0.36 (0.09)
Bailly/Bodingo/Toukoulaka	48.00	24	24	0.50 (0.19)	117	2.44 (0.11)	1	0.02 (0.02)	17	0.35 (0.11)	6	0.13 (0.13)	0	0 (0)	5	0.10 (0.07)
Lac Tele Swamp Forest	34.00	17	0	0 (0)	6	0.18 (0.10)	0	0 (0)	1	0.03 (0.03)	3	0.09 (0.06)	0	0 (0)	1	0.03 (0.03)
Lac Tele Terra Firme Forest	30.00	15	33	1.10 (0.35)	74	2.47 (0.60)	0	0 (0)	30	1.00 (0.27)	0	0 (0)	0	0 (0)	5	0.17 (0.06)
Lac Tele Seasonally Flooded Forest	42.00	21	2	0.05 (0.03)	2	0.05 (0.03)	0	0 (0)	6	0.14 (0.07)	9	0.21 (0.12)	0	0 (0)	5	0.12 (0.06)

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[9] Includes all species of red duiker (*C. callipygus, C. nigrifons, C. leucogaster, C. dorsalis*)

Figure 5. Distribution of large mammal carcasses and camps found on transects and recces
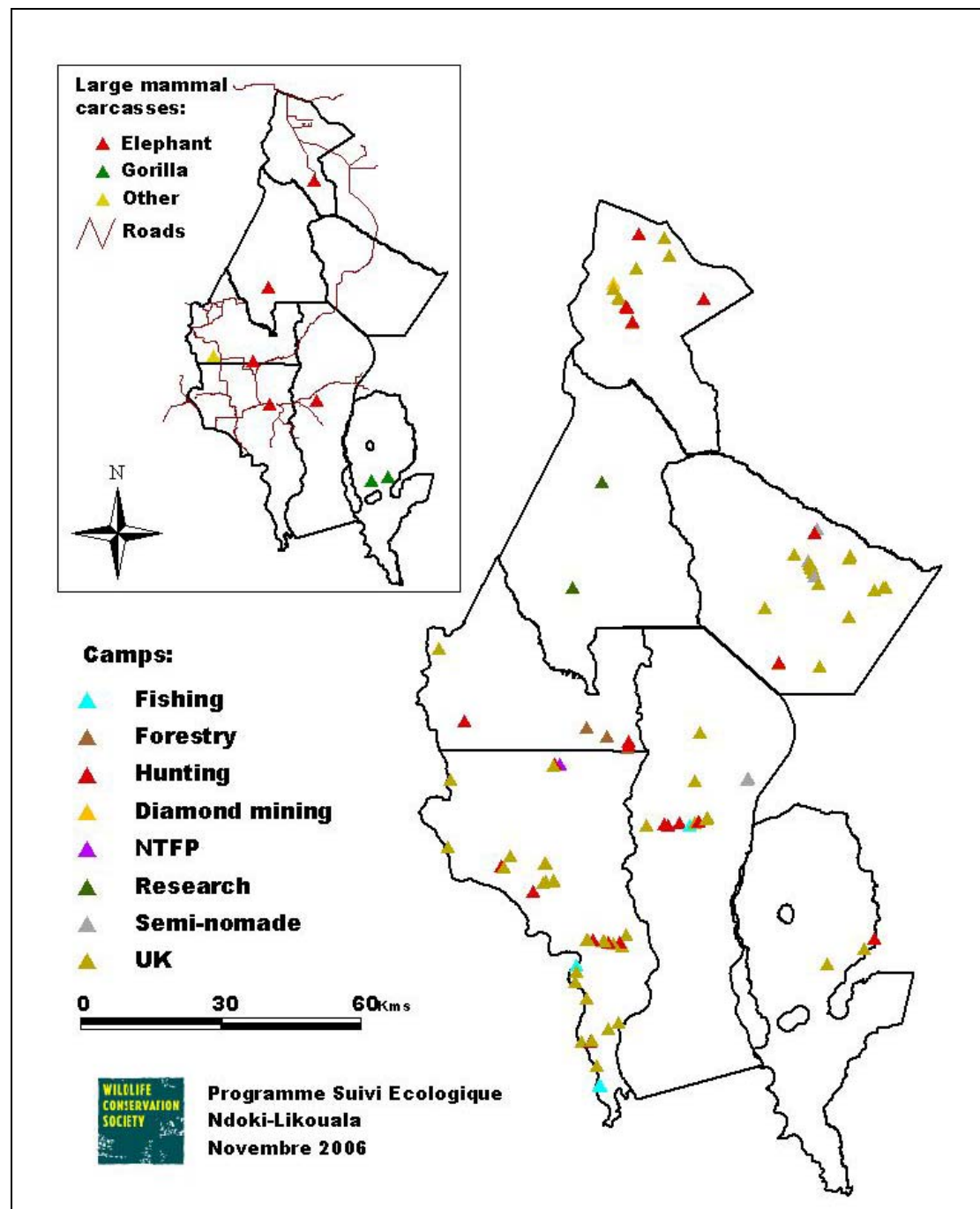
Figure 6. Interpolation map of elephant density from line transects

Densite des elephants
par transect (km2)

High : 4.330791

Low : 0.000000

0 10 20 40 60 80
Kilometers

WILDLIFE CONSERVATION SOCIETY
Programme suivi-ecologique
Ndoki Likouala
WCS Congo
Octobre 2007
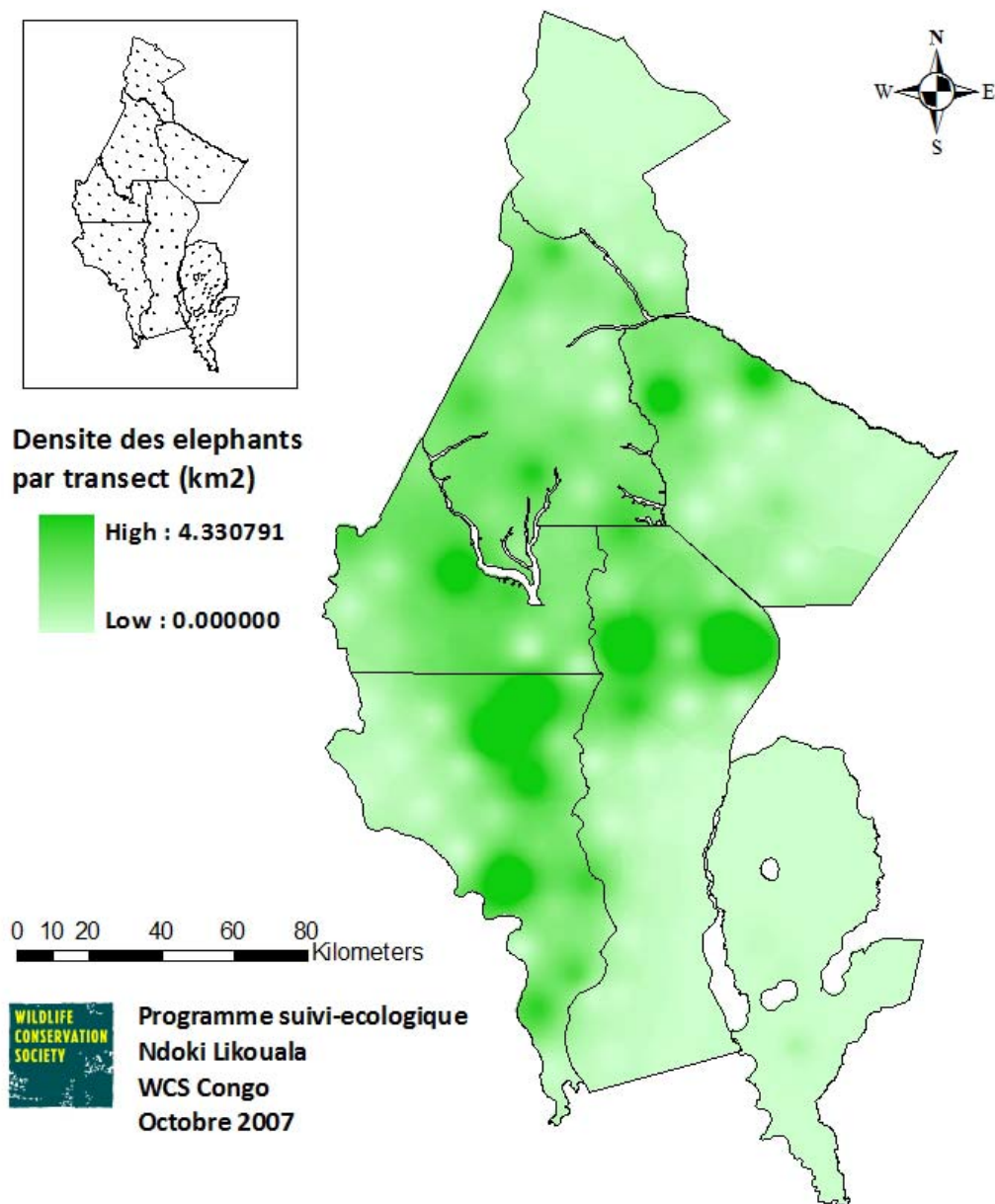
Figure 7. Interpolation map of chimpanzee density from line transects

Densite des chimpanzes
par transect (km2)

High : 3.865941

Low : 0.000000

0 10 20   40   60   80
Kilometers

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CONSERVATION
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Programme suivi-ecologique
Ndoki Likouala
WCS Congo
Octobre 2007
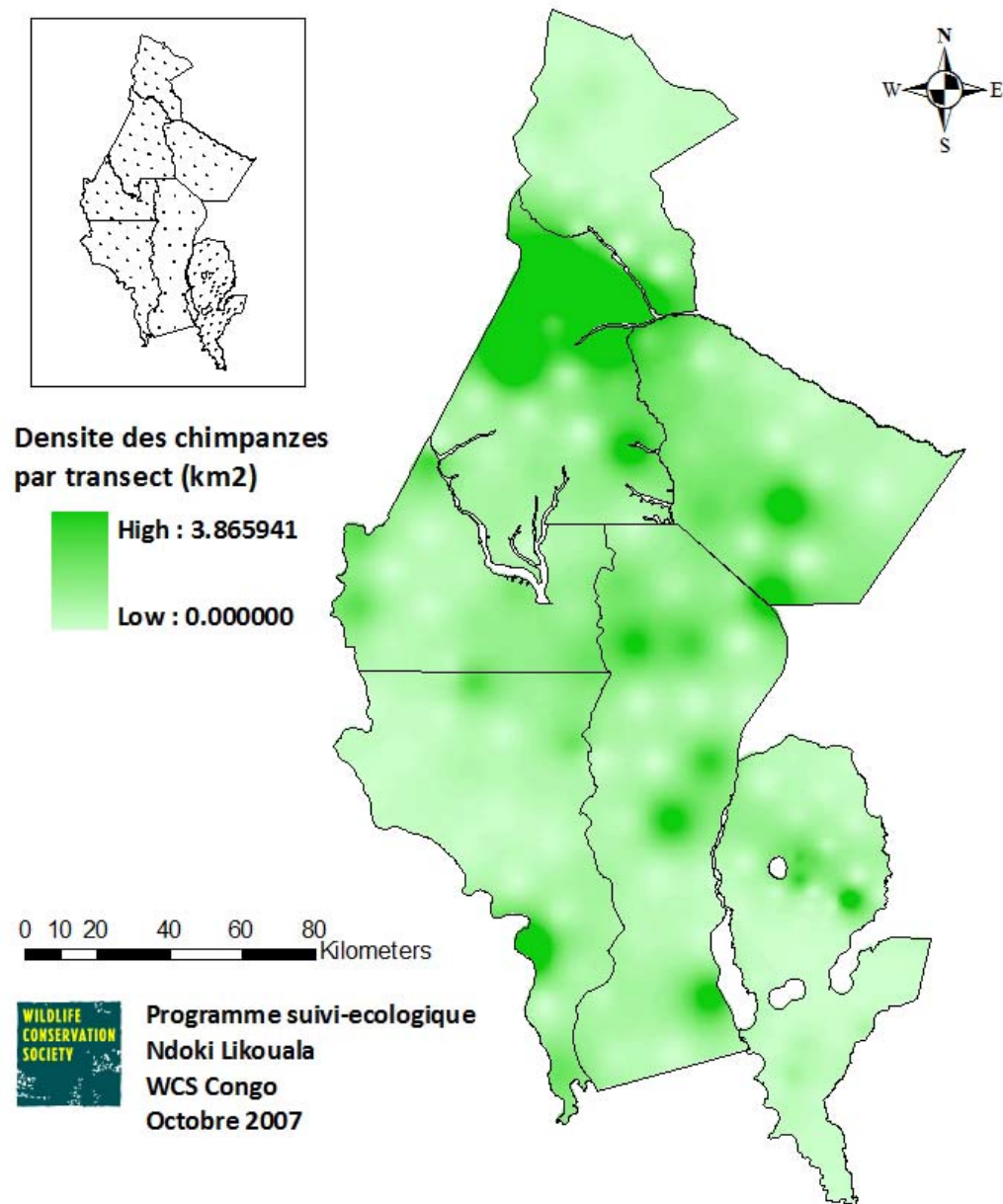
Figure 8. Interpolation map of gorilla density from line transects

Densite des gorilles
par transect (km2)

High : 17.3118

Low : 4.12748e-007

0 10 20 40 60 80
Kilometers

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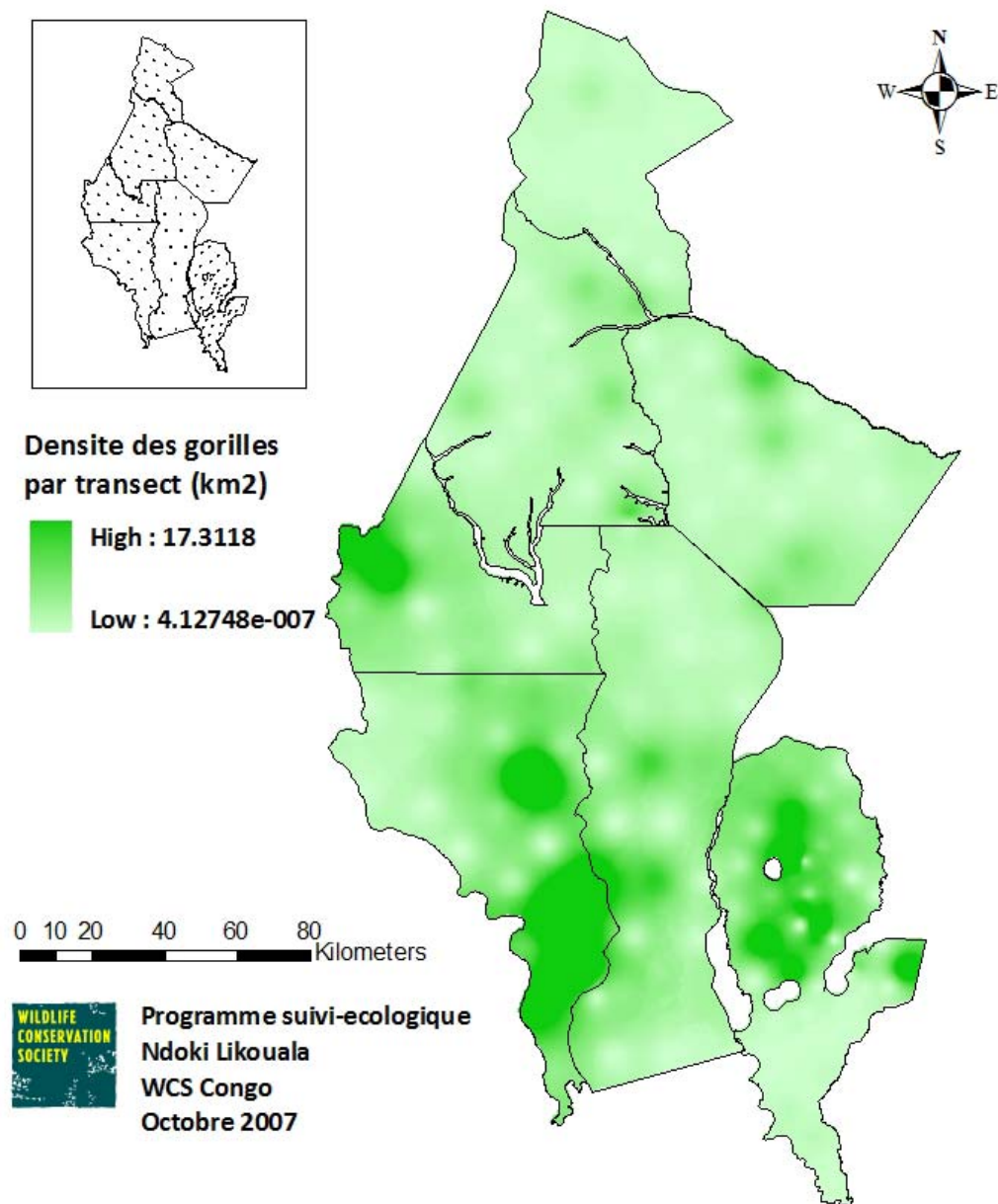
Figure 9. Interpolation map of encounter rates of bongo (*Tragelaphus euryceros*) sign on line transects
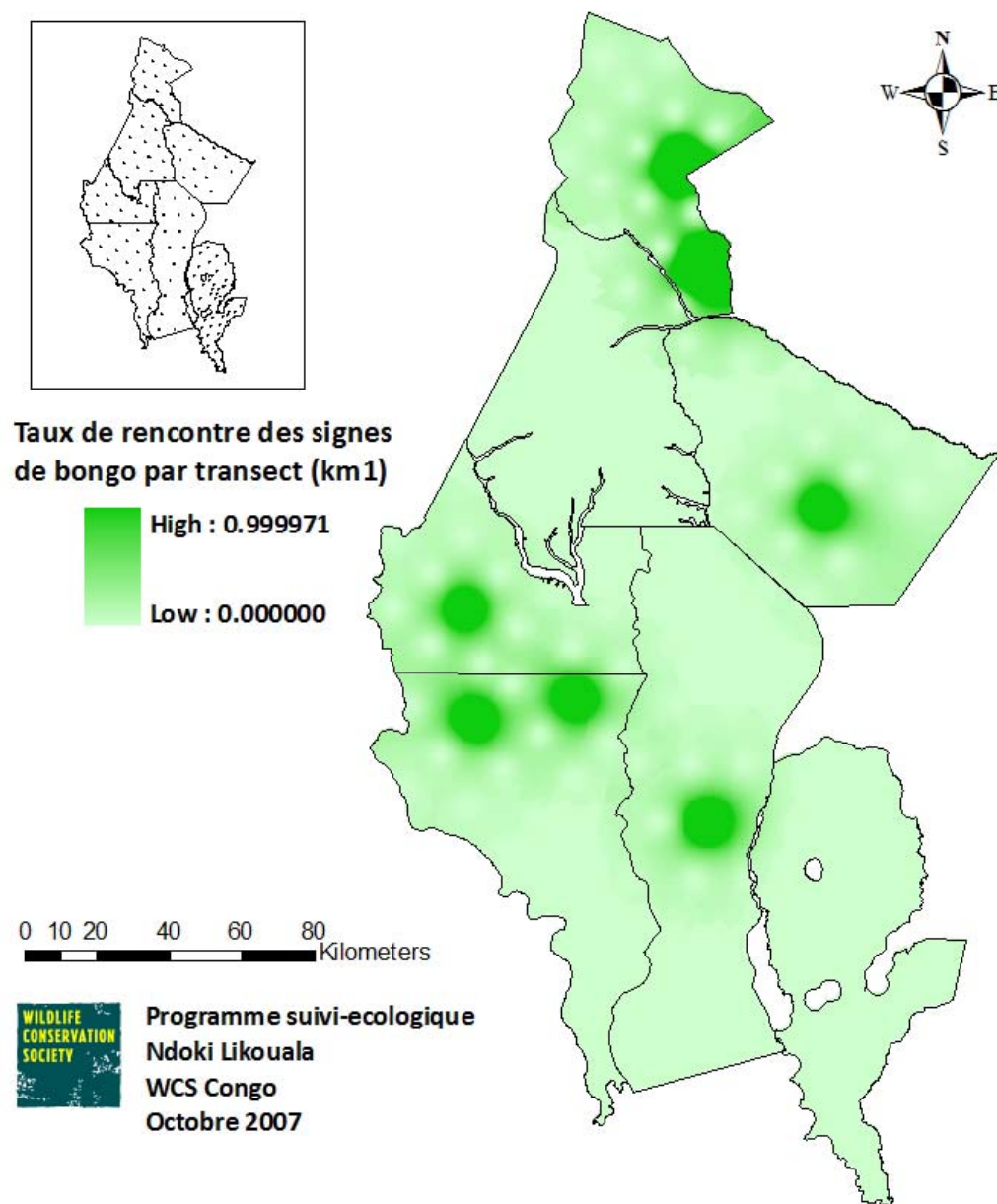
Figure 10. Interpolation map of encounter rates of buffalo (*Synercerus caffer nanus*) sign on line transects
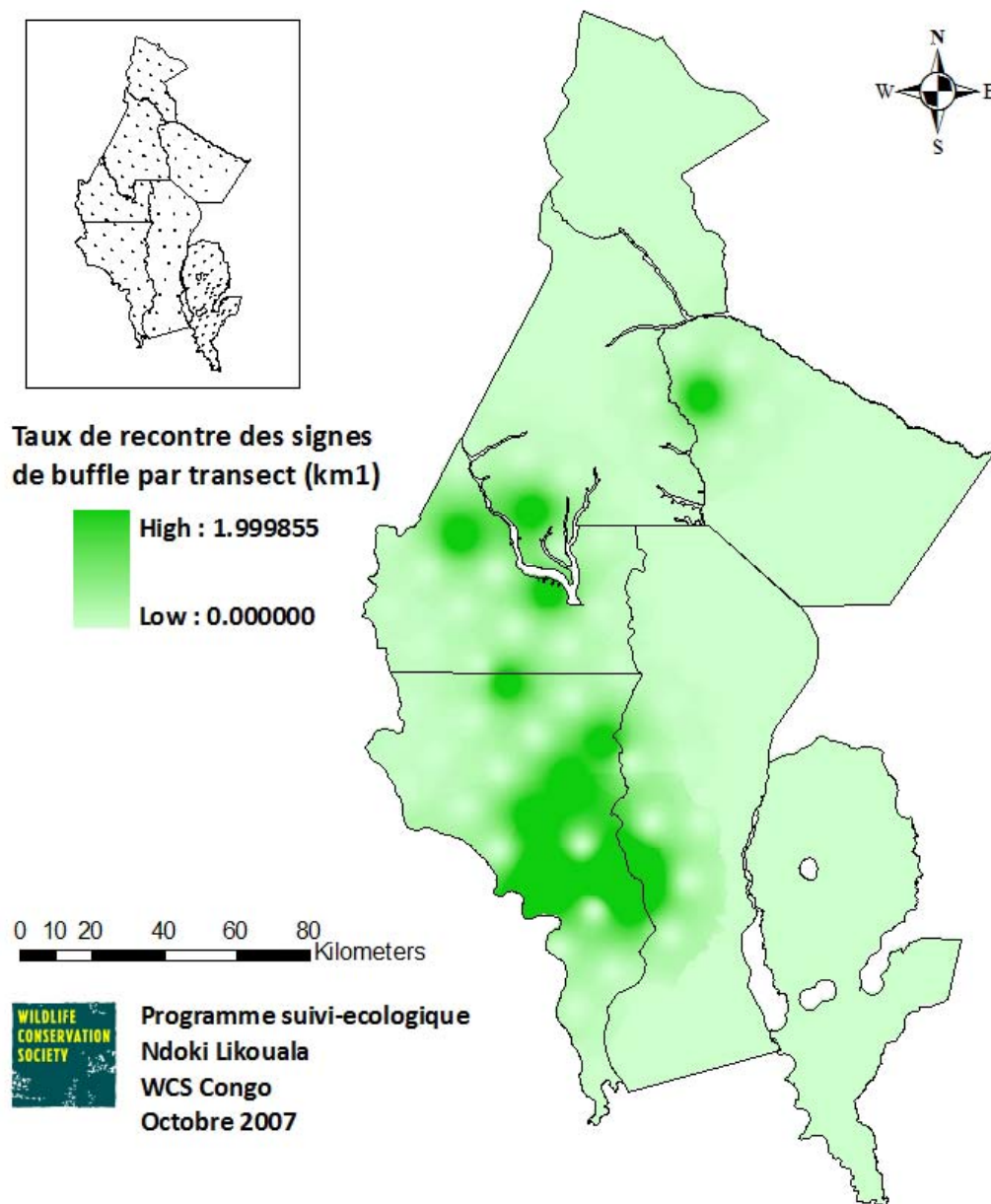
Figure 11. Interpolation map of encounter rates of sitatunga (*Tragelaphus spekeii*) sign on line transects
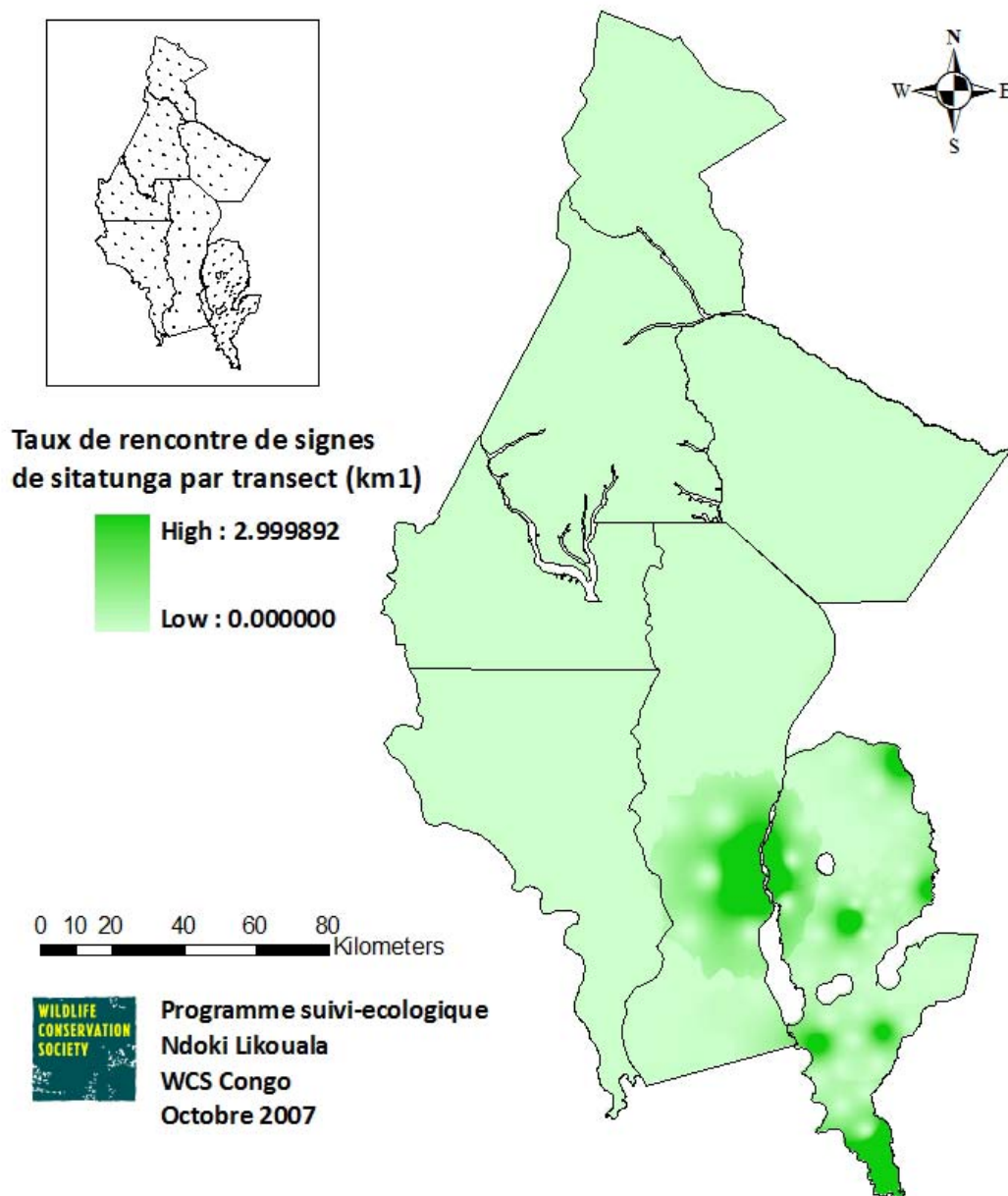
Figure 12. Interpolation map of encounter rates of red river hog (*Potamochoerus porcus*) sign on line transects
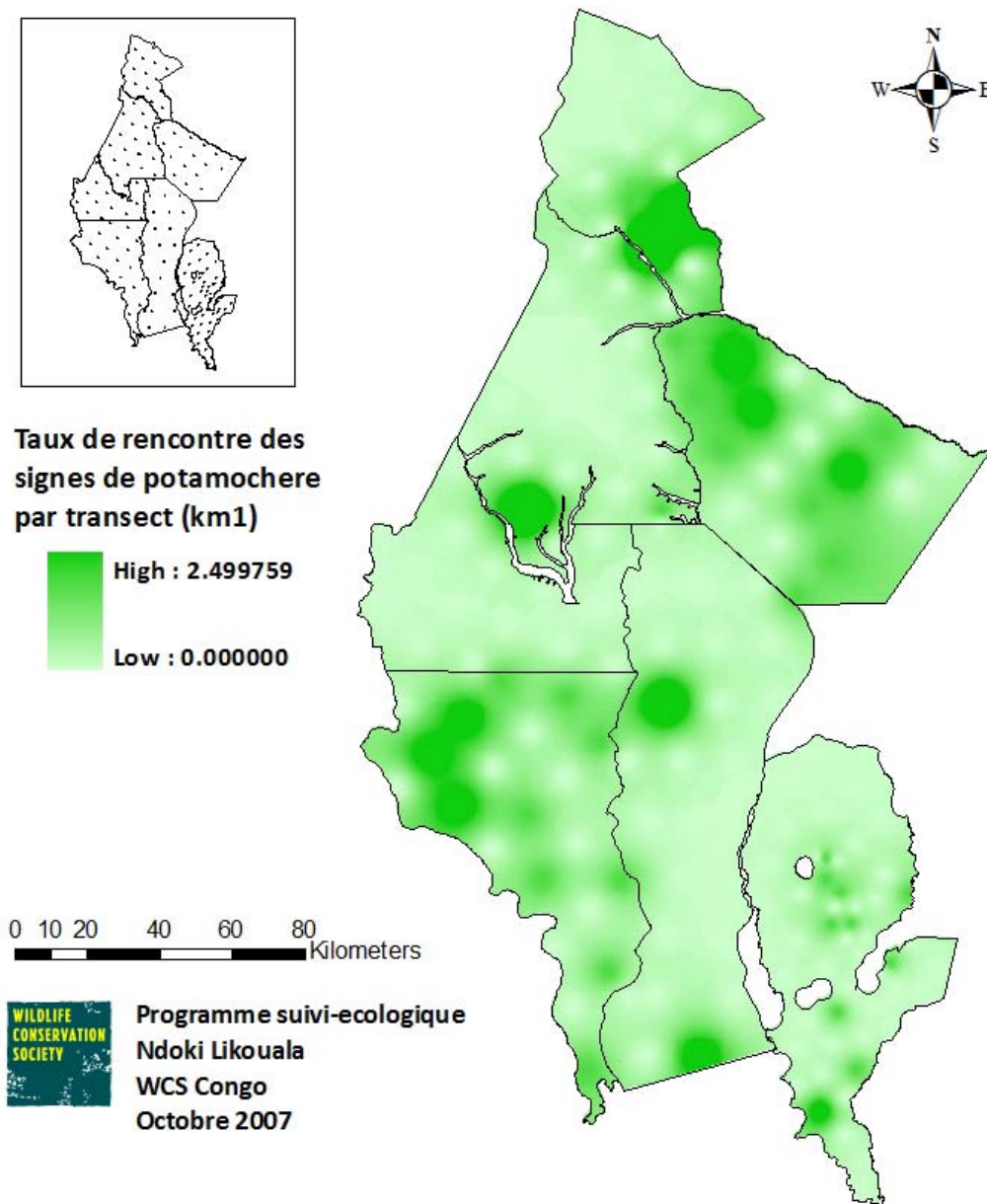
Figure 13. Interpolation map of encounter rate of elephant paths (*left = well-used, right = abandoned) on line transects (*major roads outlined in brown*)
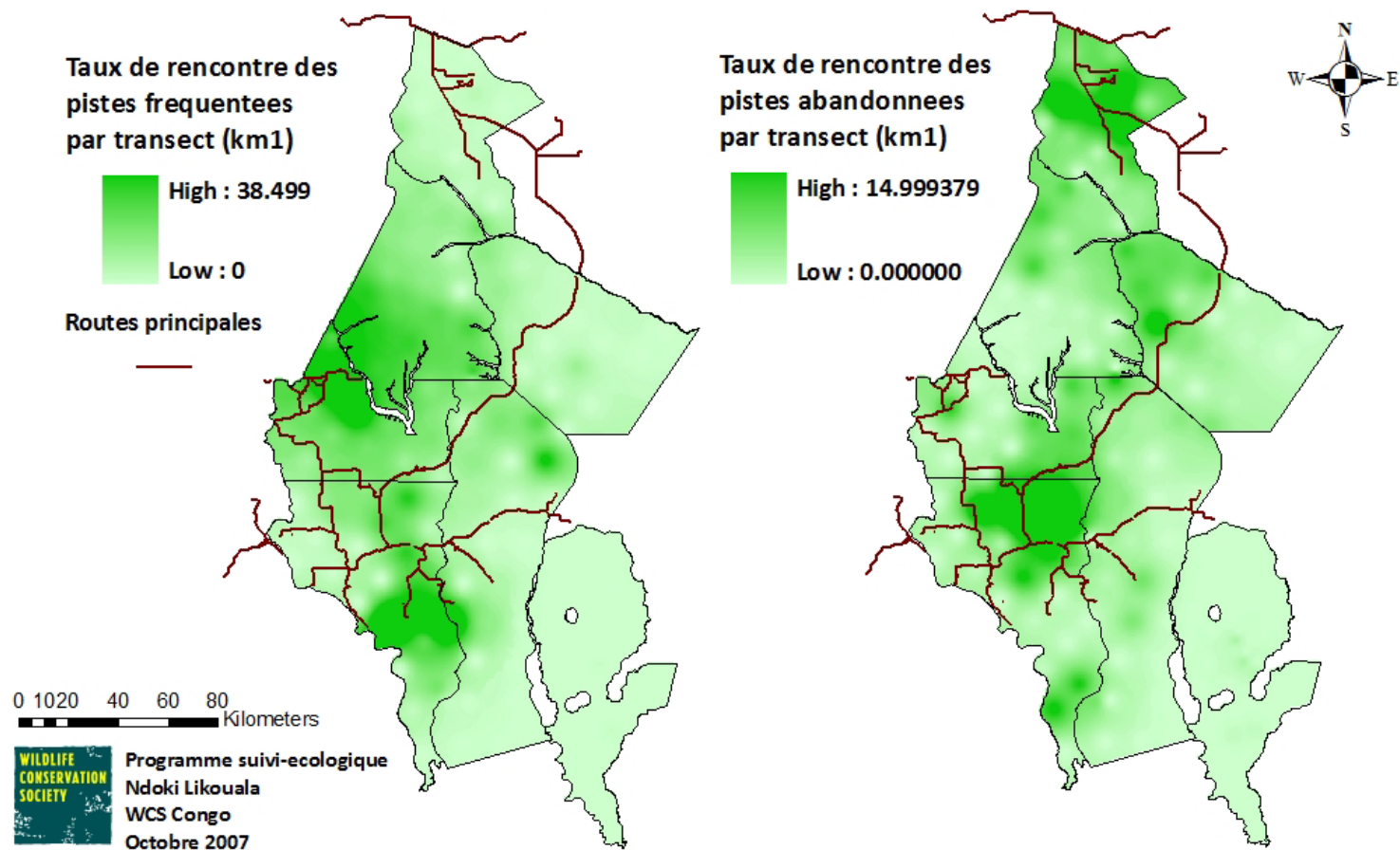
Figure 14. Interpolation map of encounter rates of all human sign on line transects

Taux de rencontre des signes
humaines par transect (km1)

High : 20.5

Low : 3.97581e-007

0 10 20   40   60   80
Kilometers

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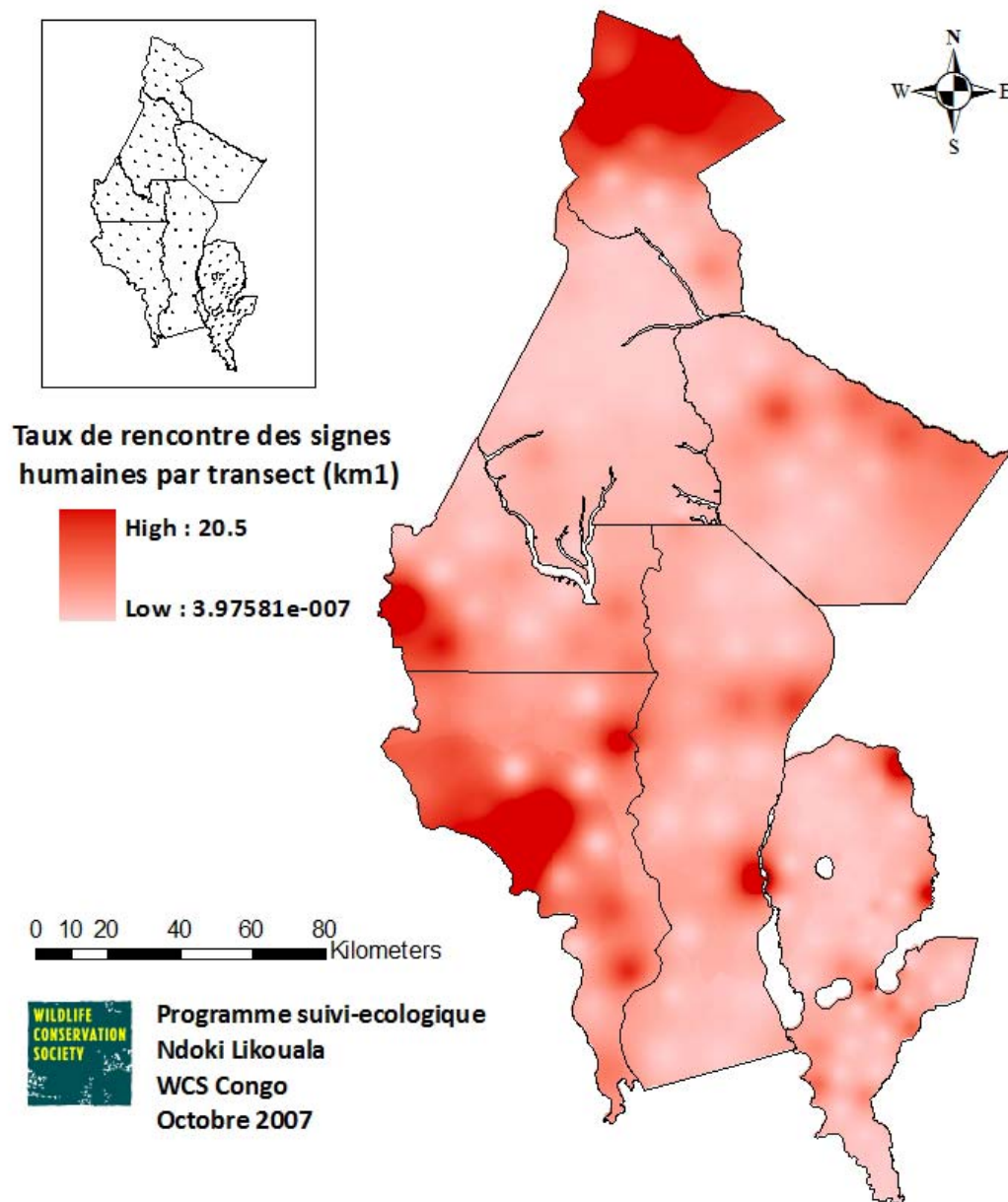
CONCLUSIONS AND RECOMMENDATIONS

The major conclusions from the first round of monitoring data can be summarized as follows:

- The Ndoki-Likouala landscape continues to harbor important populations of large mammals, particularly gorillas, chimpanzees and elephants and quite probably the single largest population of all three of these species in Central Africa. The landscape therefore continues to represent a zone of critical conservation importance. With the exception of Mokabi FMU (see below) all large mammal populations are stable since baseline surveys conducted between 2001-2003 (baseline data not shown here, no significant difference at the 0.05 level). For large and wide-ranging mammals, such as elephants, the data clearly show the wildlife and conservation benefits of a landscape management approach.

- The Nouabale-Ndoki National Park remains the most intact protected area in Central Africa, with no sign of illegal human presence, exploitation or poaching recorded during transect or recce walks.

- Wildlife management and protection programs implemented in the Kabo and Pokola logging concessions have contributed to the successful conservation of substantial populations of elephants and gorillas in this zone. Pokola FMU has the highest overall densities for gorillas and elephants, with gorilla densities significantly higher than recorded in the Nouabale-Ndoki National Park (at the 0.05 confidence level), with gorilla nest frequency significantly predicted by the presence of open-canopy and closed understorey forest (R^2 = 0.07, F = 5.423, p < 0.001). Furthermore, the presence of an effective buffer zone management program has enabled key elephant migration routes to be maintained across the NNNP and neighboring habitats in the Kabo FMU to the west and the Bodingo swamps to the south east

.
- In contrast, large mammal populations in the Mokabi FMU are in a critical condition. Great ape populations in particular appear to have declined dramatically since the CITES-MIKE surveys conducted in 2003 (baseline data not shown here). Elephant populations remain low but relatively stable in the south of the concession close to the NNNP border where NNNP anti-poaching efforts are concentrated. Human activity is encroaching towards the northern NNNP border however and in particular from cross-border incursions from Central African Republic. Uncontrolled hunting is rife, particularly of large game, with encounter rates of cartridges, hunting camps and snares an order of magnitude higher than all other zones. In contrast, reasonable populations of other mammals, such as duikers and red river hogs appear to remain from encounter rate data presented here, although the methodological limitations of these data should lend caution to interpretation of the results. At a minimum, it is critical to

retain wildlife protection activities across the border area with the Nouabale-Ndoki National Park to avoid further encroachment of poaching activities.

- Chimpanzee populations are highest in the Nouabale-Ndoki National Park, with chimpanzee density across the landscape strongly influenced by habitat type – chimpanzee nest frequency was significantly predicted by *Gilbertiodendron* monodominant forest and mixed species forest with open understorey (R^2 = 0.16, F = 13.73, p < 0.001) – both of which forest types are characteristic of mature, un-logged forest.

- The Lac Tele Reserve continues to harbor an important gorilla population in its remote swamp forests in the north of the reserve. Swamp forests in the south of the Loundougou FMU and in the Bodingo/Bailly also appear important habitat for great apes.

- Some evidence exists as to the presence of an east-west elephant migration corridor across the mid-sector of the Bailly swamps into the terra firm forests of Toukoulaka and Pokola. However, elephant populations in Lac Tele remain extremely low. Whilst the Bailly swamps – and specifically the Bodingo zone - show considerable importance for elephants and a potential corridor across to the Nouabale-Ndoki National Park, the problem of elephant poaching towards the northern Terres de Kaboungas road linking the Ndoki landscape with the Lac Tele Community Reserve needs to be addressed.

- Elephant poaching still remains a very real, albeit localized, threat throughout the landscape. A total of five carcasses were discovered throughout the surveys, of which three (Bailly, Pokola and Mokabi) were confirmed to be as a result of poaching. Outside of Mokabi, South-east Kabo, central Pokola and the Terre de Kaboungas (in the Bailly swamps) appear to be particularly targeted, which is confirmed by PROGEPP law enforcement monitoring data. A number of elephant poacher arrests and seizures were recently made by PROGEPP, operating on information coming from the south-east Kabo area.

- In spite of wildlife law enforcement activities and the current high elephant populations in the CIB concessions, roads are still exerting a major and significant impact on elephant abundance and distribution (R^2 = 0.07; F = 13.74, p < 0.001), particularly in the Pokola FMU. All poached elephant carcasses located in the concessions were adjacent to logging roads. Road development and planning should continue to be a major point of discussion in the development of forestry management plans. The implications for elephant distribution of the opening of Public Road No 2 to the south east of NNNP where elephant densities are locally high and where southeast-northwest migration routes are present should be a key discussion point in the development of the Loundougou-Toukoulaka management plan.

- From the results presented here, we recommend the second phase of these landscape surveys to be implemented in no more than four years (2010), with the same sampling effort (with the exception of Mokabi – see below) and the same statistical assumptions concerning variance and power to detect trends. However, in light of the persistent threat of elephant poaching, increasing socio-economic and infrastructural development of the region, and the omnipresent risk of Ebola, we also recommend the following complementary monitoring and research to be undertaken on a regular and much more frequent basis. Specifically:

  i. Regular monitoring of illegal human activity and effectiveness of anti-poaching efforts from data collected on law enforcement patrols.
  ii. Maintenance of the current Ebola surveillance network and rapid response system for great ape carcasses.
  iii. Localized and targeted research and monitoring programs on the response – and recovery - of wildlife to human activity such as logging and infrastructural development
  iv. Repeated surveys of the southern Mokabi zone within the first year of official wildlife management and protection activities. Sampling effort in this southern zone should be increased in accordance with the reduced encounter rates and consequent higher coefficients of variation presented here.

ACKNOWLEDGEMENTS