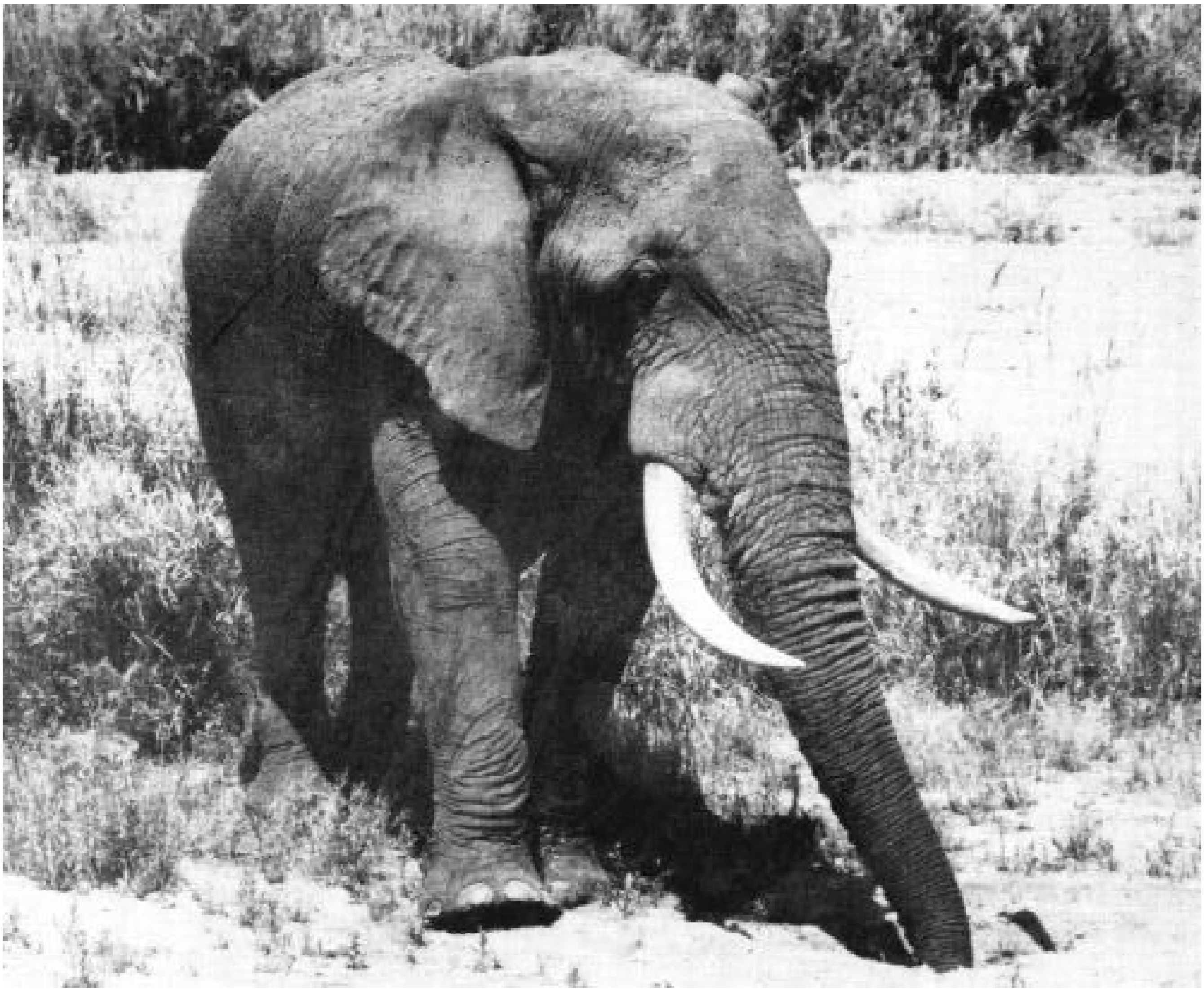
PACHYDERM

NEWSLETTER OF THE AFRICAN ELEPHANT AND RHINO SPECIALIST GROUP



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Wildlife Conservation International

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African Elephant Population Study

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SUMMARY

This paper presents the most recent elephant estimates compiled up to the end of 1986 (Table 1), and a comparison of estimates for specific areas (Table 2) both compiled by I. Douglas-Hamilton, prior to modeling elephant populations across the continent.
The most recent known elephant ranges have been entered on the UNEP/GRID computer in Nairobi by A. Burrill. Further data sets are being acquired.
In addition a new series of questionnaires were distributed in December 1986 by the AERSG secretariat to elicit recent information which will be exhaustively reviewed, together with the interim report of this project, at the 1987 meeting of AERSG. The final report will be ready in June 1987 in time for submission to the CITES Secretariat before the 1987 meeting of the parties in Ottawa, Canada.

INTRODUCTION

Improved monitoring of ivory and elephants remains a high priority, particularly in view of a new approach by the African governments that are parties to CITES to set up an ivory export quota system.
It was suggested by the FAQ working party on wildlife management and national parks, meeting in Arusha, Tanzania, in 1985, that:

> "Each African ivory producing state should determine a yearly ivory export quota based on the best available inventory of elephant populations present within its borders, and that this quota be set at a level enabling sustainable long term productivity of these elephant populations".

Subsequently governments of many African ivory exporting countries have agreed to this proposal and will restrict raw ivory exports to carefully determined quotas. It is intended that raw ivory for export will only come from natural elephant mortality, elephants shot on control, approved elephant culling schemes, or that confiscated from poachers. This should help to reduce the illegal trade. An important element in making the system work is for each state to take stock of its elephant/ivory resource and to monitor its status and trends. Each tusk exported will be marked and registered according to agreed CITES procedures, using standardized forms.
In view of the massive and widespread declines, caused by the ivory trade, that have been reported over the last decade, this action now may represent the best hope for the survival of Africa's elephants in meaningful numbers. The CITES secretariat has been asked by the parties to the convention to centralize information on ivory quotas and to circulate it to all importing, exporting and transit countries. The secretariat is in the course of setting up a database on ivory movements which will obtain data from CITES export permits submitted by the ivory exporting nations.
However, the secretariat does not have information on elephant numbers, ranges and trends and is "in favour of any effort that will result in availability of better elephant population data to quota countries and other CITES parties"
By monitoring elephant populations and trends, AERSG can provide essential data where they are lacking.
In order to meet this goal this project has been launched to use the Global Resources Information Database (GRID) of the GEMS section of UNEP, to model elephant densities for those parts of the elephant range where information is lacking. The project is sponsored jointly by WWF and the Elsa Wild Animal Appeal in collaboration with UNEP.
The models will be prepared by A. Burrill with the advice of I. Douglas-Hamilton, and the guidance of other interested scientists, in particular H. Croze from UNEP and the chairman and vice-chairman of AERSG, D. Cumming and D. Western. AERSG members are invited to participate in the project at any stage, so that a scientific consensus on the continental elephant status can be reached. Scientists coming to Nairobi can visit the GRID system at UNEP and we shall be glad to explain how the elephant computer modeling works.
Within the context of a continental estimate the elephant densities in the forests of Central Africa will be of greatest importance as quantitative information from this region has hitherto been lacking. In this connection the forest elephant study of R. Barnes of the New York Zoological Society will be a crucial input (he is presently undertaking a study to ascertain elephant densities in selected parts of Gabon and Zaire).
The approach of the project will be to develop models for extrapolating densities and trends, by use of me GRID Geographic Information System (GIS). Input will include known elephant densities, ranges, and trends, as well as vegetation type, protected areas, climate, human population, tsetse fly distribution, and other relevant data. Output on elephant numbers, and range, will be made in the form of colour maps and tables, accompanied by a written report reviewing the results of the model and the status of elephants in the ivory exporting countries.
BACKGROUND
Attempts to arrive at a continental elephant estimate began ten years ago. In July 1976, WWF, New York Zoological Society (NYZS) and IUCN initiated an African Elephant Survey and Conservation Programme (WWF Project 1389), which compiled available information on elephant range, numbers and trends from questionnaires, the published literature and field surveys. It highlighted and gave world-wide publicity to the serious declines in elephant populations taking place in many African countries. Concurrently, under the auspices of the same project, a study of the ivory trade was made on behalf of the US Fish and Wildlife Service (Douglas-Hamilton, 1979; Parker, 1979).
The overview data on elephant numbers, densities and trends were reported in detail to NYZS, WWF and IUCN in typescript reports (Douglas-Hamilton, 1977-79) and published in summary form in the WWF Year Books and other publications (Douglas-Hamilton, 1979, a, b, c, d).An international meeting ot IUCN's African Elephant Specialist Group was held in Nairobi in 1980. Information on continental elephant status has ap-

peared in the IUCN bulletin (1980), an IUCN/WWF executive summary “Africa’s Elephants: A Time for Decision” (IUCN, 1982), and popular accounts in the National Geographic Magazine (O. Douglas-Hamilton, 1980) and Animal Kingdom (Ricciuti, 1979). The ivory studies were published in summary form in the U.S. Congressional Record.

This information and the results of another questionnaire survey have also been reviewed at the Hwange meeting of the African Elephant and Rhino Specialist Groups in 1981 (Cumming and Jackson, 1984). A further questionnaire was distributed in 1983 under the auspices of the Elephant and Rhino Specialist Group (Douglas-Hamilton, report to AERSG, 1984,1987). In a consultancy for CITES, Martin (1985) has also gathered new information. Numerous accounts of individual elephant populations have been published in the AERSG newsletter, Pachyderm, and in the scientific literature. A bibliography is given below which includes sources on elephant estimates.

An account of factors affecting elephant populations and current trends has been published by Douglas-Hamilton (1983, 1984, 1987), in which the killing of elephants for ivory has been identified as the prime cause of declines in the majority of populations in Africa in the last decade – with exceptions in Zimbabwe, South Africa, Botswana and Malawi. Recent publications have lent support to this view (Pilgram and Western, 1984; Burrill et al., 1986; Western, 1986; Lindsay, 1986; Redmond, 1986; Eltringham, in press). A method of using elephant carcass ratios to determine trends has also confirmed widespread negative elephant trends in Tanzania, Kenya and Sudan (Douglas-Hamilton and Burrill, 1986). It is now generally recognised that the strict enforcement of the ivory quota system is essential if the surviving elephants are to remain as a viable resource.

Here the elephant database is presented with the view of improving its quality before entering it in the computer model. Information which is needed is as follows:

1. Correction of errors.
2. Identification and correction of biases.
3. New data or updates on ranges, estimates and densities, especially for the relatively unknown forest habitats.
4. Breakdown of elephant densities for protected and non-protected areas, and for habitat types.
5. Ideas on valid extrapolation of trends. For example do elephant declines follow a curve to a low “resistance” density, or do they proceed in a straight line to extinction? Evidence seems to support the former.
6. Provision of confidence limits or standard errors. Many of these are available from the literature or questionnaire replies, but have not yet been entered.
7. Any other relevant information which can improve the modeling.

THE PROJECT

The data compiled on elephant numbers and distribution since 1960 include a wide range of census estimates made mainly in East and Southern Africa. Covering varying degrees of protection for elephants, and different habitat types, they can be used to model the uncensused populations.

The basic form of analysis in the GRID Geographic Information System (GIS) is the superimposing of various layers of data. In order to develop a model to predict characteristics of elephant populations in unknown areas, it is first necessary to determine what factors appear to be co≠incident with the characteristics in known areas. It is thus necessary to ensure that the GIS includes data sets for all the potentially relevant factors. The UNEP system presently includes data sets for soil type, preceipitation and vegetation as well as base maps for Africa. The first stage of this project will involve the acquisition and incorporation of the following data sets.

1. Known elephant ranges: These have already been entered from the most recent information available which include revisions of the 1979 range map in the light of subsequent questionnaires.
2. Protected areas distribution: This can be entered from maps and information available in Dr. J.R. MacKinnon’s “Review of Protected Areas in the Afro-tropical Realm”. Protected status of an area has been shown to be one of the most important determinants of elephant density (Burrill et al., 1986).
3. Habitat types: The “Toulouse” vegetation map has been suggested as the most suitable. Alternatively, White’s (1981) vegetation map also covers the whole of Africa on the same projection as the GIS.
4. Human population distribution has also been cited as being of prime importance in determining elephant populations, whether as an immediate factor as claimed by Parker (1979, 1983) or as a long term factor (Douglas-Hamilton, 1979a, 1983). Data will be sought from the UN Fund for Population Activities.
5. The distribution of tsetse fly, with which elephant density may be associated, is being entered.
6. Other relevant data sets will also be incorporated as available.

In conjunction with this phase of the project will be the preparation of the existing elephant density data for input into the system. This involves presentation of the densities in graphic form on a base map of Africa, delimiting the area included in each estimate. Where an area is found to include more than one region, as determined by the other data sets (e.g. more than one vegetation type), the estimated-area will be subdivided using the appropriate GIS routines. Wherever possible, the subareas will be assigned unique elephant population characteristics, as indicated by the original source. Data from aerial surveys, for instance, will be re-aggregated to derive values for the subareas.

The GIS allows flexibility in updating information. Throughout the project the goal will be to use the best available data. As additional information is received, the GIS will be upgraded.

The next phase of the project will be use of the analytical powers of the GIS to develop a model to explain the known densities and trends of elephant populations. This model will be based on the other data layers of the GIS. A comprehensive map of the distribution of elephants on the continent will then be incorporated into the GIS and the model will be used to extrapolate density and trend values for all elephant populations without previous values, along with a measure of the reliability of the values in each area. From this information, country estimates can be derived.

A preliminary report on this project will be prepared and presented at the 1987 meeting of AERSG. On the basis of feedback from this meeting, the GIS data will be updated and the model refined. A final report will be completed by 30 June 1987, in time to be presented to the next meeting of the CITES parties to be held in Ottawa in July.

Table 1. Most recent elephant estimates

The most recent estimates for each country are summarized below. Specific areas do not overlap, but the estimates may not be comprehensive for the elephant range of each country. Each estimate is also classified according to the type of survey, the habitat type, and the protected status if any. Keys for these categories appear at the end.

Type	Zone	Habitat	Status	Year	Area	Number	%CL/SE	Density	Source
CAM E ROON									
AC	Waza	63 29A	NP	1977	1700	500		.029	Van Lavieren (1977)
IG	Benoue	7	NP	1977	1800	200		0.11	Ngog Nje (1977)
IG	Kalamaloue	63	NP	1983	400	45		0.11	Allo (1984)
IG	Bouba Njida	27	NP	1984	2200	200		0.09	Woodford (1984)
IG	Remaining range				280525				
					286625				
CENTRAL AFRICAN REPUBLIC									
AS	Bamingui-Bangoran	11A 27 29A	NP	1985	32000	1607		0.05	Douglas-Hamilton et al. (1985)
AS	Manovo-Gounda	11A 27 29A	NP	1985	32400	2701		0.08	Douglas-Hamilton et al. (1985)
GC	Dzanga-Sangha	2	RF	1985	3320	2855		0.86	Carroll (1985)
IG	Remaining range				170392				
					238112				
CHAD									
AR	Batha (ATI)		MX	1984		85			Martin (1985)
AG	Zakouma	63	NP	1986	3000	450		0.15	Bousquet (1986)
IG	Bongor (Mayo-Kebbi)		MX	1984	30105	100		0.003	Martin (1985)
IG	Chari-Banguirmi		MX	1984	66000	375		0.006	Martin (1985)
IG	Lac Bol		MX	1984	11000	600		0.05	Martin (1985)
IG	Moyen Chari (Sarh)		MX	1984	45180	275		0.006	Martin (1985)
IG	Salamat		MX	1984	32000	900		0.03	Martin (1985)
IG	Tandjile & Logon-Orien		MX	1984	26740	117		0.004	Martin (1985)
					214025				
CONGO									
IG	D'Odzala	1A	NP	1976	2500	150		0.06	N'Sosso (1977)
IG	Remaining range	1A B			244000				
					247400				
EQUATORIAL GUINEA									
IG	Elephant Range			1979	20000				Action Plan (1979)
					20000				
GABON									
IG	Elephant Range			1979	266979				Action Plan (1979)
					266979				
ZAIRE									
AS	Garamba	11A 12	NP	1983	5000	8200		1.64	Hillman-Borner (1983)
AS	Bili-Uere	11A		1985	1820	378		0.20	Douglas-Hamilton (Unpubl.)
AT	Virunga Plains	45	NP	1981	1600	751		0.47	Mertens (1983)
IG	Kahuzi-Biega	1A 4 19A	NP	1977	6600	3300		0.50	Dechryver (1976)
IG	Remaining range				1801336				
					1816356				
ETHIOPIA									
IG	Akoba Complex		GR	1984		4000			Martin (1985)
IG	Bash-Setit		WR	1984		250			Martin (1985)
IG	Metekel & Dabus		CHA	1984		400			Martin (1985)
IG	Mizan Teteni & Garafer		MX	1984		2000			Martin (1985)
IG	0mo/Mago Complex	17 29B 42	NP, W	1984		2000			Martin (1985)
KENYA							SE		
AS	Wajir District			1978	56501	93	88	0.002	Peden (1984)
AS	Marsabit District			1981	73952	231	113	0.003	Peden (1984)
AS	Samburu District			1981	17521	935	536	0.05	Peden (1984)
AG	West Pokot District			1981	9090	192	125	0.02	Peden (1984)
AG	Baringo District			1982	9885	426	146	0.04	Peden (1984)
AS	Laikipia District			1982	9718	707	522	0.07	Peden (1984)
AG	Garissa District			1983	43931	3661	1330	0.08	Peden (1984)
AG	Kajiado District			1983	19605	655	636	0.03	Peden (1984)
VS	Kilifi District			1983	12414	77	75	0.006	Peden (1984)
VS	Kitul District			1983	29388	699	389	0.02	Peden (1984)
AS	Kwale District			1983	8257	224	152	0.03	Peden (1984)
AS	Lamu District			1983	6506	2118	1188	0.32	Peden (1984)
AG	Narok District			1983	16115	2474	1109	0.15	Peden (1984)
AG	Taita Taveta District			1983	16959	12291	4756	0.72	Peden (1984)
AG	Tana Rivet District			1983	38694	1340	948	0.03	Peden (1984)
AG	Isiolo District			1977	25605	1275	478	0.05	Peden (1984)
AS	Mandera District			1977	26470	477	223	0.02	Peden (1984)
AS	Turukana District			1977	61768	859	290	0.01	Peden (1984)
IC	Aberdares	19A 65	NP	1979	2000	2000		1.00	Snyder (1979)
IG	Mt. Elgon	11A 19A 65	NP	1979	700	1300		1.86	Boy (1977)
IG	Mt Kenya	19A 65	NP	1979	2000	2000		1.00	Snyder (1979)
					487079				

Type	Zone	Habitat	Status	Year	Area	Number	%CL/SE	Density	Source
MALAWI									
AC	Liwonde	25	NP	1984	548	300		0.55	Martin (Bell, 1985)
AC	Majete	28 26	GR	1984	690	200		0.29	Martin (Bell, 1985)
AC	Vwaza Marsh	25 19A	GR	1984	1000	300		0.30	Martin (Bell, 1985)
AS	Kasungu	25	NP	1984	2316	800		0.34	Martin (Bell, 1985)
DC	Nkhostakota	19C 25 29C	GR	1984	1802	400		0.29	Martin (Bell, 1985)
DC	Nyika	19A 25	NP	1984	3134	100		0.03	Martin (Bell, 1985)
DC	Phirilongwe	29C	GR	1984	200	100		0.50	Martin (Bell, 1985)
IG	Mangochi/Nam zumi Area	25 29C		1984	600	100		0.16	Martin (Bell, 1985)
IG	Thuma	25 29C	FR	1984	200	50		0.25	Martin (Bell, 1985)
					10490				
RWANDA									
AC	L'Akagera	45	NP	1983	2510	25		0.01	Monfort (1983)
IG	Ngungwe Forest	19A		1983	900	5		0.006	Monfort (1983)
IG	Volcans	19A 65	NP	1983	230	40		0.17	Monfort (1983)
					3640				
SOMALIA									
VS	Rangelands	16A 42 54B		1984		8624	5943	S	Watson(1985)
SUDAN									
AS	Southern	27	NP	1980	36000	15400		0.43	Boitani (1981)
AS	Jonglei Cemsus Zone	61 62 64		1981	67900	2886		0.04	Cobb (1982)
AS	Shambe	27 61 64	NP	1981	15200	829		0.05	Hillman et al. (1981)
IG	Imatong Mts. S.W.	19A		1986	750	Traces			Howit (1986)
					137350				
TANZANIA									
AS	Kilombero			1986	7975	2230		0.28	Douglas-Hamilton et al. (198
VO	Rukwa			1977	26780	14018		0.52	Ecosystems (1977)
VS	Serengeti	42 45 59	NP	1977	18400	3008	74%	0.16	Douglas-Hamilton (1984)
AS	Uwanda			1977	2200	1156		0.52	Ecosystems (1977)
AS	Mkomazi		GR	1978	3900	667	213%	0.17	Douglas-Hamilton (1984)
AS	Tabora			1979	74057	7746	29%	0.10	Ecosystems (1979)
AS	AR Region Remainder			1980	27105	6195		0.23	Ecosystems (1980)
AS	Ngorongoro	19A 42 59	CA	1980	6000	550		0.09	Ecosystems (1980)
AG	Tarangiri	42	NP	1980	1571	2891		1.84	Ecosystems (1980)
AS	Yaida			1980	2414	466		0.19	Ecosystems (1980)
AS	Ruaha/Rungwa Kizigo	26 42	NP	1983	27216	34725	21%	1.27	Borner and Severre (1984)
AS	Selous	16A 26	GR	1986	74000	55000	21%	0.74	Douglas-Hamilton et al. (198
AT	Manyara	59	NP	1985	100	434		3.73	Douglas-Hamilton (1985)
IG	Kilimanjaro	16A 19A 42 54B	NP	1972	802	1197		1.49	Afoloyan (1975)
IG	Arusha	19A 65	NP	1973	137	86		0.63	Eltringham (1980)
					272330				
UGANDA									
AR	Elephant Sanctuary			1980	3850	100		0.03	Douglas-Hamilton et al. (198
AT	Kidepo	29A 42	NP	1982	1442	428		0.29	Douglas-Hamilton (1983)
AT	Murchison North Only	2 11A 29A	NP	1982	2098	979		0.47	Douglas-Hamilton (1983)
AT	Queen Elizabeth		NP	1982	1978	428		0.22	Douglas-Hamilton (1983)
IG	Kibale		FR	1980	550	100		0.18	Struhsaker (1980)
IG	Murchison South	2 11A 29A	NP	1982	2100	25		0.01	Douglas-Hamilton et al. (198
					12018				
ANGOLA									
IG	East Range	25		1979	680	7		0.01	Huntley (1979)
IG	North Range	11A 29C 14		1979	94857	948		0.01	Huntley (1979)
IG	South Range	22A 25 28 47		1979	240024	1200		0.005	Huntley (1979)
IG	West Range	28 29C 36 51		1979	15284	475		0.03	Huntley (1979)
					35084				
BOTSWANA									
AS	Chobe NP and Area	22A 28 35A	NP	1983	35000	21310		0.61	Work (1983)
AT	Tuli Block	2B	PR	1983	1250	600		0.48	Walker (1976)
AS	Remaining Range			1982	77500	17290		0.22	Melton and Patterson (1983)
					113750				
ZIMBABWE									
AS	Hwange	22A 28	NP	1984	14540	16716		1.15	Cumming (1985)
AS	Gona Re Zhou	26 28 29C	NP	1985	4964	3937		0.8	Cumming (1985)
AS	Matetsi Complex	22A 28	MX	1985	4405	4033		1.0	Cumming (1985)
AG	Sebungwe Region	26 2B	MX	1985	14109	9291		0.6	Cumming (1985)
AS	Zambezi Valley Complex	2A 26 28	MX	1985	14300	11000		0.8	Cumming (1985)
AS	Remaining Area		MX	1985		2000			Cumming (1985)
					52318				

Type	Zone	Habitat	Status	Year	Area	Number	%CL/SE	Density	Source
MOZAMBIQUE									
IG	Gile GB & Entre Rios	25 26	GR	1984	1600	50		0.03	Tello Pers. Comm. (1984)
IG	Gorongoza	29C	NP	1984	5300	2000		0.38	Tello Pers. Comm. (1984)
IG	Hunting Block 2	29C	HA	1984	3800	250		0.06	Tello Pers. Comm. (1984)
IG	Hunting Block 6	29C	HS	1984	5600	1000		0.18	Tello Pers. Comm. (1984)
IG	Rest of Area			1984	20500	2000		0.1	Tello Pers. Comm. (1984)
IG	Zambezi Valley UT	16A	UA	1984	8400	1500		0.18	Tello Pers. Comm. (1984)
IG	Remainder Niassa C	16A 25 29C		1981	86700	2000		0.02	Tello Pers. Comm. (1984)
IG	Ruvuma-Lugenda East	16A 25 26		1984	5800	5000		0.9	Tello Pers. Comm. (1984)
IG	Ruvuma-Lugenda West	16A 25 26		1984	16999	1000		0.62	Tello Pers. Comm. (1984)
IG	Banhine	28	NP	1984	6500	750		0.11	Tello Pers. Comm. (1984)
IG	Emofauna Vied Limp	28		1984	9800	50		0.005	Tello Pers. Comm. (1984)
IG	Maputo	16A	NP	1984	1100	200		0.18	Tello Pers. Comm. (1984)
IG	Olifanti-Incomati	290		1984	1300	0		0	Tello Pers. Comm. (1984)
IG	Remainder	26 28 29C 29D 76		1984	61000	1000		0.02	Tello Pers. Comm. (1984)
IG	Save-Buzi	16 29C		1984	26700	500		0.02	Tello Pers. Comm. (1984)
IG	Zinave	26 28	NP	1984	3400	500		0.15	Tello Pers. Comm. (1984)
IG	Chioco	28		1984	1500	25		0.02	Tello Pers. Comm. (1984)
IG	Furancungo	25 26 28		1984	16800	50		0.002	Tello Pers. Comm. (1984)
IG	Messenguezi	28		1984	900	75		0.08	Tello Pers. Comm. (1984)
IG	Zumbo Fingoe	26 28		1984	17200	200		0.01	Tello Pers. Comm. (1984)
					299900				
ZAMBIA									
AR	Kafue	22A 25 26 28 64	NP	1984	22400	4000	SE	0.18	Martin (Mubanga, 1985)
AS	Corridor	26 28		1985	2654	4116	1179	1.5	Kaweche and Lewis (1985)
AS	N. Luangwa	26 28	NP	1985	4460	5282	2031	1.2	Kaweche and Lewis (1985)
AS	S. Luangwa	26 28	NP	1985	9420	13841		1.5	Kaweche and Lewis (1985)
GC	Noete Sanctuary		NP	1985	15	50		3.3	Martin (Mubanga, 1985)
GR	Mweru Wantipa	25 40 76	NP	1984	3134	1000		0.32	Martin (Mubanga, 1985)
GR	Nsumbu	25 40	NP	1984	2020	800		0.4	Martin (Mubanga, 1985)
GR	Sioma Ngwezi	22A 28 64	NP	1984	3527	2500		0.7	Martin (Mubanga, 1985)
IG	Bangweulu			1981		1000			Kaweche (1981)
IG	Gwembe			1981		500			Kaweche (1981)
IG	Kafue Np		NP	1981	22500	4500		0.2	Kaweche (1981)
IG	Mweru & Sumbu Np		NP	1981		1500			Kaweche (1981)
IG	Bangweulu		GMA	1984	6470	50		0.008	Martin (Mubanga, 1985)
IG	Bilili Springs		GMA	1984	3080	0		0	Martin (Mubanga, 1985)
IG	Blue Lagoon		NP	1984	450	0		0	Martin (Mubanga, 1985)
IG	Chambeshi		GMA	1984	620	0		0	Martin (Mubanga, 1985)
IG	Chibwika-Ntambu		GMA	1984	1550	10		0.007	Martin (Mubanga, 1985)
IG	Chisomo		GMA	1984	3390	50		0.01	Martin (Mubanga, 1985)
IG	Chizera		GMA	1984	2280	0		0	Martin (Mubanga, 1985)
IG	Isangano	25 64 75	NP	1984	840	200		0.24	Martin (Mubanga, 1985)
IG	Kafinda		GMA	1984	3860	0		0	Martin (Mubanga, 1985)
IG	Kafue Flats		GMA	1984	5175	0		0	Martin (Mubanga, 1985)
IG	Kapufa		GMA	1984	3600	20		0.005	Martin (Mubanga, 1985)
IG	Kasanka	25	NP	1984	390	50		0.13	Martin (Mubanga, 1985)
IG	Ksonso Busanga		GMA	1984	7780	50		0.006	Martin (Mubanga, 1985)
IG	Lavushi Manda	2564	NP	1984	1500	50		0.03	Martin (Mubanga, 1985)
IG	Liuwa Plain		NP	1984	3660	350		0.09	Martin (Mubanga, 1985)
IG	Lochinvar		NP	1984	410	0		0	Martin (Mubanga, 1985)
IG	Lower Zambezi	26	NP	1984	4090	4000		1.0	Martin (Mubanga, 1985)
IG	Luambe	28	NP	1984	254	300		1.2	Martin (Mubanga, 1985)
IG	Luano		GMA	1984	8930	2600		0.007	Martin (Mubanga, 1985)
IG	Lukusuzi	25 26 28	NP	1984	2720	3500		1.3	Martin (Mubanga, 1985)
IG	Lukwawa		GMA	1984	2540	10		0.003	Martin (Mubanga, 1985)
IG	Lumimba		GMA	1984	4500	3000		0.66	Martin (Mubanga, 1985)
IG	Lunga-Luswishi		GMA	1984	13340	50		0.004	Martin (Mubanga, 1985)
IG	Lupande		GMA	1984	4840	2400		0.5	Martin (Mubanga, 1985)
IG	Lusenga Plain	25	NP	1984	880	500		0.0	Martin (Mubanga, 1985)
IG	Luwingu		GMA	1984	1090	0		0	Martin (Mubanga, 1985)
IG	Machya-Fungulwe		GMA	1984	1530	0		0	Martin (Mubanga, 1985)
IG	Mansa		GMA	1984	2070	300		0.14	Martin (Mubanga, 1985)
IG	Mazabuka		GMA	1984		0		0	Martin (Mubanga, 1985)
IG	Mosi-Oa-Tunya		NP	1984	66	0		0	Martin (Mubanga, 1985)
IG	Mulobesi		GMA	1984	3420	1000		0.3	Martin (Mubanga, 1985)
IG	Mumbwa		GMA	1984	3370	250		0.007	Martin (Mubanga, 1985)
IG	Munyamadzi		GMA	1984	3300	2000		0.06	Martin (Mubanga, 1985)
IG	Musalangu		GMA	1984	17350	500		0.03	Martin (Mubanga, 1985)
IG	Musele-Matebo		GMA	1984	3700	10		0.002	Martin (Mubanga, 1985)
IG	Namwala		GMA	1984	3600	0		0	Martin (Mubanga, 1985)
IG	Nkala		GMA	1984	194	0		0	Martin (Mubanga, 1985)
IG	Nyika		NP	1984	80	0		0	Martin (Mubanga, 1985)
IG	Sandwe		GMA	1984	1530	0		0	Martin (Mubanga, 1985)
IG	Sichifula		GMA	1984	3600	500		0.14	Martin (Mubanga, 1985)

Type	Zone	Habitat	Status	Year	Area	Number	%CL/SE	Density	Source
IG	Tondwa		GMA	1984	540	20		0.04	Martin (Mbugua, 1985)
IG	West Lunga	6.25	NP	1984	1684	350		0.2	Martin (Mbugua, 1985)
IG	West Petauke		GMA	1984	4140	50		0.01	Martin (Mbugua, 1985)
IG	West Zambezi		GMA	1984	38070	750		0.02	Martin (Mbugua, 1985)
					246613				
NAMBIA									
AS	Etosha	28 36 78	NP	1985		2500			AERSG Minutes (1985)
IG	Damaraland	36 51 14		1985		200			AERSG Minutes (1985)
IG	K. Caprivi				1985	2015			AERSG Minutes (1985)
IG	Kandom		GR	1985		400			AERSG Minutes (1985)
IG	N E. Kaokoland/ Ovambo			1985					AERSG Minutes (1985)
IG	W. Damaraland/ Kaokoland			1985		60			AERSG Minutes (1985)
SOUTH AFRICA									
AT	Kruger		NP	1985	19485	6900		0.35	AERSG Minutes (1985)
GC	Addo		NP	1985	40	120		3.0	AERSG Minutes (1985)
GC	Hluluwe-Umfolozi	16A 298	GR	1985		45			AERSG Minutes (1985)
GC	Pilanesberg	290	GR	1985		40			AERSG Minutes (1985)
GC	Pvt Land N.Transvaal		PVT	2985		4			AERSG Minutes (1985)
GC	Tembe Elephant Res.	16C 29E	GR	1985		100			AERSG Minutes (1985)
AR	Timbavati		NR	1977	619	85		0.11	Hall-Martin (1981)
AK	Klaserie		NR	1981	722	180		0.25	Walker (1981)
AR	Sabi Sand		GR	1981	320	30		0.09	Hall Martin (1981)
IG	Knysna		FR	1981	300	3		0.01	Hall Martin (1981)
					21486				
BENIN									
AS	Djona		ZC	1981	1180	170	135%	0.14	Bousquet et al. (1981)
AS	L'Atakora		ZC	1081	1220	0	0	0	Bousquet et al. (1981)
AS	Park W.		NP	1981	5680	850	104%	0.15	Bousquet et al. (1981)
AS	Pendjari		NP	1981	2755	580	96%	0.22	Bousquet et al. (1981)
AS	Pendjari		ZC	1981	1800	450	67%	0.24	Bousquet et al. (1981)
					12635				
BURKINA FASO									
AS	Arli Park National	29A	NP	1981	1132	0		0	Bousquet et al. (1981)
AS	Arli Reserve	29A	NP	1981	1028	0		0	Bousquet et al. (1981)
AS	Arli Zone Cynegetique	29A	ZC	1981	1150	0		0	Bousquet et al. (1981)
AS	Kourtiagou		RP	1981	674	0		0	Bousquet et al. (1981)
AS	Nord Singou/Pama	29A	FC	1981	673	0		0	Bousquet et al. (1981)
AS	Ouest Pama	29A	ZB	1981	1384	50	130%	0.04	Bousquet et al. (1981)
AS	Pama	29A	RP	1981	2272	1340	44%	0.59	Bousquet et al. (1981)
AS	Singou R.T.	29A	RT	1981	1972	1990	51%	0.60	Bousquet et al. (1981)
AS	Tapoadjer		ZC	1981	390	0		0	Bousquet et al. (1981)
AS	W. Park	29A	NP	1981	2290	610	58%	0.27	Bousquet et al. (1981)
IG	Deux Bale	29A 30	NP	1977	560	100		0.18	Green (1977)
IG	Po N.P.	29A	NP	1977	1550	275		0.18	Erickson (1977)
IG	Nazinga	29A	RANC	1983	780	300		0.38	Nazinga (1983)
GHANA									
IG	Bia National Park	1A	NP	1979				0.33	Short (in Merz, 1986)
IS	Bia/Ankasa/Goasa		MX	1979		150			Martin, C. (1979)
IG	Northern Range			1979		650			Martin, C. (1979)
MALI									
HS	Baoule		NP	1983	3500	6		0.002	Bie and Kessier (1983)
IG	R. Des Elefantes		GR	1981	28192	550		0.02	Lamarche (1981)
IG	Range 3			1981	8878	40		0.004	Lamarche (1981)
IG	Range 5			1983	3271	20		0.006	Olivier (1983)
					43841				
NIGER									
IG	Sirba		GR	1981	4200	100		0.02	Newby et al. (1981)
IG	Park W. & Tamou		NP/G	1983	4080	600		0.15	Newby et al. (1981)
IG	Remaining Range				2982	59		0.02	
					11262				
NIGERIA									
AS	Borgu		GR	1976	3924	750		0.19	Milligan (1978)
GR	Yankari		GR	1977	1600	150		0.09	Marshall (1977)
IG	Bama/Gwoza			1976	4000	175		0.04	Hall (1976)
IG	Lake Chad				400	125		0.31	Hall (1976)
					9924				
SENEGAL									
AT	Niokolo Koba	29A	NP	1982	8260	50		0.005	Hall-Martin (1984)
					8260				
TOGO									
AS	Elephant Range			1984	6000	100		0.02	Duncan (1985)
					6000				

Type	Zone	Habitat	Status	Year	Area	Number	%CL/SE	Density	Source
IVORY COAST									
AS	Comoe and Area	11A 27	NP	1982	15000	1500		0.11	Roth et al. (1984)
AT	D'Azagny	1A 8	NP	1982	200	80		0.4	Roth et al. (1984)
DC	Tai Forest	1A 2 3	NP	1982				0.23	Merz. (1982)
IG	Bagbo	1A 2 3	FC	1982	1900	240		0.13	Roth et al. (1984)
IG	Besse Boka and Area	11A 27	FC	1982	600	30		0.15	Roth et al. (1984)
IG	Bossematie and Area	1A 2 3	FC	1982	620	50		0.08	Roth et al. (1984)
IG	Cavally Mt. Sainte	1A 2 3		1982	120	15		0.12	Roth et al. (1984)
IG	Dassiekro and Area	1A 2 3		1982	250	20		0.08	Roth et al. (1984)
IG	Davo and Area	1A 2 3	FC	1982	500	20		0.04	Roth et al. (1984)
IG	Djambamkrou and Area	1A 2 3	FC	1982	300	30		0.1	Roth et al. (1984)
IG	Duekoue	1A 2 3	FC	1982	300	20		0.07	Roth et al. (1984)
IG	Foumbou and Area	1A 2 7	FC	1982	800	30		0.04	Roth et al. (1984)
IG	Go	1A 2 3	FC	1982	550	20		0.04	Roth et al. (1984)
IG	Goin And Area	1A 2 3	FC	1982	1900	100		0.05	Roth et al. (1984)
IG	Haut Bundaama & Area	1A 2 3	RF	1982	1300	60		0.05	Roth et al. (1984)
IG	Irobo and Area	1A 2 3	FC	1982	245	30		0.12	Roth et al. (1984)
IG	Keregbo and Area	1A 2 3	FC	1982	2000	80		0.04	Roth et al. (1984)
IG	Kounoumou and Area	1A 2 7	FC	1982	260	10		0.04	Roth et al. (1984)
IG	Loho and Area	1A 2 7	FC	1982	2000	40		0.02	Roth et al. (1984)
IG	Manzan and Area	1A 2 3	FC	1982	150	20		0.13	Roth et al. (1984)
IG	Marahoue	1A 2 3	NP	1982	1200	150		0.12	Roth et al. (1984)
IG	Monogaga	1A 2 3	FC	1982	350	20		0.06	Roth et al. (1984)
IG	Mont Peko	1A 2 3	NP	1982	600	30		0.05	Roth et al. (1984)
IG	Mopri and Area	1A 2 3	FC	1982	350	30		0.08	Roth et al. (1984)
IG	Mt. Gbandee and Area	1A 2 7	FC	1982	2000	50		0.03	Roth et al. (1984)
IG	Njegre and Area	1A 2 3		1982	1200	80		0.07	Roth et al. (1984)
IG	Non Classe	1A 2 7	NC	1982	400	10		0.03	Roth et al. (1984)
IG	Non Classe	1A 2 7	NC	1982	400	10		0.03	Roth et al. (1984)
IG	Non Classe	1A 2 7	NC	1982	250	10		0.04	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	355	10		0.03	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	350	10		0.03	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	600	20		0.03	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	400	15		0.04	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	400	20		0.05	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	150	10		0.07	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	150	10		0.07	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	300	20		0.07	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	200	20		0.1	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	50	10		0.2	Roth et al. (1984)
IG	Non Classe	1A 2 3	NC	1982	100	20		0.2	Roth et al. (1984)
IG	Nyangboue and Area	1A 27	FC	1982	600	30		0.05	Roth et al. (1984)
IG	Sangbe and Area	1A 2 3	NP	1982	1200	40		0.03	Roth et al. (1984)
IG	Sassandra and Area	1A 2 3	FC	1982	900	60		0.07	Roth et al. (1984)
IG	Scio and Area	1A 2 3	FC	1982	1500	50		0.03	Roth et al. (1984)
IG	Silue	1A 2 7	FC	1982	400	10		0.03	Roth et al. (1984)
IG	Yaya and Area	1A 2 3	FC	1982	2500	200		0.08	Roth et al. (1984)
					45960				
SIERRA LEONE									
DC	Gola East	3	FR	1982	290	60		0.28	Merz (1983)
DC	Gola North	3	FR	1982	454	50		0.12	Merz (1986)
IG	Kangari Hills		GR	1982	120	30		0.25	Roth and Merz (1983)
IG	Tonkoli/Tama	3	FR	1982	60	50		0.9	Roth and Merz (1983)
					924				

KEY TO TYPE OF SURVEY

AS Air Sample Count
AT Air Total Count
AC Air Court Unspecified
AR Aerial Reconnaisance
DC Dropping Count
GC Ground Count
GR Ground Reconnaisance
IG Informed Guess

KEY TO STATUS

Protected Status appears to affect elephant densities more than any other single factor. Mackinnon's classification of protected status will be incorporated into the model, as mill the effectiveness of heal protection. The official status of each census zone is at present keyed in as it appears in the original data, as follows.

KEY TO VEGETATION TYPES

The habitat types in Table 1 follow the nomenclature of the continental vegetation map of White (1981). In the modelling it is planned to use the more recent "Toulouse" vegetation map when it becomes available. However the White nomenclature may be useful at this stage in provoking comments and suggestions on correct habitat classifications that should be used in the model. The explanatory key below follows White's classification of habitat types.

FORESTS

1. Lowland rain forest – wetter types
a. Guineo-Congolian
2. Guineo-Congolian rain forest – drier types
3. Mosaic of 1a and 2
4. Transitional rain forest
5. Malagasy moist montane forest
6. Zambezi dry evergreen forest
7. Malagasy dry deciduous forest
8. Swamp forest

FOREST TRANSITIONS AND MOSAICS

11. Mosaic of lowland rain forest and secondary grassland e. Guineo-Congolian
12. Mosaic of lowland rain forest, Isoberlina woodland and secondary grassland
13. Mosaic of lowland rain forest, secondary grassland and montane elements
14. Mosaic of lowland rainforest, Zambezian dry evergreen forest and secondary grassland
15. West African coastal mosaic
16. East African coastal mosaic
    a. Zanzibar-Inhambane
    b. Sahelomontane
    c. Malagasy J = Juniperus procera forest
    M = Mixed forest
17. & 18. Cultivation and secondary grassland replacing upland and montane forest
19. Undifferentiated montane vegetation
    a. Atromontane
    b. Sahelomontane
    c. Malagasy J = Juniperus procera forest
21. Mosaic of Zambezian dry evergreen forest and wetter miombo woodland
22. Mosaic of dry deciduous forest and secondary grassland
    a. Zambezian
    b. Malagasy

WOODLAND

25. Wetter Zambezian miombo woodland dominated by Brachystegia. Julbernardia and Isoberlina
26. Drier Zambezian miombo woodland dominated by Brachystegia and Julbernardia
27. Sudanian woodland with abundant Isoberlina
28. Colophospermum mopane woodland and scrub woodland
29. Undifferentiated woodland
    a. Sudanian
    b. Ethiopian
    c. North Zambezian
    d. South Zambezian
    e. Transition to Tongalan-Pondoland bushland
30. Sudanian undifferentiated woodlands with islands of Isoberlina
31. Mosaic of wetter Zambezian woodland
35. Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland
    a. Zambezian
    b. Ethiopian
    c. The Windhoek Mountains
36. Transition from Colophospermum mopane scrub woodland to Karoo-Namib shrubland

BUSHLAND AND THICKET

38. & 39. Evergreen and semi-evergreen bushland and thicket
38. East African
39. South African
40. & 41. Deciduous thicket
40. Itigi
41. Malagasy
42. Somalia-Masai Acacia-Commiphora deciduous bushland and thicke
43. Babel Acacia wooded grassland and deciduous bushland
44. Kalahari Acacia wooded grassland and deciduous bushland

BUSHLAND AND THICKET MOSAICS

45. Mosaic of East African evergreen bushland and secondary Acacia wooded grassland
48. Mosaic of Malagasy deciduous thicket and secondary grassland
47. Mosaic of Brachystegia bakerana thicket and edaphic grassland

TRANSITIONAL SCRUBLAND

48. Tugela basin wooded bushland
49. Transition from Mediterranean Argania scrubland to succulent semi desert shrubland
50. Cape Shrubland Fynbos)

SEMI DESERT VEGETATION

51. Bushy Karoo-Namib shrubland
52. Succulent Karoo shrubland
53. Dwarf Karoo shrubland
54. & 55. Semi desert grassland and shrubland
54a. Northern Sahel
54b. Somali-Masaii
55. Sub-Mediterranean
58. The Kalahari/Karoo-Namib transition

GRASSY SHRUBLAND

57. Karoo grassy shrubland
    a. Montane Karoo grassy shrubland
    b. Transition from Karoo shrubland to Highveld

GRASSLAND

58. Highveld grassland
59. Edaphic grassland on volcanic soils
60. Edaphic and secondary grassland on Kalahari Sand
61. Edaphic grassland in the Upper Nile Basin

EDPAHIC GRASSLAND MOSAICS

62. with Acacia wooded grassland
63. with communities of Acacia and broad-leaved trees
64. with semi-aquatic vegetation

ALTIMONTANE VEGETATION

65. in Tropical Africa

DESERT

67. Absolute desert
68. Coastal desert
    a. Atlantic
    b. Red Sea
69. Desert dunes without perennial vegetation
70. Desert dunes with perennial vegetation
71. Regs, hamadas, wadis
72. Saharomontane vegetation
73. Oasis
74. The Namib Desert

AZONAL VEGETATION

75. Herbaceous swamp and aquatic vegetation
76. Halophytic vegetation

Table 2. Comparison oh Elephant Estimates
Successive estimates made in the same census zones are given below, with some 95% confidence limits, or standard m errors. Areas may overlap as in the case of the Mere census zones which were of different sizes. Some estimates compared have different areas, e.g. Bili Uere in Zaire 1976 and 1985, but lie in the same general area, in which case densities may be compared.

Table 2. Comparison of Elephant Estimates

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Type	Zone	Status	Year	Area	Number	%CL/SE	Density	Source
CENTRAL AFRICAN REPUBLIC								
AS	Bamingui	NP	1977	14700	2550		0.17	Spinage (1977)
AS	Bamingui	NP	1985	14700	569		0.04	Douglas-Hamilton et al. (1985)
AS	Koum-Goun		1980	1152	1256		1.09	Douglas-Hamilton et al. (1985)
AS	Koum-Goun		1985	1152	44		9.04	Douglas-Hamilton et al. (1985)
AS	Manovo St. Floris	NP	1978	9195	6278		0.68	Douglas-Hamilton et al. (1985)
AS	Manovo St. Floris	NP	1985	9195	0		0	Douglas-Hamilton et al. (1985)
CHAD								
IG	Range		1979		15000			Martin (1985)
IG	Range		1985		3000			Martin (1985)
IG	Zakouma	NP	1978	3000	1200		0.4	Newby (1980)
AS/A	Zakouma		1985	3000	450	20%	0.13	Bosquet via Froment
ZAIRE								
AS	Bili Uere		1976	9552	6018		0.63	Savidge et al. (1976)
AR	Bili Uere		1985	1895	378		0.20	Douglas-Hamilton (unpub. data)
AS	Garamba	NP	1976	4480	22670		5.06	Savidge et al. (1976)
AS	Garamba	NP	1983	4900	7742		1.58	Hillman et al. (1983)
AT	Virunga Plain	NP	1958	600	1071		1.8	Bouliere & Verschuren (1960)
AT	Virunga Plain	NP	1981	1600	751		0.47	Mertens (1983)
KENYA								
IG	Isiolo District		1973	25605	2000	SE	0.08	Jarman (1973)
AS	Isiolo District		1977-78	25605	1275	478	0.05	Peden (1984)
IG	Kilifi District		1973	12414	1000		0.08	Jarman (1973)
AS	Kilifi District		1977	12414	1586	815	0.13	Peden (1984)
AS	Kilifi District		1978	12414	25	22	0.002	Peden (1984)
AS	Killfi District		1980	12414	338	156	0.03	Peden (1984)
AS	Kilifi District		1983	12414	77	75	0.006	Peden (1984)
IG	Kwale District		1973	8065	2000		0.25	Jarman (1973)
AS	Kwale District		1983	8257	224	152	0.03	Peden (1984)
IG	Laikipia District		1973	9702	1000		0.01	Jarman (1973)
AS	Laikipia District		1977	9718	3524	2841	0.36	Peden (1984)
AS	Laikipia District		1978	9718	2577	1324	0.26	Peden (1984)
AS	Laikipia District		1981	9718	1786	687	0.18	Peden (1984)
AS	Laikipia District		1982	9718	707	522	0.07	Peden (1984)
AS	Lamu Garissa	MX	1973	50437	43000		0.85	Jarman (1973)
AS	Lamu Garissa	MX	1976	20500	9979		0.49	Bunderson (1978)
AS	Lamu Garissa	MX	1977	43931	11427		0.23	Peden (1984)
AS	Lamu Garissa	MX	1978	43931	9582		0.19	Peden (1984)
AS	Lamu Garissa	MX	1983	43931	3661		0.11	Peden (1984)
IG	Mandera District		1973	26470	500		0.02	Jarman (1973)
AS	Mandera District		1977-78	26470	477	223	0.02	Peden (1984)
IG	Mara Area	GR	1958		500			Darling (1980)
AT	Mara Area	GR	1961		455			Talbot and Stewart(1964)
AT	Mara Area	GR	1967		460			Dublin & Douglas-Hamilton (in Press)
AT	Mara Area	GR	1970		729			Dublin & Douglas-Hamilton (in Press)
AS	Mara Area	GR	1977	3760	711	184%	0.19	Dublin & Douglas-Hamilton (in Press)
AC	Mara Zone	GR	1968	6221	532		0.09	Casebeer
AC	Mara Zone	GR	1974	6000	1200		0.2	Taiti, Modha, Soba (1975)
AC	Mara Zone	GR	1979	6400	1027	68%	0.16	Stelfox et al. (1980)
AC	Mara Zone	GR	1980	6400	1047		0.16	Amyungu (1981)
AC	Mara Zone	GR	1981	6400	1231		0.19	Otticholo & Amuyunzi (1982)
AT	Mara Zone	GR	1982	6400	458		0.07	Otticholo (in Press)
AT	Mara Zone 2		1984 Apr		843			Dublin & Douglas-Hamilton (in Press)
AT	Mara Zone 2		1984 Oct		756			Dublin & Douglas-Hamilton (in Press)
AT	Mara Zone 2		1985 May		815			Dublin (1985)
AT	Mara Zone 2		1986 May		1134			Dublin (1986)
IG	Marsabit District		1973	70284	1000		0.01	Jarman (1973)
AS	Marsabit District		1977	73952	1685	1563	0.02	Peden (1984)
AS	Marsabit District		1978	73952	112	67	0.001	Peden (1984)
AS	Marsabit District		1981	73952	231	113	0.003	Peden (1984)
AT	Mara	NP	1965	844	544		0.64	Douglas-Hamilton & Hillman (1976)
AT	Meru	NP	1974	844	1520		1.80	Douglas-Hamilton & Hillman (1976)
AT	Meru	NP	1976	844	1328		1.57	Douglas-Hamilton & Hillman (1976)
AS	Meru Zone	NP	1976	2575	2948	987	1.14	Douglas-Hamilton & Hillman (1976)
AS	Meru Zone	NP	1977	2425	2948	2123	1.2	Wetmore et al. (1977)
AS	Meru Zone 2	NP	1977	8075	8609		1.07	Kremu (1979)
AS	Mera Zone 2	NP	1978	8075	2379		0.29	Kremu (1979)
AS	Meru Zone 2	NP	1981	8075	4070		0.50	Kremu (1979)
IG	Narok District		1973	16947	5000		0.30	Jarman (1973)
AS	Narok District		1977	16115	1174	1286	0.07	Peden (1984)
AS	Narok District		1978	16115	2668	2116	0.15	Peden (1984)
AS	Narok District		1980	16115	2274	1401	0.14	Peden (1984)
AS	Narok District		1983	16115	2474	1109	0.15	Peden (1984)
IG	Samburu District		1973	20209	9000		0.44	Jarman (1973)
AS	Samburu District		1977	17251	1702	843	0.05	Peden (1984)
AS	Samburu District		1981	17521	935	536	0.05	Peden (1984)
AS	Tana River District		1973	38694	32000		0.82	Jarman (1973)
AS	Tana River District		1974-77	38694	14000		0.36	Allaway (Pers Comm.)
AS	Tana River District		1977	38694	9483	3727	0.24	Peden (1984)
AS	Tana River District		1978	38694	3565	984	0.09	Peden (1984)
AS	Tana Rivet District		1980	38694	5745	1650	0.15	Peden (1984)
AS	Tana River District		1983	38694	1340	948	0.03	Peden (1984)
1G	Tana River District		1969	23000	8000		0.14	NcCabe (1969)
AS	Tsavo Ecosyst	NP	1974	43300	34699		0.80	Cobb (1976)
AS	Tsavo Ecosyst	NP	1975	43300	33066		0.76	Leuthold (1976)
AD	Tsavo Ecosyst	NP	1976 Jun	43300	20200		0.47	WCMD (1976)
AG	Tsavo Ecosyst	NP	1976 Sep	43300	18500		0.43	WCMD (1976)
AG	Tsavo Ecosyst	NP	1978	43100	21779		0.49	Douglas-Hamiton
AG	Tsavo Ecosyst	NP	1980	38000	9329		0.25	Otticholo (1981)
AG	Tsavo Taita	MX	1983	16959	12291	4756	0.72	Peden (1984)
IG	Wajir District		1973	56501	1000		0.01	Jarman (1973)
AS	Wajir District		1978	56501	93	88	0.002	Peden (1984)
SOMALIA								
CALC	Rangelands		1980		33950			Calculated from (Watson, 1985)
AS	Rangelands		1984		8624	5943		Watson (1985)
TANZANIA								
AS	Kilombero		1976	7975	5848	1228	0.73	Rodgers et al. (1976)
AS	Kilombero		1986	7975	2330	640	0.28	Douglas-Hamilton et al. (1986)
AT	Manyara	NP	1965	85	421		4.95	Watson & Turner (1965)
AT	Manyana	NP	1967-70	85	380		4.47	Douglas-Hamilton (1972)
AT	Manyara	NP	1976	85	453		5.33	Douglas-Hamilton (1984)
AT	Manyara	NP	1981	85	485		5.71	Douglas-Hamilton and Weyerhaeuser (Unpublished)
AT	Manyara	NP	1984	85	373		4.39	Douglas-Hamilton (1984)
AT	Manyara	NP	1985	100	434		4.34	Douglas-Hamilton (1984)
AS	Ruaha	NP	1972	10200	14816		1.45	Norton-Griffiths (1975)
AS	Ruaha	NP	1977	10200	22852		2.24	Barnes & Douglas-Hamilton (1982)
AS	Ruaha	NP	1983	13100	11929		0.91	Borner & Serverre (1984)
AS	Rangwa	GR	1977	15400	13481	0.98	0.87	Barnes & Douglas-Hamilton (1982)
AS	Rungwa	GR	1983	13800	19575		1.42	Borner & Serverre (1984)
AS	Selous Census Zone		1976	74000	109000	16%	1.47	Douglas-Hamilton (1976)
AG	Selous Census Zone		1986	74000	55000	21%	0.74	Douglas-Hamilton et al. (1976)
AS	Selous NE	GR	1976	19550	29026		2.56	Douglas-Hamilton (1984)
AG	Selous NE	GR	1981	19550	22589		1.99	Borner (1981)
AS	Selous NE	GR	1986	19550	16492		0.84	Douglas-Hamilton et al. (1986)
AS	Selous RF	GR	1976	6354	14471		2.07	Douglas-Hamilton (1984)
AG	Selous RF	GR	1979	6354	10081		1.45	Ecosysems(1980)
AG	Selous RF	GR	1986	6354	5565		0.87	Douglas-Hamilton et al. (1986)
AT	Serengeti	NP	1961	11112	510		0.05	Dublin & Douglas-Hamilton (in Press)
AT	Serengeti	NP	1965-68	11112	2102		0.18	Dublin & Douglas-Hamilton (in Press)
AT	Serengetl	NP	19070-75	11112	2496		0.22	Dublin & Douglas-Hamilton (in Press)
AG	Serengeti	NP	1977	11112	2778		0.25	Dublin & Douglas-Hamilton (in Press)
AT	Serengeti Nth.	NP	1961	5500	440		0.08	Dublin & Douglas-Hamilton (in Press)
AT	Serengetl Nth.	NP	1965-68	5500	1520		0.28	Dublin & Douglas-Hamilton (in Press)
AT	Serengetl Nth.	NP	1970-75	5500	1431		0.26	Dublin & Douglas-Hamilton (in Press)
AT	Serengeti Nth.	NP	1977	5500	1759		0.32	Dublin & Douglas-Hamilton (in Press)
AT	Serengeti Nth.	NP	1984	5500	668		0.12	Dublin & Douglas-Hamilton (in Press)
GC	Tarangire	NP	1958				0.25	Lamprey (1964)
GC	Tarangire	NP	1959				0.7	Lamprey (1964)
AT	Tarangire	NP	1960				3.15	Lamprey (1964)
GC	Tarangire	NP	1960				1.15	Lamprey (1964)
GC	Tarangire	NP	1961				1.63	Lamprey (1964)
AS	Tarangire	NP	1980				1.8	Ecosystems (1980)
AS	Ugalla	GCA	1977	5947	3216		0.54	Ecosystems (1979)
AS	Ugalla	GCA	19799	2493	170	32%	0.07	Ecosystems (1980)

Type	Zone	Status	Year	Area	Number	%CL/SE	Density	Source
SUDAN								
CALC	Shambe		1976		1507			Douglas-Hamilton (estimate)
AS	Shambe		1981	15200	892	429	0.05	Hillman et al.(1981)
UGANDA								
AT	Kidepo	NP	1967	1442	277		0.19	Ross et al. (1976)
AT	Kidepo	NP	1968	1442	417		0.29	Ross et al. (1976)
AT	Kidepo	NP	1969	1442	540		0.37	Ross et al. (1976)
AT	Kidepo	NP	1970	1442	471		0.33	Ross et al. (1976)
AT	Kidepo	NP	1972	1442	820		0.57	Ross et al. (1976)
AT	Kidepo	NP	1975	1442	333		0.23	Edroma (1975)
AT	Kidepo	NP	1981	1442	411		0.29	Douglas-Hamilton (1984)
AT	Kidepo	NP	1982	1442	428		0.30	Douglas-Hamilton (1984)
AT	Murchison Nth.	NP	1963 Oct	1759	1170		0.67	Buss & Savidge (1966)
AT	Murchison Nth.	NP	1964 Mar	1759	1903		1.08	Buss & Savidge (1966)
AT	Murchison Nth.	NP	1964 May	1759	1894		1.08	Buss & Savidge (1966)
AT	Murchison Nth.	NP	1970	1759	3637		2.07	Eltringham & Malpas (1980)
AT	Murchison Nth.	NP	1971	1759	3351		1.91	Eltringham & Malpas (1980)
AT	Murchison Nth.	NP	1973	1759	3923		2.23	Eltringham & Malpas (1980)
AT	Murchison Nth.	NP	1974	1759	1979		1.13	Eltringham & Malpas (1980)
AT	Murchison Nth.	NP	1975	1759	1185		0.67	Eltringham & Malpas (1980)
AT	Murchison Nth.	NP	1976	1759	903			Eltringham & Malpas (1980)
AT	Murchison Nth.	NP	1976	1759	975		0.55	Eltringham & Malpas (1980)
AT	Murchison Nth.	NP	1980	1759	1248		0.71	Douglas-Hamilton (1984)
AT	Murchison Nth.	NP	1982	1759	978		0.55	Douglas-Hamilton (1984)
AT	Murchison Sth.	NP	1963 Jul	2100	5611		2.67	Buss & Savidge (1966)
AT	Murchison Sth.	NP	1963 Oct	2100	6126		2.92	Buss & Savidge (1963)
AT	Murchison Sth.	NP	1964 Mar	2100	7454		3.55	Buss & Savidge (1966)
AT	Murchison Sth.	NP	1964 May	2100	7815		3.72	Buss & Savidge (1966)
AT	Murchison Sth.	NP	1966 Nov	2100	7779		3.70	Laws et al. (1973)
AT	Murchison Sth.	NP	1967 Aug	2100	7913		3.77	Laws et al. (1973)
AT	Murchison Sth.	NP	1967 Feb	2100	8713		4.15	Laws et al. (1973)
AT	Murchison Sth.	NP	1969	2100	9364		4.46	Laws et al. (1973)
AT	Murchison Sth.	NP	1973	2100	9971		4.75	Eltringham & Malpas (1980)
AT	Murchison Sth.	NP	1974	2100	4072		1.94	Eltringham & Malpas (1980)
AT	Murchison Sth.	NP	1975	2100	1061		0.51	Eltringham & Malpas (1980)
AT	Murchison Sth.	NP	1976 Mar	2100	1682		0.80	Douglas-Hamilton (1984)
AT	Murchison Sth.	NP	1976 Sep	2100	1113		0.53	Eltringham & Malpas (1980)
AT	Murchison Sth.	NP	1980	2100	160		0.08	Douglas-Hamilton (1984)
AT	Murchison Sth.	NP	1982	2100	25		0.01	Douglas-Hamilton (1984)
AT	Qep	NP	1963 Jul	1978	1758		0.89	Buss & Savidge (1966)
AT	Qep	NP	1963 Oct	1978	1389		0.70	Buss & Savidge (1966)
AT	Qep	NP	1964 Mar	1978	1295		0.65	Buss & Savidge (1966)
AT	Qep	NP	1964 May		2222			Buss & Savidge (1966)
AT	Qep	NP	1966 Jun	1978	1891		0.96	Field (1971)
AT	Qep	NP	1966 Sep	1978	3884		1.96	Field (1971)
AT	Qep	NP	1967 Dec	1978	2757		1.39	Field (1971)
AT	Qep	NP	1967 May	1978	4139		2.09	Field (1971)
AT	Qep	NP	1968 Aug	1978	1353		0.68	Field (1971)
AT	Qep	NP	1968 May	1978	2039		1.03	Field (1971)
AT	Qep	NP	1968 Nov	1978	3410		1.72	Field (1971)
AT	Qep	NP	1969 Dec	1978	2948		1.49	Field (1971)
AT	Qep	NP	1969 Mar	1978	3581		1.81	Field (1971)
AT	Qep	NP	1970 Aug	1978	1543		0.78	Eltringham (1977)
AT	Qep	NP	1970 Dec	1978	2540		1.28	Eltringham (1977)
AT	Qep	NP	1971 Feb	1978	1678		0.85	Eltringham (1977)
AT	Qep	NP	1971 Jul	1978	1624		0.82	Eltringham (1977)
AT	Qep	NP	1971 May	1978	2355		1.19	Eltringham (1977)
AT	Qep	NP	1971 Nov	1978	3230		1.63	Eltringham (1977)
AT	Qep	NP	1972 Jan	1978	1616		0.82	Eltringham (1977)
AT	Qep	NP	1972 Jul	1978	2009		1.01	Eltringham (1977)
AT	Qep	NP	1972 May	1978	3002		1.52	Eltringham (1977)
AT	Qep	NP	1973	1978	2773		1.40	
AT	Qep	NP	1974	1978	1861		0.94	Eltringham & Malpas (1980)
AT	Qep	NP	1975	1978	854		0.43	Eltringham & Malpas (1980)
AT	Qep	NP	1975	1978	1047		0.53	Eltringham & Malpas (1980)
AT	Qep	NP	1976 Mar	1978	1232		0.62	Parker & Douglas-Hamilton (1976)
AT	Qep	NP	1976 Sep	1978	704		0.35	Eltringham & Malpas (1980)
AT	Qep	NP	1980	1978	153		0.08	Douglas-Hamilton (1984)
AT	Qep	NP	1982	1978	428		0.22	Douglas-Hamilton (1984)
ZAMBIA								
IG	Luangwa				1934		7000	Pitman (1934)
AS	Luangwa	NP	1973	16280	56000		3.44	Caughley & Goddard (1975)
AS	Luangwa	NP	1979	16280	35478		2.18	Douglas-Hamilton et al. (1979)

Type	Zone	Status	Year	Area	Number	%CL/SE	Density	Source
NAMIBIA								
IG	Kaokoland		1913		1200-1500			Steunhardt (Shortridge 1934)
IG	Kaokoland		1923		250			Manning (Shortridge 1934)
IG	Kaokoland		1930's		20000			Police Est. (Shortridge 1934)
IG	Kaokoland		1934		600-1000			Shortridge (1934)
IG	Kaokoland		1962		3000			Odendaal Report
IG	Kaokoland		1970		600-800			Owen-Smith (1983)
IG	Kaokoland		1977		250			Owen-Smith (1983)
AC	Kaokoland		1982		36			Owen-Smith (1983)
SOUTH AFRICA								
GC	Addo	NP	1960	22	29		1.32	Penzhorn et al. (1974)
GC	Addo	NP	1962	22	33		1.5	Penzhorn et al. (1974)
GC	Addo	NP	1963	22	35		1.59	Penzhorn et al. (1974)
GC	Addo	NP	1964	22	40		1.82	Penzhorn et al. (1974)
GC	Addo	NP	1965	22	45		2.05	Penzhorn et al. (1974)
GC	Addo	NP	1966	22	50		2.27	Penzhorn et al. (1974)
GC	Addo	NP	1967	22	52		2.36	Penzhorn et al. (1974)
GC	Addo	NP	1968	22	57		2.59	Penzhorn et al. (1974)
GC	Addo	NP	1969	22	63		2.86	Penzhorn et al. (1974)
GC	Addo	NP	1970	22	63		2.86	Penzhorn et al. (1974)
GC	Addo	NP	1971	22	64		2.91	Penzhorn et al. (1974)
GC	Addo	NP	1972	22	65		2.95	Penzhorn et al. (1974)
GC	Addo	NP	1974	22	62		2.82	
GC	Addo	NP	1976	22	77		3.5	Hall-Martin (1986)
GC	Addo	NP	1979	22	102		4.64	Hall-Martin (1986)
GC	Addo	NP	1980	22	104		4.73	Oryx Update (1980)
GC/A	Addo	NP	1981	40	108		2.7	Hall-Martin (1981)
GC	Addo	NP	1985	40	120		3.0	AERSG Minutes (1985)
IG	Kruger	NP	1912		25			Pineaar (1963)
IG	Kruger	NP	1936		24			Pineaar (1963)
AT	Kruger	NP	1967	19485	6586		0.34	Hall-Martin (1981)
AT	Kruger	NP	1968	19485	7701		0.40	Hall-Martin (1981)
AT	Kruger	NP	1969	19485	8312		0.43	Hall-Martin (1981)
AT	Kruger	NP	1970	19485	8821		0.45	Hall-Martin (1981)
AT	Kruger	NP	1971	19485	7916		0.41	Hall-Martin (1981)
AT	Kruger	NP	1972	19485	7611		0.39	Hall-Martin (1981)
At	Kruger	NP	1973	19485	7965		0.41	Hall-Martin (1981)
AT	Kruger	NP	1974	19485	7702		0.39	Hall-Martin (1981)
AT	Kruger	NP	1975	19485	7498		0.38	Hall-Martin (1981)
AT	Kruger	NP	1976	19485	7275		0.37	Hall-Martin (1981)
AT	Kruger	NP	1977	19485	7715		0.39	Hall-Martin (1981)
AT	Kruger	NP	1978	19485	7478		0.38	Hall-Martin (1981)
AT	Kruger	NP	1980	19485	7454		0.38	Hall-Martin (1981)
AT	Kruger	NP	1981	19485	7500		0.38	Hall-Martin (1981)
AT	Kruger	NP	1985	19485	6900		0.35	AERSG Minutes (1985)
ZIMBABWE								
AS	Hwange	NP	1968	14540	6581		0.45	Williamson (1975)
AS	Hwange	NP	1969	14540	6045		0.42	Williamson (1975)
AS	Hwange	NP	1970	14540	7840		0.54	Williamson (1975)
AS	Hwange	NP	1971	14540	8141		0.56	Williamson (1975)
AS	Hwange	NP	1973	14540	100001		0.69	Cumming (Personal Comment)
AS	Hwange	NP	1974	14540	14000		0.96	Cumming (Personal Comment)
AS	Hwange	NP	1977	14540	12000		0.83	Cumming (Personal Comment)
AS	Hwange	NP	1979	14540	16000		1.10	Cumming (Personal Comment)
AS	Hwange	NP	1983	14540	21668		1.49	Cumming (Personal Comment)
AG	Hwange	NP	1984	14540	16718		1.15	Cumming (1985)
MALI								
IG	Bouc Baou	NP	1977		70			La Marche
IG.	Bouc-Baou	NP	1980		20			La Marche
IG	Bouc-Baou	NP	1984		6			Van Wijngaarden
SENEGAL								
AC	Niok-Koba	NP	1967	9000	69		0.008	Du Puy (1967)
AC	Niok-Koba	NP	1968	9000	67		0.007	Du Puy (1968)
AC	NioK-Koba	NP	1969	9000	63		0.007	Du Puy (1969)
AC	Niok-Koba	NP	1970	9000	141		0.02	Du Puy (1970)
AC	Niok-Koba	NP	1971	9000	142		0.02	Du Puy (1971)
AC	Niok-Koba	NP	1975	9000	230		0.03	Du Puy (1975)
AC	Niok Koba	NP	1977	9000	350		0.04	Du Puy (1977)
AC	Niok-Koba	NP	1978	9000	80		0.01	Du Puy (1978)
AC	Niok Koba	NP	1979	9000	450		0.05	Du Puy (1979)
AC	Niok-Koba	NP	1980	9000	223		0.02	Du Puy (1980)
AC	Niok-Koba	NP	1981	9000	170		0.02	Du Puy (1981)
AC	Niok-Koba	NP	1982	9000	67		0.007	Du Puy (1982)
AC	Niok-Koba	NP	1984	9000	50		0.01	Hall-Martin (1986)

INTERPRETATION OF ESTIMATES

The data on most recent estimates and comparisons of estimates need to be sifted carefully for possible biases in data acquisition.

It must be borne in mind that as counting techniques improved so estimates increased. Early aerial counts were usually total counts or sample counts with wide strip widths of 250 metres or more. Narrow strip widths tend to give higher estimates than wider ones (Caughley, 1977). In addition, sample counts tend to give higher estimates than total counts. Informed guesses tend to be on the low side compared to aerial sample or total counts. For example, in the Selous Game Reserve, B. Nicholson, the game warden, estimated 50000 elephant compared to a sample count estimate of 110 000 in 1976. This is only one case which refers to the largest censused elephant population in Africa, but most estimates made without aerial surveys were similarly low.

Any apparent build-up in elephant numbers must therefore be analysed to see what is due to real increase and what is due to observer improvements. In Kruger, Hwange and Tsavo national parks some of the build-up is thought to be due to better counting.

On the other hand informed guesses about trends have often been confirmed by later aerial counts, (Douglas-Hamilton, 1983a). Hunters or naturalists familiar with specific areas have been able to give an early warning of negative trends. Unfortunately, these have often been ignored, or dismissed as unconfirmed reports and speculation. In Somalia, Sudan, Chad, CAR, Zaire and many other countries reports of changes occurring on a vast scale have not attracted much attention until later confirmed by aerial counts (Douglas-≠Hamilton, 1983), or by the method of using elephant carcass ratios to determine trends (Douglas-Hamilton and Burrill, 1986).

An interpretation of probable trends based on these data is given by Douglas-Hamilton (1987). Informed comment from AERSG can further refine the analysis of trends.

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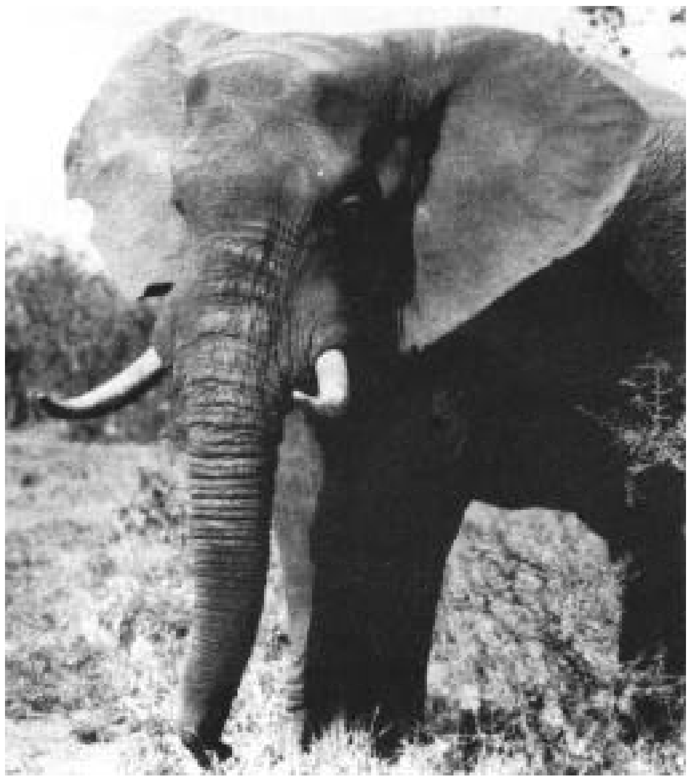

Elephants and Woodlands II

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A brief article on elephant/woodland interactions, published in the AERSG newsletter (Jachmann and Bell, 1984) has generated a lively discussion on elephant feeding strategies and on the equilibria between elephants and their food sources (Lindsay and Olivier, 1984; Bell, 1985; Lindsay, 1987). Although I feel that, at this point, the dialogue seems primarily to concern semantic issues, I would like to clarify and expand some of my ideas on these topics. The various arguments will be treated separately below.

ELEPHANT DIETARY REQUIREMENTS

In his last response, Lindsay (1987) addresses the question whether elephants are primarily grazers or browsers, probably misunderstanding the essence of our point in Bell's reply (1985). Once more I would like to make it clear that the information available shows that elephants require a diet consisting of at least 50% browse on a year-round basis. This observation results from the simple fact that in any given situation grasses rapidly become too fibrous (thereby decreasing their digestibility and diluting the nutrients present) to make up a substantial part of an elephant's diet for an extended period.
Furthermore I do not believe that it is correct to state that the'"cell walls of grasses are not highly lignified" (Lindsay, 1987). As compared to what? In comparison with woody browse, but certainly not with foliage; firstly, because""not highly lignified" only applied to a relatively short period and secondly, grass lignins differ from browse lignins in structure and/or in composition (Swain, 1979). Browse and grass species with a similar lignin content may show a difference in digestibility (by reducing the availability of carbohydrates and proteins to herbivores) in favour of browse species. Moreover, the lignin content of grasses ≠between 2% and 8% dry weight (Soest and Wine, 1967) – is the same as that of the foliage of the **Brachystegia** woodlands (miombo) of Kasungu National Park, Malawi, also containing between 2% and 8% lignin, i.e. 4.74 **+/–** 1.73% in the early wet season (Jachmann, in prep.). The lignin content of miombo leaves slowly increases over the seasons by about 1%, whereas the lignification process in grasses takes place more rapidly and to a greater extent. By reducing overall digestibility, lignins appear to be an important factor determining selective feeding by elephants (Jachmann, in prep.). A certain amount of crude fibre (cellulose and hemicellulose), however, appears to be an essential component of an elephant's diet (Jachmann, in prep.). A high protein/fibre ratio, as in young grasses, may give a rapid throughput and a low absolute rate of assimilation (R.H.V. Bell, pers. comm.) necessitating the intake of a certain amount of browse. In addition, for a given area, the concentration of minerals like magnesium, calcium and sodium may be two to four times lower in grasses than in browse, on a year-round basis (Dougall et al., 1964). It was shown by Jachmann (1983a, 1985 and in prep.) that these minerals significantly contribute to the selective utilisation of browse species by elephants in the miombo woodlands of Malawi.

WOODLAND RESPONSE TO ELEPHANT DAMAGE

Plant secondary chemicals may be important factors, both in contributing to the relative instability of woodlands in arid eutrophic areas under the influence of elephant feeding and in promoting the existence of equilibria between coppice phase woodlands and elephants in moist oligotrophic areas. As shown by Waring et al. (1985), carbon-based defensive compounds such as tannins increase with a decreasing nutrient availability. In Kasungu National Park, tree species growing in "valley areas" with a relatively high soil nutrient status exhibit low levels of phenolic compounds compared to-those species growing on the infertile""plateau areas" (Jachmann, unpubl.). In general, trees growing on eutrophic soils may exhibit relatively low levels of carbon-based defensive compounds as compared with trees growing on oligotrophic soils.
Tree foliage of the Kasungu miombo woodlands varies in total phenolic content from 1 to 16% dry weight (Jachmann, in prep.), whereas the protein precipitating capacity varies from 0 to 1 mg protein per mg of dried plant material. The threshold values, at which elephants avoid feeding on the tree, are about 100/a total phenolics with a protein precipitating capacity of about 0.5 mg protein per mg dried plant material. South African researchers have shown that after a tree has been damaged by browsers, the tannin-C content (proanthocyanidins) of several miombo species increases by as much as three times within a period of only one hour – after which several species sustained a relatively high tannin-C level for a couple of days (van Hoven, 1985).
Acacia tortilis, a species mainly occurring in arid eutrophic areas and very susceptible to elephant attack, not only increased phenolic content from a low basic level of **2.3%** to **3.3%** in one hour (43%) but also showed a rapid decrease back to its normal level. Apart from the fact that miombo tree species have a high basic level of phenolic compounds, the extent to which the increase in these occurs as well as the period of decrease probably differ from species found on richer soils. This implies that in areas with predominantly miombo woodland and relatively high elephant densities, in addition to other secondary chemicals, a large number of trees will have a phenolic content exceeding the threshold value for elephants. Mature trees however, with a canopy above the maximum feeding level for elephants, will not be damaged up to the moment until the tree is pushed over Although the protein/fibre ratio of such a mature tree may be lower than that of its coppice neighbour, other components may occur in similar concentrations and the phenolic content will be relatively low (Jachmann, in prep.).
Hence, depending on the conditions, the short term benefit of feeding on foliage with low levels of phenolic content seems to be more important than the longer term advantage (side effect) of stimulating grass production and/or enhancing the occurrence of coppice phase trees in miombo woodlands. We could say that the direct feeding necessity is the proximate causal factor that brings about the tree felling behaviour.

Activity areas of family units and entire kin groups, however, appear to be relatively stable, depending on the human/animal conflict situation (Jachmann, 1983b). In combination with the long lifespan and social organisation of elephants, there appear to be conditions under which the effect of the long term advantage of the tree felling behaviour should not be underestimated. As pointed out by Bell (1985), the Namibia desert elephants utilise trees on a sustainable basis. This shows that in arid conditions, the negative long term effect is strong enough for the "minimal damaging trait" to penetrate the population and in the long run outweigh the short term benefits.

Certain tree species in arid eutrophic areas may have relatively low basic levels of phenolics. Moreover the phenolic content cycle, occurring after damage inflicted by herbivores, may generally take place within a relatively short period. This implies that herbivores can browse on a single tree with its canopy within feeding range during a relatively long period. Other tree species may show a similar severe response in phenolic activity as those found in miombo woodlands.

Instability of woodlands in arid eutrophic areas, however, is the outcome of interactions between a large number of factors, several of which will be briefly outlined below:

1. Growth and regeneration
   - 1.1 Seed germination: Seeds are often highly nutritious and low in defensive compounds (Acacia), encouraging utilisation by beetles and monkeys amongst others. Rainfall and soil infiltration rates are low, resulting in low water potentials, inhibiting seed germination.
   - 1.2 Growth is affected by the large biomass of other browsers causing a vast amount of damage to seedlings and saplings, whereas in some areas the grass biomass results in hot fires, increasing the probability of death in the youngest trees. The growth of saplings and seedlings is also inhibited by low water potentials.
   - 1.3 Regeneration of trees after breakage by elephants may follow a species dependent pattern. A dominating top meristem in combination with a relatively small tap-root in certain **Acacia** species may inhibit multi-stemmed coppicing and the growth of side branches (Jachmann, unpubl.).
2. The density of trees seems to follow an inverse relationship with the soil nutrient availability.
3. Shade intolerance in certain tree species will select for height growth rather than strength and longevity, resulting in a relatively thin stem and a heavy canopy in mature trees. The tree will be easy to push over, even at higher ages (low safety factor).
4. Factors inherent to the animal populations, like the time lag in reproductive response in elephants. This is, however, beyond the scope of this contribution.

Although basic levels and cycles in phenolic activity may significantly contribute to woodland instability under the influence of herbivores, another phenomenon may also be involved. In arid eutrophic areas, high densities of browers, a minimal coppicing rate and slow regeneration in a number of tree species may be major factors contributing to a possible shift of a large part of the tree canopy to levels above the feeding range for elephants, necessitating tree felling to bring the biomass within reach.

THE NON-DAMAGING TRAIT IN THE NAMIBIA DESERT ELEPHANTS

Why did this non-damaging trait evolve under these particular conditions and not elsewhere? Significant factors may be the size and location of the seasonal activity areas of the units of the various kin groups that belong to a clan. The size of an area depends on the number of animals in the unit, due to food competition ($P < 0.001$; Jachmann, 1983b). The size, location and overlap of activity areas also depend on the food availability at that particular time of year (Jachman, 1983b). In Kasungu National Park, dry season activity areas are mainly located in the "plateau" woodlands and are relatively large with little overlap. Early wet season areas, however, are all concentrated in the tall grass""valley" regions and are relatively small with a lot of overlap. Large aggregations of elephants of "clan gatherings" only occur during the early wet season. Long communual feeding periods of the units belonging to a kin group also appear to fully depend on the abundancy of food. On a seasonal basis, the density of elephants increases with food availability. Hence, during the early wet season, the degree of relationship between any two members of a group of elephants occupying a certain area appears to be low as compared to the dry season or low food availability situation. Under these circumstances, elephants that carry the non-damaging trait do not in the long run profit from the side-effect of this behaviour. The situation of the Namibia desert elephants, however, is rather different: minimal food availability most likely results in (1) low reproductive rate (Jachman, 1986), (2) high mortality rate, (3) low density, (4) very large activity areas, (5) limited overlap of activity areas and hence (6) high degree of kinship between elephants occupying a certain area and a limited time period that elephants spend with non-kin. These factors combined present an ideal situation for kin selection to facilitate the penetration of a""minimal damaging trait".

We could thus describe the relevant parameter as being the mean degree of kinship per elephant per time unit per area unit.

I agree, however, that""maladapted" is not a suitable term for elephants damaging woodlands. Maybe "adapted" should be sufficient to describe the Namibia desert elephants.

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References are ***continued on P. 18***

The Yemeni Rhino Horn Trade

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From the early 1970s to 1984 the Yemen Arab Republic (North Yemen) imported almost half of all the rhinoceros horn put onto the world market. Its wholesale value in North Yemen was a total of approximately US$10 000 000[1]. Under pressure from various international organizations the government passed a law in 1982 which prohibited the import, but not the export, of rhino horn. Unfortunately, due to a variety of reasons (published elsewhere[2]), the government did not enforce this law. However, from 1980. to 1984 the quantity of horn imported dropped to a yearly average of about one and a half tonnes, compared with at least three tonnes in the 1970s. Although significantly less, one must remember that in 1970 there were about 65 000 black rhinos and by 1980 only 15 000 were left.[3]

The relatively open market in North Yemen makes this the single most threatening country to the conservation of the African rhinos. Consequently, I went back to the Yemen Arab Republic in late 1986 for the purpose of urging the government to take action to enforce the law against rhino horn imports, to implement additional legislation prohibiting the export of rhino horn and to encourage the use of substitutes for rhino horn in making dagger handles. Since my last visit to the country in 1984, there have been some very dramatic changes, especially in the economy which has slowed down from a 3% growth to an annual average of just 1.5% in 1985 and 1986. From a per capita point of view, this means that the economy has been going backwards at an average rate of minus 1.8% per year.[4] Foreign remittances to banks in North Yemen from migrant workers (the main source of hard currency for the government) have declined from just over $1 000 000 000 in 1984 to $600 000 000 in 1986, mainly due to the economic recession in Saudi Arabia and other Gulf States.

The government of North Yemen has been experiencing other economic difficulties, too. Foreign aid in the form of grants has declined from $400000000 in 1982 to $100000000 in 1986 because the two main donors, Iraq and Saudi Arabia, have had their own problems as a result of the decline in oil prices and the diversion of funds to the Iraqi-Iranian War.[5] Another very serious economic problem in North Yemen is that of the limited value of the country's exports, which has remained at only about $10000000 per annum for the past five years. In 1985 this was just one per cent of the total value of North Yemen's imports[6]——a bizarre statistic! North Yemen's main exports are biscuits (around half the value of all its exports), fruits, hides and skins. Coffee exports, which used to be the country's main foreign exchange earner, fell from $2 217 734 in the financial year 1969/70[7] to a mere $192 000 by 1980.[8] This is because almost all the land suitable for growing coffee has been turned over to qat **(Catha edulis)** production, which is more profitable to the farmers but which is sold only domestically. In actuality, there are essentially no meaningful exports from North Yemen.

Given these predicaments, it is not surprising that the North Yemen government is very short of hard currency. Central Bank reserves have fallen from $1 400 000 000 in 1980[9] to $322 000 000 in 1985.[10] This state of affairs has, in turn, led to a sharp decline in the value of the rial in a very short period of time. From 1973 to 1983 the official exchange rate remained at 4.58 Yemeni rials for one US dollar. The unofficial rate was just slightly higher, and the money changers on the streets of Sanaa always had sufficient dollars for their customers. However, beginning in October, 1983, the rial began to depreciate; in December, 1985, the bank rate had fallen to 7.79 rials to the US dollar and by the end of November, 1986, the rate had dropped to 11.86. At the time of my arrival in North Yemen in early December, 1986, all the money changers' shops had been closed down by the government and even some of them had been imprisoned for overcharging for the purchase of US dollars, according to the government. At this time the market rate for one US dollar was 15 rials, due to a severe shortage of hard currency.

On top of all these serious economic problems has been the chronic smuggling of large quantities of goods, mainly consumer items, into the country.[11] The United States Embassy in Sanaa estimates that the total value of the economy, including the informal (smuggling) sector as well as the formal (legal) economy amounted to more than $7000000000 in 1986, and of this total, $350000000 was unrecorded remittances brought into the country and $1 350 000 000 was the worth of goods smuggled in.[12] The majority of the smuggled items are brought in from Saudi Arabia overland, and include such items as food, electrical gadgets and clothes. Other commodities are brought in illicitly from the United Arab Emirates and, until recently, fuel and liquor were brought in by truck from South Yemen. In addition, there is the infamous liquor trade based in and around the port of Mocha, which relies on large quantities of beer and whisky purchased in Djibouti by Yemeni merchants and transported by **zarouk** (Yemeni dhows) to the beaches around Mocha. In October, 1986, a 0.75 litre bottle of Johnny Walker Whisky sold at Mocha for $6.44; in Sanaa, in December, 1986, that same bottle of whisky retailed for $31.50 due to the number of hands it had passed through, the bribes paid at roadblocks on the way to the capital and the profit demanded by the merchant who sold it.

The main incentive for smuggling goods into North Yemen is the avoidance of having to pay high government taxes on imports. In 1986 import duties on luxury goods were raised to 105%,[13] and, moreover, it was almost impossible to obtain legal foreign exchange to pay for them. The government is well aware that large amounts of convertible currencies are not being brought back to North Yemen by the migrant workers and that they are being used to purchase consumer items in Saudi Arabia and other places≠and that these are eventually smuggled into North Yemen. Therefore, the government has tightened the controls at the Saudi Arabian frontier, and smuggling is now decreasing, but this has caused severe shortages of goods in the country. Some merchants have attempted to circumvent the controls by switching from large trucks to smaller pick-ups for transporting smuggled goods; with the smaller vehicles the transport costs are, of course, higher, but they can more easily evade roadblocks in the desert.

While disastrous in many respects, North Yemen's economic decline has been beneficial to international conservation efforts to decrease the quantity of rhino horn brought into the country. From 1980 to 1984 about 1 500 kg were imported annually on average, and these were all illegal after August, 1982. In 1.985 the quantity decreased to about one tonne, and for 1986 perhaps under 500 kg came in. Although the wholesale price in US dollars for the rhino horn has gone up only a little since 1984, in Yemeni rials it has more than doubled; in late 1986, a trader in Sanaa paid an importer between $600 and $1 000 per kg for rhino horn, depending upon its size and quality, compared with $800 in 1984 for an average 1.5 kg horn. However, in rials, this meant that the price sky-rocketed from 4 300 to 10 000 rials per kg. On account of this very high price in rials, some of the craftsmen and consumers can no longer afford to buy rhino horn.

The main traders with whom I spoke said that for the best quality horn – which they believed was from a middle-aged rhinoceros possessing horns in good condition weighing in excess of 1.5 kg≠they would pay from $800 to $1 000 per kg. An acquaintance of mine in December, 1986, posed as a dealer and tried to obtain the equivalent of $1 200 in rials for a kilogram of good quality horn, but could not. The main merchant in Sanaa, who claims that he handled between two-thirds and 80% of all the horn used in the Yemen Arab Republic until the mid-1980s, does not himself go to Africa to purchase it. Usually, Sudanese, Ethiopian and Kenyan importers, some of whom are of Yemeni origin, bring the horn to Sanaa, either by air or overland, and offer it to the merchant who pays them in rials, and then they exchange the rials for US dollars, using Yemeni money changers.

From 1980 to 1983, according to this merchant, the rhino horn came from the Sudan, Tanzania, Kenya, Ethiopia and Somalia. A lot of it was brought into Sanaa by air, although some was carried by dhows from East Africa up to Djibouti and thence to the coast of the Yemen Arab Republic. In 1984 the horn came mostly from Tanzania, Somalia and India; the horn which came from India was smuggled out of East Africa. In 1985 and 1986 almost all the horn purchased by the largest merchant in Sanaa originated from the Sudan, but there were some small consignments from Ethiopia, also. The horn from the Sudan is exported illegally to Jeddah by Sudanese who have family connections in the Yemen. They arrange for it to be packed in large food sacks which contain rice, flour or sugar, and brought to Sanaa clandestinely.

Aside from the most prominent trader, there are several others involved in buying rhino horn. Some of these told me that they have obtained their most recent supplies from Kenya, India and the United Arab Emirates (UAE). The UAE connection has become a very important one in the past few years. Large quantities of rhino horn originating from dead rhinos in Tanzania, Zambia, Zimbabwe and Mozambique have been exported illegally to Burundi, but this trade in Burundi is, apparently, not illegal and it brings in much-needed convertible currency. There is a group of merchants in the capital, Bujumbura, most of whom are Somalis, Senegalese and Malians, who handle all types of animal products for re≠export, including elephant ivory, leopard skins and rhino horns, plus gold, diamonds and other valuable merchandise. Ian Parker, who spent some time in Bujumbura in September, 1986, confirmed to me that large amounts of rhino horn are **available there:** he personally saw at least one tonne comprising 700 pieces ready to leave the country. Most of the horn shipped out of Burundi goes by air on the weekly Ethiopian Airlines flight to Addas Ababa; from there it is sent on another Ethiopian Airlines plane to Dubai where it is re≠packed and put onto trucks which go overland through the Saudi Arabian Empty Quarter to the relatively unpatrolled eastern boundany of North Yemen. Apparently, some of the rhino horn in Bombay is also moved into the UAE for transhipment to Sanaa through the desert, It is because customs controls at the Sanaa airport have been tightened that rhino horn from the UAE is now being sent into the country overland.

One trader told me that some diplomats in African countries send rhino horn in diplomatic pouches to their embassies in Sanaa for sale. This is in addition to the rather well-known fact that a particular eastern Asian communist country has had its diplomats involved in clandestine rhino horn trade for several years; the diplomats from that country deal in horn from poached rhinos in Zimbabwe and Zambia. I have myself seen a confiscated consignment of theirs. They trade in rhino horn for the purpose of obtaining convertible currencies, and they never send the horn back to their own country (where, in fact, there is a certain demand for it as a medicine) because their government considers rhino horn a luxury item which the people can do without – and it is much more important to conserve scarce foreign exchange for necessities. This is the same reason why rhino horn daggers are no longer made in the People's Democratic Republic of Yemen (South Yemen), which also has a Marxist government and foreign exchange is unavailable to traders.

On this most recent trip to North Yemen, I found another piece to the jigsaw puzzle of the rhino horn trade. In the 1970s shavings left over from the carving of rhino horn handles were exported to Hong Kong, but when the Crown Colony began conforming to the principles of CITES in 1979, this trade stopped.[14] In the early 1980s a Chinese in Sanaa began sending them to mainland China for use in patent medicines. Now, South Koreans have entered the market for rhino horn shavings in Sanaa, and although there are Koreans from both North and South Korea working in the Yemen Arab Republic, I believe it is only the South Koreans who are buying them. In 1985 one craftsman sold his shavings for $139 (1 000 rials) per kg to Yemeni middlemen and "Orientals", but in 1986 he received $227 (2 200 rials) pen kg for them. The largest trader in rhino horn in Sanaa sold his shavings for $253 pen kg in December, 1986, to a Chinese.

All the craftsmen working on dagger handles complained to me that the rial price of rhino horn has increased so much since 1984 that they cannot make a worthwhile profit when they sell them to retailers. Consumer resistance to the higher prices has made it more and more difficult to sell the djambias, especially because the recession has taken its toll on the middle class, the former potential buyers who are no longer in a position to purchase expensive daggers. Yet the craftsmen are also complaining that is becoming "almost impossible" to replenish their supplies of rhino horn; some of that now being used is from earlier stockpiling.

The main trader in rhino horn in North Yemen is now in his eighties, and, with some of his family members, owns today a total of seven dagger-making stalls and nine retail shops. He was carving dagger handles fnom rhino horn in the 1930s, but he said that in those days there were also daggers imported from the Sunday, Kenya, Tanzania and India. After North Yemen's Revolution and Civil War this merchant began purchasing large quantities of rhino horn and from the mid-1970s until the end of that decade he bought about 3 000 kg of rhino horn pen year, much of which he admitted originated from Kenya. His employees made almost 6000 daggers with rhino horn handles a year then; very few djambias were made with cheaper handles since the demand for"“the best” was so great that it could hardly be met; there was neither time nor particular incentive for the carvers to work in other materials.

The situation is now quite different, and although the merchant’s business has continued to grow, less than 2 400 daggers with rhino horn handles were made in his workshops in 1986, but some 24 000 with cheaper handles were produced by him. The wholesale price of rhino horn, which increased sharply after 1977, encouraged the use of substitutes first, then the various restrictions imposed on the export of rhino horn from source countries in Africa and the passing of the North Yemeni law prohibiting legal import of rhino horn further led to a higher and higher percentage of the daggers being made with water buffalo horn handles, not just by this merchant, but others as well. One craftsman has, in fact, introduced plastic handles ($9 to $17 each wholesale) because he thinks that water buffalo horn, which is only $400 a tonne imported from India, is now too difficult to obtain with the problems of trying to wrangle an import licence for it. With rhino populations continuing to fall in Africa, several governments are becoming very concerned and are putting more effort into rhino conservation and into law enforcement against the export of rhino horn. Supply is, therefore, likely to continue to decline, so despite major successes in lowering the demand for it in eastern Asia, its wholesale price may remain roughly the same in the near future. While high prices in the late 1970s encouraged poaching, they may now be beginning to have the opposite effect because of the steadily decreasing demand and the realization on the part of government authorities of the very real need to protect the small remaining numbers of rhinos – less than 4 500 black rhinos are thought to live in the wild today.[15]

Westernization of the elite in North Yemen, which was an encouraging factor for the lowering of the demand for rhino horn two years ago, is slowing down due to the economic recession, but this is not as worrisome as we might have expected because people are accepting daggers with water buffalo horn and plastic handles today. Interestingly, the numbers of workshops and numbers of craftsmen in the dagger-making section of the Sanaa souq increased from 41 and 61 in 1984[16] to 51 and 84, respectively, by December 1986, when I made my latest survey.

Today, plain daggers without rhino horn handles sell from $13 upwards, and those with rhino horn handles (excluding scabbard) vary in price from $170 to $845; the cheaper daggers have very small rhino horn handles and are not very popular because, traditionally, a small handle on a dagger indicated that the owner was of a lower caste. Outside Sanaa, daggers with rhino horn handles are no longer being made in North Yemen. Some people have thought that they were produced in the southern part of Saudi Arabia where there are some Saudis of Yemeni origin, but this is not true and those who have such daggers have purchased them in North Yemen.

From August, 1982, when North Yemen prohibited imports of rhino horn, until the end of 1986, approximately five tonnes of rhino horn were smuggled into the country, representing the deaths of a least 1 735 rhinos,[’7] or 45% of the remaining black rhinos in Africa now. When I met Dr. Abdul al-Iryani, the Deputy Prime Minister of North Yemen, on 13 December 1986, the American ambassador to North Yemen, William Rugh was present. He told the Deputy Prime Minister, who is also the Minister of Foreign Affairs and holds a Ph.D. from Yale University in zoology, that the American government is extremely concerned about rhino horn Imports into North Yemen and referred several times to the Congressional Hearing on the Rhinoceros[16] in which it had been strongly suggested that the U.S.A. government’s foreign aid appropriations to North Yemen, amounting to $35 000 000 a year, should be reduced if the North Yemen government did not put more effort into stopping this trade. The British ambassador, David Tatham, was also at the meeting with Dr. Abdul al-Iryani and he pointed out that Her Britannic Majesty’s government was equally concerned oven the matter. In addition Brian Goldbeck, Economic Officer at the United States Embassy, and Lucy Vigne from the African Wildlife Foundation were present. I stated that the interna-national press corps wanted to expose North Yemen as the main culprit of rhino conservation, but I had managed to fend off interviews on the subject pending the outcome of this meeting. Dr. al-Iryani was not only sympathetic to the problem, he was well informed about the imports and even knew the main trader by name. He was eager to work out some permanent solutions with us. Moreover, he assured me that other senior members of the North Yemen government would co-operate in initiating action to curtail rhino horn imports.

The meeting lasted for about 45 minutes, and by the end of it we had drawn up a six-point strategy which Dr. al-Iryani promised to have implemented by the end of January, 1987:

(1) The Customs Department would encourage water buffalo horn imports (as a substitute for rhino horn) by eliminating all duties on it.

(2) The government would issue a decree prohibiting the export of rhino horn shavings.

(3) Both the Prime Minister and Dr. al-Iryani would appeal to the main trader to desist from importing rhino horn.

(4) The government would request the Grand Mufti to issue a **fatwa** (religious edict), stating that it is against the will of God for man to eliminate an animal species, which is what is happening as a result of Yemenis continuing to insist on having daggers with rhino horn handles; the edict would be supported by quoting an appropriate passage from the Koran.

(5) Although less than 5% of the daggers are now made with rhino horn handles, the government would persuade craftsmen in the souk to stop using it entirely.

(6) Dr. al-Iryani would talk to the President of the United Arab Emirates, Sheikh Zayid, in late December, 1986, when he was scheduled to arrive in Sanaa on an official visit, about the need to ban rhino horn imports from his country.

Following the meeting with the Deputy Prime Minister, I then went to see the Minister of Economy, Mohamed al-Khadam al-Wajih, also accompanied by the British and American ambassadors and by Brian Goldbeck and Lucy Vigne. Mr. al≠Khadam al-Wajih agreed with the six points and promised that his Ministry would fully support them. He further suggested that since each dagger workshop in the Sanaa souk has to be officially licensed, the government could threaten to withdraw or refuse to renew licences to those in which the craftsmen persist in using rhino horn for handles. This could be the most forceful means of stopping the carving of rhino horn in North Yemen, and I fully support t. However, I do not want to see the craftsmen lose their jobs making djambias, and I feel that they should be strongly encouraged to try making dagger handles out of other high quality materials so that this artistic and cultural tradition of long standing is not denigrated. I stressed this to the Minister of Economy.

Before I left North Yemen, Dr. al-Iryani telephoned me at the hotel where I was staying in Sanaa, to tell me about further discussions he had held with Mohamed al-Khadam al-Wajih. Together, they had decided that dagger workshop licences would only be re-issued under the condition that each of the craftsmen employed would sign an affidavit promising not to use rhino horn. When the licences have been re-issued and a craftsman is caught working rhino horn, the licence for that particular workshop will be withdrawn. Dr. al-Iryani said that this regulation would be put into effect by the end of January, 1987.

If this does come to pass, and if the other points of North Yemen's proposed strategy to curtail the making of daggers with rhino horn handles are enacted, then the country which has been more directly responsible than any other for abetting African rhino poaching will cease to be a problem to rhino conservationists.

I am most appreciative of the support I received from the British and American ambassadors in Sanaa, which rendered it possible for me to meet with the Deputy Prime Minister and other members of the North Yemen government, and I am greatly encouraged by the widespread interest and concerted efforts being taken to stop the rhino horn trade. Certainly, I am more optimistic than I have been since I first started studying the problems of rhino conservation – almost ten years ago – about future prospects for rhino in Africa.

ACKNOWLEDGEMENTS

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Table1. Quantities and values of rhino horn purchased by the main trader in Sanaa, Yemen Arab Republic, 1980-1986.

		Price paid per kg		
Year	Kg	Rials	U.S. Dollars	Exporting Countries
1980	1 050	3 500	764	Tanzania, Kenya, Ethiopia and Somalia
1981	1 320	3 500	764	India, Tanzania, Ethiopia and Sudan
1982	1 585	3 600	786	Tanzania, Ethiopia and Sudan
1983	1 120	4 100	891	India, Kenya and Sudan
1984	1 058	4 300	796	Tanzania, Somalia and India
1985	475	8 300	1150	Ethiopia and Sudan
1986*	100	10000	1032	Sudan

*Up to 12 December 1986.

Source:personal records kept by the trader.

NOTES:

1. This figure is based on estimates of the amount of rhino horn brought into North Yemen each year, multiplied by the landed cost of the horns in U.S. dollars.
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7. Yemen Arab Republic (1973). Central Bank of Yemen Annual Report 1972-73. Central Bank, Sanaa. p. 152.
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10. U.S.A. Department of Commerce (1986). As in 4.
11. J.D. Orr (First Secretary, Commercial — British Embassy Sanaa). Economic Roundup — Yemen Arab Republic. Typescript prepared by British Embassy, Sanaa (1 October 1986).
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13. U.S.A. Department of Commerce (1986). As in 4.
14. Parker, I.S.C. and Martin, E.B.M. (1979). Trade in African rhino horn. Oryx, 15 (2): 157.
15. Cumming, D. (1986). Chairman's report. Pachyderm, No. 6:1.
16. Martin, E.B. (1984). As in 2.
17. This figure is calculated from the total amount of horn imported into North Yemen over the period, divided by the average weight of a pair of horns on an East African black rhino (2.88 kg).
18. U.S.A. House of Representatives, Washington D.C. Committee on Science and Technology (Sub-committee on Natural Resources, Agriculture, Research and Environment). James Scheuer, Chairman. 25 September, 1986.

This modern rhino horn jambia was on sale for U.S.$600 in December 1986.

Raising A Baby Rhino

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PREAMBLE

Being mother to a wild animal is undoubtedly a most enlightening and rewarding experience, but it is not always quite as simple as it might at first appear. It is not just a question of finding the correct milk formula, shoving a bottle into the animal's mouth, slotting the animal into a human routine, and devoting to it only the time one can spare now and then. In order to be successful and to be able to derive most benefit from this unique opportunity of close contact with a wild animal, one must be a mother more than just in name. One must be wholly committed, understand certain truths about animals in general, and be totally sincere in one's love. For an animal can gauge such things with an uncanny and almost eerie accuracy. There can be no pretence. What one is prepared to put into the relationship will be the measure of what one will reap in return.

There are sacrifices that must be made, too. No matter what your experience, never presume to know all the answers, because you never will. Humility is a valuable prerequisite to being a successful foster mother.

The first basic fact one must understand is that each animal is an individual in its own right, with its own unique temperament, its own special idiosyncracies and peculiarities, its own very special personality. No two are exactly alike just as no two people are quite the same. Forget doubts about being labelled anthropomorphic in one's approach. Such scientific dogmas are not only being proved outdated and incorrect, but shutter an ability to probe the thinking and the mind of an animal. Anyone who subscribes to this philosophy will never be able to penetrate the barrier that isolates human from animal, for absent in their makeup will be some of the vital ingredients for opening the door to confidence, sympathy, compassion and an ability to project oneself beyond human ignorance and arrogance, and see things from the other side. This, I suppose, is what is meant by the term "an empathy for animals". An empathy for animals is a must.

One should understand that animals are "different" to ourselves **–** not inferior. Therefore one should never gauge their intelligence by human standards. They have evolved in an older world than us and along a different branch of the tree of life. They are endowed with mysterious – "senses" that we have either lost, or never had. Whereas we communicate by the power of speech and the written word, animals communi≠cate no less effectively by much more subtle means; by tele≠pathy, by ritual, by scent, by body language and by instinct; that inborn "memory" inherited over eons of evolution that is the blueprint that dictates certain actions, survival tactics and aspects of social behaviour. So, it is necessary to under≠stand that animals are not always masters of themselves; that instinct might intervene at any moment. However, al≠though raised by a human, it has been my experience that most wild animals know exactly what they are. They know what and what not to eat, what and what not to fear, where and where not to venture. But, instinct is something that needs honing by exposure to a wild situation, and it is vital to understand this simple truth when raising a wild animal.

Don't mete out "smother-love". Don't shelter the animal too much. As it grows up it MUST be allowed freedom and the space to venture into its own world in its own time; to be actually exposed to all that the world harbours; to hear and understand the language of the birds, explore the events of yesterday on the grasses and scent trails; interpret the different messages borne on the wind, and "know thine enemy'. Never assume that a wild animal belongs to you, or is a pet. Regard it as being only "on loan" and be happy that you have been privileged to share its life until it responds to the call of the wild and takes its rightful place amongst the natural order. You must learn to say "goodbye", and very often, if one can do this, a goodbye turns into an "au revoir". The animal will remember you with affection, and return periodically to re-establish contact. Never confine a wild animal for selfish reasons. This is unforgiveable, and if one cannot offer it some form of freedom and a near natural life, it is better not to raise it in the first place.

It is also important to know the social characteristics of your charge. Is it, for instance, from the ranks of the gregarious types, on one of Nature's "loners". Does it seek seclusion and solitude when young, or is the constant companionship of others a basic need for its psychological well-being. An animal's psychological well-being is equally as important as its physical, so one must try and simulate what it takes to give the baby a sense of security. If it "lies out" during infancy, for instance, provide the necessary cover to enable it feel hidden. Understand animal codes of behaviour too; what are aggressive actions and what are subservient signals. Never stare at a primate, for instance, or hold the head or horns of an antelope. Above all, know that ALL animals have very long and unforgiving memories. One must respect this, for an unkindness or cruelty will be remembered, and perhaps a grudge harboured until an opportunity presents itself to get even. I have raised most antelopes, and 22 buffaloes, over the years, and never has there ever been an accident. Remember that animals have feelings and emotions, likes and dislikes. Like us, they sorrow and are happy, they have loved ones, and deep loyalties too.

Rhino babies are, strangely enough, one of the easiest and most uncomplicated of wild infants, and perhaps also one of the easiest to near when one knows how. However, rhinos are delicate in many aspects, and when subjected to any kind of trauma, tend to go down to pneumonia and tick and fly borne diseases normally latent in their blood. Even a very young rhino will fight and charge its captors with all the aggression for which its species has been labelled, and if this be the case, be warned that within about four days of capture, the baby will become very ill, even though it has settled down and tamed easily.

Therefore, upon capture, dose the animal immediately with one of the sulphur based drugs, and forestall babesia and trypanosomiasis with injectable Berenil. Guard against pneumonia by keeping the animal warm, if necessary by tying a small blanket around its body at night and during the cool morning and evening hours.

Rhino babies are very endearing. They quickly lose the head-heavy infant look, and but for a blunt nose and soft smooth skin, become perfect miniatures of an adult, sturdy and rounded. At birth a rhino stands between 18” and 25” only at the shoulder, and weigh between 60 and 90 lbs. Rhinos tame quicker and easier than any other animal. Even an adult can be tamed within only a few days. They slot into a routine with philosophical ease, being very much creatures of habit. They love a comfortable “rut”, and are content with less than most other orphans. Their food on time; a dry warm stable at night, a mudwallow and sandpit at their disposal, a patch of bush in which to hide, and a “friend” is all a baby rhino needs in order to be thoroughly content. Never do they shove or jostle for the bottle, as does a buffalo, but ask with a plaintive “mew”, and gently take whatever is offered. They need a companion close by at all times, to replace the mother that would have been a part of their early life. And they thrive best wandering free with a human attendant and an animal companion, romping and playing, investigating the scents and sounds of the bush. All this avoids the tedium of boredom; another important aspect in the raising of young animals.

THE FORMULA

A “humanised” brand of baby milk is the key to raising a rhino. One must use a baby preparation with a full cream base. I have always used LACTOGEN, and on the following formula have raised four baby rhinos without any difficulty whatsoever; one from the day it was born, (Still in the foetal sac).

Feed four hourly during the day, i.e. 6 a.m., 10 am., 2 p.m., 6 p.m., and when the calf is very young, once at night, at 10 p.m.

INITIAL RATIO = 8 scoops milk powder to 24 f l. ozs. water.

Gauge amounts by appetite demand. All baby animals know what they want and know when they have had enough.

After a few days, increase the ratio to 10 scoops Lactogen: 24 fl. ozs., and aim for 1 scoop per 2 fl. ozs. You will then be mixing 12 scoops of powder per 24 fl. ozs. When the calf is having this ratio, that is FULL STRENGTH, and the milk base will be mixed according to this for the entire time it is on milk (about 18 months).

Because one will be soon dealing with sizeable quantities, it is much easier to do the scoops by measurement. At 41/2 months the calf will be taking 41/2 pints of milk 4 times a day. One can drop the night feed after a month.

At 5 months old the calf will be taking 51/2 pints per feed.

Having achieved FULL STRENGTH ratio, one then introduces the CEREAL. Start by adding 1 tablespoon of NESTUM baby cereal and 1 tablespoon ENERGEX wheat germ two times a day, then three times a day, and finally to all feeds.

At about 4 months each feed will be:
41/2 pints warm water: 7 ozs. LACTOGEN powder
(7 ozs. = 45 scoops)
5 tablespoons Nestum Cereal
2 tablespoons Energex
1 tablespoon Glucose
Pinch of Salt

At 5 months each feed will be:
5 1/2 pints Water
9 ozs. Lactogen
9 tablespoons Nestum Cereal
1 tablespoon Glucose
Pinch of Salt

The calf will very soon begin to browse a little, and at this time it can go onto 3 milk feeds per day. The cereal can also be changed to OATMEAL uncooked, and the calf will now have:
6 pints Water
10 1/2 ozs. Lactogen Powder
11 ozs. Oatmeal (15 tablespoons)
4 tablespoons Energex
Salt

This is the maximum milk feed. As the calf browses more, it will be noticed that its appetite for milk drops, and the lunch time feed can be dropped.

The calf will probably go off its food whilst teething. Don’t be hasty to give drugs. Mix milk according to demand. Always allow some ticks, but not too many. It is important that the calf acquires an immunity to tick borne diseases, and the way to do this is to allow it to have some ticks on t. Feeding, and the quantities to give, is really a matter of common sense. A lot of cereal and a lot of Vitamin B is essential to the good health of a rhino calf. On the above formula, the calf will gain about 1 kg per day.

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