GRID
GLOBAL RESOURCE INFORMATION DATABASE

GRID
CASE STUDY SERIES
NO. 2

NAIROBI
JUNE 1987

African Elephant Database Project: Final Report

Anne Burrill and Iain Douglas-Hamilton

Funded by World-Wide Fund for Nature (WWF)
and the Elsa Wild Animal Appeal
in co-operation with

GEMS
GLOBAL ENVIRONMENT MONITORING SYSTEM
UNITED NATIONS ENVIRONMENT PROGRAMME

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TABLE OF CONTENTS

LIST OF APPENDIXES: PAGE

LIST OF MAPS:

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African Elephant Database Project

ABSTRACT

The objective of this report is to provide information on elephant numbers, distribution and trends, and factors affecting these, which will be helpful to countries in reviewing and setting quotas under the CITES Ivory Export Quota agreement.

The data on elephants have been acquired from published scientific literature, reports of aerial or ground surveys, and from a series of questionnaires distributed up to December 1986. They have been exhaustively reviewed by the African Elephant and Rhino Specialist Group (AERSG) of IUCN. The total range of the elephant is estimated at 5,921,000 km2 46% in Central Africa, 25% in East Africa, 25% in Southern Africa and 5% in West Africa. Of the total range nearly 30% is rainforest and largely uncensused to this day.

On the basis of these data, and computer modelling, the factors correlated to elephant density have been determined. The most significant positive correlation was with effective protection.

Elephant numbers were then projected for each country, by computer modelling. The regional totals were West Africa 24,000 East Africa 176,000, Southern Africa 236,000. For Central Africa the only data input came from areas of abundance in Gabon and CAR. When extrapolated to other forested areas they gave a regional total of 585,000, thought to be unrealistically high.

Trends were also calculated from successive estimates. The East African weighted trends were -6.8% per annum for protected areas, and -14.2% per annum for unprotected areas, with an overall weighted annual trend of -8.1%. In Southern Africa the weighted trend for countries with little poaching was 0.7% per annum, and in the heavily poached countries -8.2% per annum. Trend data for the rest of Africa were fragmentary, but in the northern savannahs elephants were mainly decreasing in a band across the continent from Somalia to Senegal, with a weighted mean of -17.8% per annum. No quantitative data were available for trends in the forest, but informants suggest variations from stability or increase in Gabon, to rapid decrease in Eastern Zaire.

Through this project, a central database of elephant populations has been established at UNEP within the Global Environment Monitoring System (GEMS) as part of its Global Resource Information Database (GRID). As further data concerning elephants are obtained, they can also be incorporated into the database for the purposes of updating the results reported herein.

Projet de base de données sur l'éléphant africain

RESUME

L'objectif de ce rapport est de fournir de l'information sur le nombre des éléphants, leur distribution et leur tendance évolutive, ainsi que sur les facteurs qui les affectent. Cette information pourra être utile pour les pays désirant renouveler ou établir des quotas selon l'Accord du Quota d'Exportation de l'Ivoire du CITES.

Les données sur les éléphants ont été tirées de publications scientifiques, de rapports de sondages aériens ou terrestres, ainsi que d'une série de questionnaires distribués jusqu'au mois de décembre 1986. Elles ont été revues d'une façon exhaustive par le Groupe Spécialisé sur les Eléphants et les Rhinos du IUCN (le AERSG). L'étendue totale des éléphants a été estimée à 5.921.000 km^2 : 46 % en Afrique Centrale, 25 % en Afrique de l'Est, 25 % en Afrique Australe et 5 % en Afrique de l'Ouest. 30 % du total de cette étendue est représentée par les forêts humides qui ont été peu recencées jusqu'à aujourd'hui.

Grâce au support de ces données ainsi qu'à une modélisation faite par ordinateur, les facteurs corrélés à la densité des éléphants ont été déterminés. La corrélation positive la plus probante est une protection efficace.

Le nombre des éléphants a été ensuite projeté pour chaque pays, grâce à une modélisation faite par ordinateur. Les totaux étaient pour l'Afrique de l'Ouest de 24.000, pour l'Afrique de l'Est 176.000 et pour l'Afrique Australe de 236.000. En ce qui concerne l'Afrique Centrale, les seules données de base provenaient de zônes abondantes du Gabon et de la République Centrafricaine (RCA). Une fois ces données extrapolées vers les autres zônes forestières, le total régional représentait 585.000, ce qui est excessif par rapport à la réalité.

Les tendances évolutives ont aussi été calculées à partir d'estimations successives. Les tendances évolutives pondérées pour l'Afrique de l'Est étaient de -6,8 % par an dans les zônes protégées, et de -14,2 % par an dans les zônes non protégées, avec une tendance évolutive globale et annuelle de -8,1 %. En Afrique Australe, la tendance évolutive pondérée pour les pays ayant beaucoup de braconnage était de -8,2 % par an, et pour les pays ayant peu de braconnage de 0,7 % par an. Les données des tendances évolutives pour le reste de l'Afrique sont fragmentaires, mais dans les savannes du Nord, les éléphants diminuaient au travers d'une bande coupant le continent de la Somalie au Sénégal, avec des taux annuels variant de 0 % à -40 %, avec une moyenne pondérée de -17,8 %. Aucune donnée quantitative n'était disponible pour les tendances évolutives.

African Elephant Database Project

INTRODUCTION:

At the fifth meeting of the CITES Parties in Buenos Aires in 1985, a Resolution of the Conference of the Parties in 1985, dealing with Trade in Ivory from African Elephants, noted that:

> "Illegal ivory now imperils the future of some populations of African elephant and could imperil others if it continues at its present level".

The May 1987 meeting of the African IUCN Elephant & Rhino Specialist Group (AERSG) similarly reached a consensus that present continental levels of ivory offtake are unsustainable, with the exception of those countries with successful management and conservation programmes.

In order to tackle these problems, the CITES Resolution recommended a new system of Quotas for Ivory Exports intended to control offtake. The rationale for this Ivory Quota system originated from an FAO working party on wildlife management and national parks meeting in Arusha in 1983, which crystallized the idea in the following words:

> "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".

It was intended that raw ivory for export would come from natural elephant mortality, elephants shot on control, approved elephant culling schemes, legal hunting or that confiscated from poachers. It was thought that the quotas would help to reduce the illegal trade.

An essential element of setting quotas is therefore the inventory of elephant populations, so that a sustainable yield can be calculated. However in many countries, and for the continent as a whole, reliable estimates of elephant numbers have been lacking.

While the CITES secretariat was asked by the parties to centralize information on ivory movements in relation to quotas, and to circulate it to all importing, exporting and transit countries, no equivalent database existed for continental elephant populations.

In order to meet this goal, the African Elephant Database Project was launched to collect all available elephant data and to make use of the Global Environment Monitoring system (GEMS) Global Resource Information Database (GRID) at UNEP, to model elephant densities for those parts of the elephant range where information was lacking.

BACKGROUND - THE HISTORY OF ELEPHANT POPULATION ESTIMATION:

Attempts to estimate Africa's elephant population began ten years ago in July 1976, with an African Elephant Survey and conservation programme sponsored by World Wildlife Fund (WWF), New York Zoological Society (NYZS) and the International Union for the Conservation of Nature and Natural Resources (IUCN). This programme distributed a questionnaire to experts across Africa, carried out surveys, and compiled available information on elephant range, numbers and trends. It highlighted and gave world-wide publicity to the major declines in elephant populations taking place in the seventies in numerous 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).

This overview of the elephants' status was reported in typescript reports to the sponsors (Douglas-Hamilton, 1977-1979) and published in summary form in the WWF Year Books and other publications (Douglas-Hamilton, 1979, a,b,c). An international meeting of IUCN's African Elephant Specialist Group was held in Nairobi in 1980. Information on continental elephant status appeared in the IUCN bulletin (1980), an executive summary "Africa's Elephants - A Time for Decision" (IUCN/WWF/UNEP, 1982) and popular accounts in National Geographic Magazine, (Douglas-Hamilton, O. 1980) and Animal Kingdom (Ricciuti, 1979). The ivory studies were reviewed in the U.S. Congressional Record.

This information and the results of another questionnaire survey were also reviewed at the Hwange meeting of the African Elephant and Rhino Specialist groups (AERSG) in 1981 (Cumming and Jackson, 1984). A further questionnaire was distributed in 1983 under the auspices of the African Elephant and Rhino Specialist Group, (Douglas-Hamilton, report to AERSG, 1984; 1987). In a consultancy for CITES, Martin (1985) has also gathered new information on elephant status. Data on the distribution and status of West African elephants have been compiled by Roth and Douglas-Hamilton (in prep).

Numerous accounts of individual elephant populations, and the views of the successive chairmen, Dr Western and Dr Cumming, have been published in the AERSG newsletter, Pachyderm, and in the scientific literature, as summarized in the select bibliography below.

The critical factors affecting elephant populations and current trends have also been discussed by Douglas-Hamilton (1975, 1979,1983, 1984, 1987), who suggested that killing of elephants for ivory was causing most populations to decline, 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). Other factors believed to influence elephant trends include human population increase, the proliferation of firearms and political instability.

METHODOLOGY:

A Geographic Information System (GIS) is a specialized computerized database manager which stores data with reference to their geographical location. The information processed in a GIS may come from a variety of sources, including remotely obtained imagery, conventional maps of varying scales and projections and even tabular data, provided that the data are related to a specific location. A GIS enables rapid overlaying and combination of data from these various sources and so to examine their interrelationship. After establishing such relationships, a GIS can also be used to conduct modelling and extrapolation.

A GIS thus provides an ideal tool with which to investigate elephant numbers. By incorporating known elephant densities into a system, together with factors which may affect them, it is possible to perform analyses to determine how these factors are related to elephant numbers. It is also possible for the GIS to make projections of density estimates for other areas based on the observed relationships. In this manner, the African Elephant Database Project has attempted to derive continent-wide estimates. The GIS used for the purpose was the Arc/Info system run on a Prime 2250 in GRID at UNEP.

DATA:

Elephants - The baseline elephant data used in this study are from a wide variety of sources. Many individuals and organisations have been involved in compiling elephant data for over a decade, and we have included the most recent estimates available from professionals across Africa. As the number and density estimates were compiled, each was assigned a quality rating on a scale of 1 to 3 to indicate its relative reliability. In general, these numbers reflected the method of estimation with aerial surveys ranking the highest (with a value of 1), and with informed guesses by experts as the lowest (with a value of 3).

All of the assembled elephant population data were then circulated in Pachyderm, the newsletter of AERSG, with a view to improving its quality prior to using it as the basis for modelling. At the AERSG meeting in Nyeri, Kenya, in May, the existing range map was modified by experts in regional committees; some of their revisions reflected real changes in elephant range since the last assessment, whereas others were actually corrections of mis-information. As a result of this process, the range map now reflects the best available information about the extent of the African elephant (see Map 1). The total range was 5,921,000 Km2, with 46% in Central Africa, 25% in East Africa, 25% in Southern Africa and 5% in West Africa. Of the total range nearly 30% was rainforest.

The data concerning elephant numbers and densities were also reviewed. The Southern expert group provided many newly acquired estimates and the other groups were able to supply updates for various areas. There remained, however, the question of how to handle out-of-date estimates, from areas for which no new information existed. It was agreed that the best solution was to extrapolate from trends in elephant numbers in nearby "similar" areas. It was noted, however, that this method obviously decreases the reliability of the estimates and their quality ratings were accordingly lowered.

Appendix VII (Page 68) contains a list of the areas for which estimates were compiled and reviewed, with a brief description of their quality. The elephant input totalled 347,000. Map 2 illustrates these data by displaying the elephant densities for all of these areas. In all, there are 295 estimates covering 1,939,400 square kilometers, one third of the elephants' range.

Other Data Layers - In order to develop a model to predict characteristics of elephant populations in unknown areas, it was first necessary to determine what factors appear to be co-incident with the characteristics of known populations. It was important to ensure that the GIS included data sets for all the potentially relevant factors. Two criteria were used in choosing factors for inclusion:

1. The belief that the factor was of relevance to elephant density, and;
2. The availability of continent-wide information about the factor in some geographic format. This second criterion has precluded, for instance, poaching levels from being an explicit factor; it is believed,

however, that the combination of other factors (effective protection, socio economic) acts as a surrogate.

The data sets proposed for inclusion, described below, were presented at the AERSG meeting, which supplied an endorsement of the proposed approach to analysis and modelling.

Vegetation Type: Two continental maps were considered as sources for this data layer - White's vegetation map prepared for UNESCO and the new, as-yet-unpublished, FAO "Toulouse" map. Their relative merits were discussed at the AERSG meeting and it was decided that White's map was more appropriate because of its classification system and because of certain known inaccuracies in Zimbabwe on the Toulouse map. However, White's map contains too many categories to be suitable for analysis with the amount of elephant information available. It was, therefore, necessary to combine many of the categories in order to reduce their number to be appropriate to the amount of elephant data. Appendix III (Page 47) contains a description of the combinations used and Map 3 shows the result.

Human Population: For most parts of Africa, information about human numbers is out of date or available only on a national scale. The national scale data were deemed inappropriate for use in this project because the distribution within most countries is very uneven. Thus, it was necessary to use the only available map showing population gradient across the continent - a map produced by Philips in the late 1960's (see Map 4). It is believed that the age of this data layer is not an impediment for 2 reasons:

1. For the purposes of this project, we are most interested in the relative distribution of humans from one place to another. This has changed little on the continental scale since the map was published, and;

2. Past human distribution is itself a valid factor in determining present elephant densities.

Protected Areas: This data set was originally digitized from J & K MacKinnon's map of protected areas. However, it was found that many of the areas were too imprecisely delineated on the original map for use in a GIS. Therefore, most of the "major" protected areas were re-digitized from large scale maps. (Appendix IV, Page 48, lists those areas which were re-entered.) The dataset also includes an estimation of the effectiveness of the area's protection, as assigned in MacKinnon's 'Afrotropical Review of Protected Areas'. A few of these ratings were changed at the AERSG meeting in consultation with local experts and K. MacKinnon. The areas' boundaries and their protection levels are displayed in Map 5.

Rainfall: - UNEP and FAO had already compiled this information within GRID into a data layer digitized by the Environmental Systems Research Institute of Redlands, California. It has not been modified and is shown in Map 6.

Tsetse Fly: The presence of Tsetse flies in an area renders it relatively inhospitable to man. Such areas are likely to be relatively undisturbed and thus potential elephant habitat. The Inter-African Bureau of Animal Research (IBAR), a branch of the Organisation of African Unity (OAU), has produced detailed maps showing the continental distribution of tsetses by species. However, the species of the tsetse is of little relevance to their impact on elephants, so the tsetse data were entered to reflect presence or absence only. This is displayed in Map 7.

Socio-Economic and Political Factors: As was the case for population data, these data are generally only available on a country basis. However, these factors, in particular the political ones, are generally constrained by national boundaries, and are relatively uniformly distributed within a country. These factors were thus deemed suitable for use as country attributes and were incorporated into the database using country boundaries already included among the UNEP/FAO datasets. One factor, the reliability of the military (as estimated on a scale of 1 to 5 in 'The War Atlas'), is displayed in Map 8. The others are listed in Appendix V (Page 50).

The base map used for this project, showing the coastline and major water bodies, is one of the GRID-UNEP/FAO datasets. It was originally acquired at a scale of 1:5,000,000 in the Miller Oblated Stereographic projection, as were most of the new datasets used in this study. The new data layers thus simply needed to be properly aligned. The human population map, however, was obtained in Lambert's Azimuthal Equal-Area projection (at 1:9,000,000), so the appropriate GIS functions needed to be applied to this map to convert it to the Miller Oblated Stereographic projection before aligning it with the others.

DATA MANIPULATION AND ANALYSIS:

After all of the datasets were acquired, it was necessary to manipulate and combine them with the GIS prior to the actual statistical analysis.

The elephant population data were acquired in different formats: some estimates were densities, some were numbers and some were both. In all cases where a number was supplied, it was assumed to be more precise than the density and thus preferable for use in the study. However, in order to compare areas and perform extrapolations, it is necessary to work with densities. Therefore, all of the population numbers, were tranformed into densities based on the area delineated for the population. The GIS automatically calculates map area; it was necessary, however, to correct for scale and make adjustments based on map projection scale deviations. The scale departure diagram on White's map was used for this purpose.

There was concern that those areas having population estimates tended to be the areas where elephants were known to be abundant; any extrapolation based on these data might yield densities that were too high. The areas of known non-elephant range were therefore added to the data set containing estimates, with a density of 0, so that they might be included in the analysis. It was decided not to include the non-range areas of Namibia and South Africa because they ceased to be range long ago and are now subject to constraints such as extensive fencing, which are not related to the factors examined in this study, nor are they applicable to the rest of the continent. The Mediterranean countries were similarly excluded. Eventually, these entries of 0 for non elephant range were not used in the final analysis, for reasons discussed below.

After the elephant dataset was finalized, it was combined in the GIS with all of the other data sets. In this process, the computer intersects the polygons in each data set with the polygons in all of the other data sets. The 295 population estimates thus became 4755 areas and the non-range, another 9286. Each of these areas had attributes from each dataset: density

(CALLDENS), area (REAL AREA), estimate quality (QUAL) (assigned as 5 for non-range for easy identification), protection effectiveness (EFFECT), presence/absence of tsetse (ANY), vegetation category (VEG), human population density (DENSITY), average annual rainfall (MIDVALUE), GDP per capita (GDP), annual change of GDP (GROWTH), military reliability (MILREL) and years at war (1945 - 1982) (WAR YRS).

These 14041 data points were next analyzed using the statistical analysis package SPSS/PC (on an IBM AT). After obtaining some preliminary descriptive statistics, a series of regressions and analyses of variance were run to determine the relationship between density (weighted by area) and each of the other attributes. The data were divided to permit examination of several subsets as well as the whole: with the non-range excluded, with non-range given half of its weight by area, without quality 3 data, etc. There were so few quality 1 estimates for most parts of the continent that they were not considered as a separate subset.

On the basis of these analyses, the vegetation classes were further combined, a decision was made concerning non-range, certain variables were log transformed and multiple regression analyses were conducted. These yielded two sets of equations from which densities were extrapolated across the non-estimated section of the range.

RESULTS:

The density data of qualities 1 to 3 were first compared to the other numeric factors, yielding the following correlations:

Table 1: Correlation between Density Estimates (Qualities 1 - 3) and Other Factors.

	With non-range at full weight		with non-range at half weight		without non-range	
	R for X	R for ln(X+1)	R for X	R for ln(X+1)	R for X	R for ln(X+1)
Effective Protection (EFFECT) (1 is high)	-.52	-.48	-.55	-.50	-.50	-.50
TSETSE PRESENCE (ANY) (1 is present)	.15	-	.19	-	.23	-
Human Population (DENSITY)	-.04	-	-.05	-	-.07	.15
RAINFALL (MIDVALVE)	.03	-	.04	-	.19	.17
GDP/CAPITA (GDP)	.05	.10	.06	.13	.19	.28
(% Change in GDP) (GROWTH)	-.05	-	-.06	-	-	.15
MILITARY RELIABILITY (MILREL) (1 is high)	-.04	-	-.05	-	-.07	-.18
YEARS AT WAR (WARYRS)	-.06	-	-.07	-	-	-

* Values shown are significant at .01, those underlined are significant at .001.

** The log values for GROWTH were calculated as LN (GROWTH + II)

It should be noted that all significance levels are artificially high because the number of data points does not reflect the actual degrees of freedom, since estimates were subdivided.

Effective protection appears to be the single factor most closely correlated to elephant numbers, with the highest levels of protection corresponding to the most elephants. The presence of tsetse fly is also a consistently relevant factor. For many of the factors, the correlation coefficient varies substantially depending on whether or not non-range is included. Since the total area of non-range included in the analysis (approx. 14,800,000 sq. kms.) is five times the size of the total estimated areas, it is not surprising that its inclusion has a large impact on any factor whose relationship with density in the non-range differs from that in the range. Therefore, examining the coefficients obtained from the first dataset (that with non-range) actually yields information about what factors today correspond to a historical loss of range (excluding Namibia and South Africa). The third set of data shows the actual relationship with elephant density within the present range. Rainfall, for instance, does not have much correlation to loss of range, although it does correlate with the density of elephants within the range. Conversely, areas with wars over the past 40 years tend to have alot of non-range, but this factor bears little relationship to numbers within the remaining range. The present military reliability (or the log thereof) and present GDP per capita, the growth thereof have a much stronger relation to density within range. However, they do not help in predicting the extent of range; this is not surprising as the loss of range antedates these factors. Human population density and growth in GDP show similar patterns -- this may be largely due to the fact that growth is not expressed per capita. The positive correlation between population and elephant density, while somewhat unexpected may be related to the fact that in many zones of heavy human population, elephants have been compressed; this lessens the extent of range but increases the density in what remains. Furthermore both elephants and people tend to chose the same habitat and ecological conditions. The negative correlation in the first data set, however, indicates the loss of range in areas of high human population.

The average elephant density for each value of the other factors, for the first and third datasets is shown below.

Table 2: Average Density Estimates (Quality 1 - 3, with non-range) by other Factors.

QUAL

1	.46563
2	.08912
3	.10421
5	0.0

EFFECT

1	.45930
2	.31205
3	.21943
4	.03838
5	.00772

ANY

0	.00996
1	.04374

DENSITY

.5	.02084
4.5	.03476
12.0	.01726
24.0	.00547
48.0	.00544
96.0	.00464
192.0	.01473
384.0	.00160

MIDVALUE

25	.00003
75	.00010
125	.00009
150	0.0
175	.00008
225	.00075
250	.00117
275	.00180
325	.00320
350	.00968
375	.00715
425	.00870
450	.01155
475	.04895
525	.08822
550	.01714
575	.35250
650	.08546
700	.12173
750	.02923
800	.01689
850	.02832
900	.03438
950	.02972
1250	.02432
1750	.02370
2500	.00327
3500	.00063

GDP

88	.00204
145	.02491
149	0.0
152	.02341
164	.00905
178	.00119
185	.00158
187	.00042
205	0.0
210	.02637
230	.01449
237	.14129
245	0.0
255	0.0
259	.00045
260	.00750
263	.00178
272	.00702
273	0.0
291	.03694
294	0.0
298	.00429
327	.00801
343	1.4599E-07
389	.00009
407	.00021
460	.06357
506	0.0
592	.08285
691	.01200
739	.00229
826	.00551
896	.11737
921	2.5245E-06
960	0.0
1076	.03249
1083	.00066
2559	.00189
2654	.35998
2955	.37461

GROWTH

-10.6	0.0
-7.9	.00750
-5.4	.03249
-3.9	.01200
-2.4	.02341
-2.1	.00204
-1.8	.06634
-1.3	.06357
-1.0	.00372
-.5	.00045
.2	.03694

Table 3: Average Density Estimates (Quality 1 - 3, without non-range) by Other Factors.

QUAL	
1	.46563
2	.08912
3	.10421
5	0.0

EFFECT	
1	.48582
2	.40417
3	.47818
4	.10932
5	.09169

ANY	
0	.12524
1	.22629

DENSITY	
.5	.21739
4.5	.20774
12.0	.14017
24.0	.07948
48.0	.07795
96.0	.10213
192.0	.39323
384.0	.02575

MIDVALUE

25	.00846
75	.00507
125	.00596
150	0.0
175	.00427
225	.00294
250	.01020
275	.01008
325	.04194
350	.06031
375	.07053
425	.13344
450	.06274
475	.11645
525	.24880
550	.08922
575	.52390
650	.35254
700	.34391
750	.41060
800	.06767
850	.12120
900	.19305
950	.10666
1250	.22461
1750	.31780
2500	.11847
3500	.19950

GDP

88	.03799
145	.08115
152	.10174
164	.17015
178	.20465
185	.21934
187	.01213
210	.19574
230	.11862
237	.31395
259	.22077
260	.06292
263	.01471
272	.08000
291	.05060
298	.08005
327	.29079
343	.00500
389	.14880
407	.00500

460	.33356
592	.54108
691	.07386
739	.32273
826	.19178
896	.64586
921	.33009
1076	.03249
1083	.42277
2559	.32955
2654	.35998
2955	.39000

GROWTH

-7.9	.06292
-5.4	.03249
-3.9	.07386
-2.4	.10174
-2.1	.03799
-1.8	.31226
-1.3	.33356
-1.0	.09212
-.5	.22077
.2	.05060
1.0	.64586
1.9	.39000
2.0	.14880
2.1	.54108
3.3	.17015
3.8	.00500
4.1	.01471
4.5	.08000
4.7	.35998
5.8	.20887
6.1	.42277
7.0	.19178
7.5	.32955
7.6	.19574
9.7	.11862

MILREL

1	.23527
2	.16344
3	.05471
4	.28054
5	.21910

WARYRS

0	.11060
1	.36496
2	.06290
3	.08000
4	.10027
5	.32661
6	.31395
8	.19454
9	.05506
10	.29079
12	.20465
13	.35998
14	.08115
17	.64586
18	.03799
19	.08005
22	.33009

The results from the second dataset in Table one (Page 10) show that by reducing the weighting of the non-range, its effect is lessened. The original reasons for including the non-range in the dataset were related to offset the bias towards counting elephants in areas where they are prevalent, as discussed above. However, it was decided that although this inclusion has yielded some interesting relationships, that for the purposes of building a model, it is inappropriate. If the effect of the various factors appeared to be parallel inside and outside of the range, then including non-range (appropriately weighted) would have been a possible means of balancing the bias. However, as has been seen, the factors seem to play quite different roles depending on whether or not non-range is included; both the magnitude, and in some cases, the direction of the correlations change. In addition, even without the inclusion of non-range, the distribution of elephant densities is positively skewed (with over 75% of the values below the mean) from the ideal "bell-shaped" curve, for which regression analysis is appropriate. The non-range drastically compounds this problem.

Thus, for the multiple regression, the third dataset was selected, using the logarithms as appropriate.

Before conducting the multiple regression, the single correlation coefficients were also obtained for the dataset excluding the quality 3 data, as follows:

Table 4: Correlation of Density Estimates (Qualities 1 - 2) with Other Factors

	With non-range at full weight		with non-range at half weight		without non-range	
	R for X	R for ln(X+1)	R for X	R for ln(X+1)	R for X	R for ln(X+1)
Effecting Protection (EFFECT) (1 is high)	-.52	-.60	-.56	-.63	-.54	-.64
TSETSE PRESENCE (ANY) (1 is present)	.13	.05	.17	.07	.26	-
Human Population (DENSITY)	-.05	-	-.06	-	-.11	-
RAINFALL (MIDVALUE)	0.3	-	.04	-	.28	.15
GDP/CAPITA (GDP)	.06	.13	.08	.17	.21	.42
(% Change in GDP) (GROWTH)	-.03	-	-.04	-	-	.09
MILITARY RELIABILITY (MILREL) (1 is high)	-	-	-	-	-.14	-.30
YEARS AT WAR (WARYRS)	-.05	-	-.06	-	-	-

* Values shown are significant at .01, those underlined are significant at .001.

** The log values for GROWTH were calculated as LN (GROWTH + II)

Table 5: Average Density Estimates (Quality 1 -2, with non-range) by Other Factors.

QUAL	
1	.46563
2	.08912
5	0.0

EFFECT	
1	.46075
2	.33998
3	.22259
4	.01870
5	.00598

ANY	
0	.00878
1	.03400

DENSITY	
.5	.01927
4.5	.02922
12.0	.01085
24.0	.00151
48.0	.00367
96.0	.00063
192.0	.00198
384.0	0.0

MIDVALUE	
25	9.8590E-07
75	8.7834E-06
125	8.3885E-06
150	0.0
175	.00001
225	.00022
250	.00106
275	.00172
325	.00320
350	.00650
375	.00682
425	.00837
450	.01147
475	.05659
525	.09676
550	.01000

575	.42194
650	.06963
700	.12173
750	.02267
800	.01689
850	.01857
900	.00689
950	.01940
1250	.01861
1750	.02301
2500	.00079
3500	.00063

GDP

88	.00204
145	.00062
149	0.0
152	.02341
164	0.0
178	0.0
185	.00158
187	0.0
205	0.0
210	.02345
230	0.0
237	.12163
245	0.0
255	0.0
259	0.0
260	0.0
263	.00117
272	.00702
273	0.0
291	.02979
294	0.0
298	.00001
327	.00773
343	0.0
389	.00007
407	0.0
460	.05626
506	0.0
592	.08285
691	.00035
739	.00044
826	.00085
896	.11747
921	6.1088E-10
960	0.0
1076	.04257
1083	.00066
2559	0.0
2654	.35998
2955	.37461

GROWTH

-10.6	0.0
-7.9	0.0
-5.4	.04257
-3.9	.00035
-2.4	.02341
-2.1	.00204
-1.8	.05183
-1.3	.05626
-1.0	.00014
-.5	0.0
.2	.02979
1.0	.10832
1.9	.37461
2.0	.00007
2.1	.08285
3.3	0.0
3.8	0.0
4.1	.00117
4.3	0.0
4.5	.00702
4.7	.35998
5.3	0.0
5.8	.00766
6.1	.00066
7.0	.00085
7.5	0.0
7.6	.02345
9.7	0.0

MILREL

1	.02446
2	.00968
3	.00727
4	.02415
5	.00379

WARYRS

1	.05592
2	0.0
3	.00676
4	.00044
5	.05409
6	.12163
8	.00819
9	.02426
10	.00773
11	0.0
12	0.0

13	.35998
14	.00062
15	0.0
17	.11747
18	.00204
19	.00001
22	6.1088E-10

Table 6: Average Density Estimates (Quality 1 - 2, without non-range) by Other Factors.

QUAL

1	.46563
2	.08912

EFFECT

1	.48745
2	.54250
3	.76357
4	.09124
5	.11715

ANY

0	.16098
1	.32129

DENSITY

.5	.28670
4.5	.27462
12.0	.15392
24.0	.13188
48.0	.08136
96.0	.01509
192.0	.07985
384.0	0.0

MIDVALUE

25	.00100
75	.00077
125	.00100
150	0.0
175	.00100
225	.00100
250	.00987

275	.01003
325	.04194
350	.04655
375	.07752
425	.16169
450	.07115
475	.20832
525	.38996
550	.05605
575	.70093
650	.41706
700	.34391
750	1.00280
800	.06767
850	.24091
900	.04980
950	.15522
1250	.39698
1750	.37864
2500	.13417
3500	.20000

GDP

88	.03799
145	.59374
152	.10174
185	.21934
210	.23610
237	.38168
263	.01000
272	.08000
291	.04085
298	.09735
327	.40044
389	.20000
460	1.05782
592	.54213
691	.40000
739	.93600
826	.68297
896	.64952
921	.00100
1076	.04257
1083	.42277
2654	.35998
2955	.39000

GROWTH

-5.4	.04257
-3.9	.40000
-2.4	.10174
-2.1	.03799
-1.8	.38274
-1.3	1.05782
-1.0	.57229
.2	.04085
1.0	.64952
1.9	.39000
2.0	.20000
2.1	.54213
4.1	.01000
4.5	.08000
4.7	.35998
5.8	.20921
6.1	.42277
7.0	.68297
7.6	.23610

MILREL

1	.30865
2	.86027
3	.04205
4	.28861
5	.20921

WARYRS

0	.21831
1	.36544
3	.08000
4	.66598
5	.97103
6	.38168
8	.24747
9	.04362
10	.40044
13	.35998
14	.59374
17	.64952
18	.03799
19	.09735
22	.00100

These results show similar patterns to those in tables 1 to 3. This confirms that quality 3 estimates have the same general properties as estimates of qualities 1 and 2. However, after eliminating the non-range, the magnitude of the correlation increases, suggesting that some of the variation seen in the overall data may be attributed to variations in the quality 3 estimates. As discussed above, the non-range estimates will not be used in the multiple regression analysis of this data set either.

The density estimates were similarly related to vegetation type. Since this is a non-numeric variable, a one-way analysis of variance was used with Scheffe's test of multiple comparison. The following tables show the average elephant density estimates by vegetation class and which vegetation types had statistically different average elephant densities, pairwise.

Table 7: Average Density Estimates by Vegetation Class

Vegetation Class	Quality 1-3 with non-range	Quality 1-3 without non-range	Quality 1-2 with non-range	Quality 1-2 without non-range
A	.03059	.29838	.02824	.40737
B	.02172	.50293	.02146	.51993
C	.00527	.20929	.00440	.34331
D	.03836	.11116	.02669	.12616
E	.01257	.16908	.00277	.04174
F	.05768	.27594	.05181	.52813
G	.01053	.12125	.00551	.12793
H	.09454	.32326	.10147	.62219
J	.00036	.01400	0.0	
K	.02336	.09372	.01530	.06541
M	.00020	.00330	.00013	.00233
N	.00860	.03788	.00221	.03213
O	.00004	.00647	2.07923E-06	.00100
P	.03630	.14204	.0310	.23119

Table 8: Comparison of Density Estimates (with non-range) by Vegetation Class

	A	B	C	D	E	F	G	H	J	K	L	M-P
A												
B												
C												
D												
E												
F	X		X	Y	X							
G						XY						
H	X	X	X	X	X	X	XY					
J	X	X				X		X				
K	Y					XY		XY				
M	XY			X		XY		XY	X			
N						XY		XY				
O	X			X		X		X	X			
P								X				

X - Classes are different if non-range is included.
Y - Classes are different if non-range is excluded.

See Appendix III (Page 47) for Vegetation Category descriptions.

Table 9: Comparison of Density Estimates (without non-range) by Vegetation Class.

	A	B	C	D	E	F	G	H	J	K	L	M-P
A												
B												
C												
D												
E	Y											
F			X	Y	XY							
G	Y					XY						
H	X	X	X	XY	XY	X	XY					
J	X					X		X				
K	Y					XY		XY				
M	XY					XY		XY				
N						XY		XY				
O	X					X		X				
P						Y		XY				

X - Classes are different if non-range is included.
Y - Classes are different if non-range is excluded.

See Appendix III (Page 47) for Vegetation Category Descriptions.

It can be seen that by including the non-range, more pairs of veg. class are found to be statistically different. This may be partly attributed to the increase in sample size. The fact that a pair of classes is not discriminated in Table 9 (Page 28) does not mean that the density within the range does not vary between the classes, but only that our data are not able to prove that the variation is significant. It is, for instance, widely believed that elephant densities in forest differ from those in swamp forests; our data cannot support this since less than 1 % of the data are from swamp forests, but they certainly do not disprove it.

For the purposes of the multiple regression, however, data were sub-divided by vegetation type only where there was a clear distinction in average elephant densities. Thus, on the basis of the above results, the data were assigned to one of the following three categories: Forest (A and B), Miombo (F and H) and Other (C, D, E, G, J, K, L, M, N, P).

The multiple regression analysis was carried out on density estimates without the non-range as discussed above. The goal was to derive two sets of equations from which continent-wide extrapolations could be made, based first on all the density estimates and then on the quality 1 and 2 estimates only. For each set of data, separate analyses were conducted for each new vegetation category (Forest, Miombo and other).

Number of years at war (WARYRS) was excluded from the analyses, as it appears not to be related to elephant density. The other variables were selected for inclusion on the basis of a backward elimination, starting with all variables in the equation and eliminating those which do not contribute significantly.

Some of the variables, namely: GDP, GROWTH and MILREL are missing for some data points. (They were not available in the original source). This means that either those data points must be excluded from the analysis if all of the factors are used, or in order to include all data points, the analyses must be attempted without these factors. Both methods were tried.

For both datasets, GDP, GROWTH AND MILREL were log transformed prior to analysis. For qualities 1 and 2, effectiveness of protection (EFFECT) was also transformed. These decisions were made on the basis of the univariate analyses. It was unclear whether to transform human population (DENSITY), so the analyses were conducted both ways; in most cases, however, the transformed value produced a closer fit.

By examining the results of these many analyses, the following equations were derived (see pg.---, for the list of variable):

<u>Data Set One - Qualities 1 to 3</u>

<u>All Vegetation Types</u>:

<u>Forests</u>:

$$D = .43127 - .00937592 * DENSITY \pm .16429$$

Including all of the factors in this analysis reduced the data points so greatly that the analysis could not be conducted. The above equation was obtained by dropping the 3 factors with missing data points.

Miombo:

$$D = .70846 + .43379 * [LN (GROWTH + 1)] + .0001476233 * MIDVALUE - .11913 * EFFECT - .18527 * [LN (DENSITY + 1)] - .15109 * [LN (GDP + 1)] \pm .38911$$

This equation was derived by starting with all of the factors except MILREL.

Other:

$$D = .56583 - .04916 * [LN (MILREL + 1)] - .09879 * EFFECT + .06174 * ANY \pm .23295$$

This equation was derived by starting with all of the factors.

Data Set TWO - Qualities 1 and 2

Forests:

$$D = 1.31010 - .00660611 * DENSITY + .19101 * [LN (EFFECT + 1)] - .14935 * [LN (GDP - 1)] \pm .03702$$

As for the qualities 1-3 dataset, some factors had to be eliminated to allow for sufficient datasets.

Miombo:

$$D = 4.63162 - .44830 * [LN (MILREL + 1)] - .75039 * [LN (EFFECT + 1)] - .19920 * [LN (DENSITY + 1)] - .90758 * [LN (GROWTH + 11)] \pm .45110$$

This equation was derived by starting with all of the factors.

Other:

$$D = .16535 - .01653 * [LN (DENSITY + 1)] - .27607 * [LN (EFFECT + 1)] + .05129 * ANY + .00009103698 * MIDVALUE + .05912 * [LN (GDP + 1)] \pm .19625$$

This equation was derived by starting with all of the factors.

These equations were obtained for the purpose of projecting elephant numbers in 66% of the range for which estimates do not exist. The summary results by vegetation group were as follows:

Table 10: Summary Estimates by Vegetation Group.

			RESULTS QUAL 1-3		RESULTS QUAL 1-2	
	Quality	AREA	Estimate from Model 1	Estimated Density	Estimate from Model 2	Estimated Density
Forest :	project.	1,416,800	477,750	.337±.164	904,150	.638±.037
	1	200	100	.400	100	.400
	2	55,600	23,100	.415	23,100	.415
	3	27,900	2,650	.095	2,650	.095
	total	1,500,500	503,550	.336	930,000	.620
Other :	project.	1,353,350	88,550	.065±.233	184,850	.137±.196
	1	159,500	30,800	.193	30,800	.193
	2	573,650	28,900	.050	28,900	.050
	3	348,350	41,750	.120	41,750	.120
	total	2,434,850	190,000	.078	286,300	.118
Miombo	project.	1,211,350	106,850	.088±.389	424,600	.351±.451
	1	270,700	169,550	.626	169,550	.626
	2	56,250	9,150	.163	9,150	.163
	3	447,600	41,450	.093	41,450	.093
	total	1,985,950	327,000	.165	644,750	.325

Ests. - 1,939,400 (33%)
Proj. - 3,981,500
5,920,900

The most obvious feature in this table is the vast difference between the projections obtained from the two different models. We have already discussed the fact that all of the original estimates tend to come from areas where elephants are abundant, thus inflating the projections made therefrom. This problem is even more acute when only quality 1 and 2 estimates are used. As can be seen quality 3 estimates are from areas of less dense elephant numbers than the higher quality estimates. Therefore, the projections from the second model are inflated and will not be considered further. The projections from the first model are probably more accurate, however, they too are probably similarly biased upwards, but to a lesser degree.

This is probably especially true in the forest areas, where the original estimates were very few in number and the major fraction came from little poached and relatively high density areas and the extrapolations therein should be taken only as an upper bound.

The projection from the first model and the original estimates have been further broken down by country, vegetation type and protected status and are presented in Table 11 (Appendix VI, Page 53), together with range statistics. This Table is baseline information useful for planners for the management and conservation of elephant populations. It includes the original estimates and should be used in conjunction with Tables 12 and 13 (Page 37 - 38) and the specific area estimates in Appendix VII (Page 68). As has been noted, the projected figures presented are probably somewhat inflated especially in the forest zone, but represent the best estimate possible from the available information. (See also Maps 9-12)

DISCUSSION

In both the univariate and multivariate analyses, effective protection is consistently positively correlated with elephant densities. As such, it seems to be the most important factor in estimating numbers in unknown areas. All of the other factors evaluated also seem to have some relationship to elephant numbers within the present range, with the exception of the years at war. This, however, was seen to have a relationship to the present extent of range.

While these correlations are useful in establishing relationships and developing a model, it is important not to assume a direct causal link between the factors and elephant numbers. This is particularly true of the human factors which may correlate with elephant numbers for other reasons.

In using these correlations to make projections, it is also important to remember the various factors which have introduced error into the model. The most significant source of error is the problem already discussed of the tendency to count in areas where elephants are abundant and the related fact that the input data are not from a random sample.

However there are other sources as well. Errors in input data have several root causes: aerial surveys are subject to confidence limits and may also suffer from biases based on strip widths variations, sample counts tend to estimate higher than total counts and informed guesses tend to be lower. For example, in the Selous Game Reserve, the game warden estimated 50,000 elephants in 1976 when a sample aerial count estimated 109,000. No attempt has been made to quantify these.

Many of the estimate areas span a range of values for several factors -- where the estimate cannot be subdivided, it has been assumed that the elephant distribution is even across the area. This may not be the case. Finally, the extrapolations have been made over the range map which itself is indefinite. It errs on the side of overestimating range, which means for many countries, the extrapolations may be inflated. Taken in combination, these errors can significantly affect the results presented in table 11.

All of these problems are most prevalent in the central area of Africa, where the estimates are very few in number. Dr. Richard Barnes of the New York Zoological Society has developed a new method of estimating forest elephants using tracks and droppings and has assessed the errors involved (Barnes and Jensen 1986). He has already made the first large scale quantitative study of forest elephants in Gabon, and plans to extend this study into Zaire and Congo. He has written a review of what is known about the forest elephants of Central Africa. (See Appendix II, Page 41). His forest estimates, and those of Carroll in CAR, have been used in the model, but are thought to represent a high density sample. As he has pointed out much of the forest in Cameroon, Zaire and Congo has been heavily poached and densities are likely to be much lower than in Gabon. Extrapolating from these areas has probably seriously inflated the continental total.

Some overestimation has also probably occured in Angola where the range has not been revised for 12 years, and where a guerilla war has been active for many years. Some of the northern areas of Central Africa and Chad are thought to have been inflated from higher sample densities in savannahs elsewhere in the continent.

The extrapolations are thought to be less subject to bias elsewhere, especially in East and Southern Africa.

This project has attempted to estimate elephant numbers across Africa as an essential piece of information for planners and CITES parties. With the bias generally being towards overestimation, the projected estimates can be regarded as maxima.

In evaluating and using this information, it is important to remember that what is presented herein is a static picture, whereas elephant populations are dynamic. Any efforts to set ivory quotas or to manage populations must also consider population trends. There is not enough information available to make comprehensive models of elephant trends as has been done for elephant numbers; however, the data available indicate a downward trend for most parts of the continent. Appendix I (Page 34) contains a summary of the data available and some regional weighted averages based thereon. Appendix V11 compares the projections of this project with previous continental estimates.

CONCLUSIONS

Any extrapolation is only as good as the data on which it is based. The most recent available data have been used in this exercise. However, as has been discussed above, these data are far from perfect, although they probably represent one of the more comprehensive examinations of numbers and distribution developed for a threatened species. The factors included in the model are similarly the best available, but are not flawless. Some datasets are outdated and some which might be desirable, such as a detailed land use map, are not included, because they are not yet available. Nevertheless, the significant correlation between effective protection and elephant density underscores the importance of this factor for the future of the species.

The results of the model appear to be inflated for the forest and some other habitats and should be used circumspectly. Databases such as this should be continually updated, and as new information is obtained, the models can be revised. In future it is planned to continue updating the database as new information is obtained, and to refine the model so that the numbers of elephants, their trends, and the areas in which they live can be more accurately predicted.

In the meanwhile, it is hoped that the contents of this report will contribute to the AERSG review of the Ivory Export Quotas undertaken on behalf of CITES, and will help provide planners with baseline population data from which to set sustainable limits and develop sound management plans for the African elephant.

APPENDIX I

Regional Elephant Trends

In making decisions on ivory quotas it is important to consider the dynamic aspect of elephant numbers. Continental elephant numbers are currently declining fast due to overexploitation for ivory. This is not the first time in history that this has happened and a similar continental population crash occured for most savanah elephants in the 19th century (Spinage, 1973).

With the introduction of new game laws at the turn of the century, elephant populations in many countries and regions, such as Sudan, Zaire, East Africa, Zambia, Zimbabwe and South Africa, stabilized and then began to increase (Pitman, 1930-1936; Offerman, 1951; Anderson, 1955; Swynnerton, 1923; Percival, 1924; Stigand, 1909; Blunt, 1933; Kerr and Fraser, 1975; Pienaar, 1963; Hall-Martin, 1980). By the 1960's despite some reduction of elephant populations due to human expansion, there had been an overall increase since the turn of the century. Zimbabwe is a typical example where it has been estimated there are ten times more elephants now than in 1900 (Cumming, pers comm).

Elephants in the 1960's in these countries were so numerous that many thousands were shot annually in order to protect crops, without any overall negative impact on numbers. The ivory from these "control" operations, and licence fees from elephant sport hunting, helped to make the wildlife departments of those countries self sufficient. "Elephant problems" arising from too many elephants immigrating into the national parks were also characteristic of this decade (Douglas-Hamilton, 1987).

The new wave of killing for ivory began in 1970 with a sharp rise in the ivory price (Parker, 1979). It was first documented in Kenya in 1973, and then spread to other parts of East, Central and West Africa and to Angola, Zambia, and Mozambique in Southern Africa (Douglas-Hamilton, 1987).

Available trend data are not complete enough for modelling on the GRID GIS, but trends can be quantified for East Africa and parts of Southern Africa which have been well sampled. Fragmentary data exist for Central and West Africa savannahs, but are lacking for the rainforest. Trend data and sources are given below in Tables 12 and 13 (Page 37-40).

In some places trends have been calculated from the ratio of dead to live elephants, e.g. Arusha and Tabora regions in Tanzania, Zakouma census zone in Chad, Shambe census zone in Sudan, and Somalia, (for method see Douglas-Hamilton and Burrill, 1986 in press, and Watson, 1985). These trends have then been extrapolated up to date where necessary so that country regional trends can be calculated weighted by present populations.

All the trends are calculated as annual rates of change according to the compound interest formula:

$$r = (n1/n2) \wedge (1/(t1 - t2)) - 1$$

Where r = rate of change
n1 = Number of elephants at t1
n2 = Number of elephants at t2
t1 = Year of first estimate
t2 = Year of second estimate

For the Southern African countries where elephant poaching is well controlled, that is Namibia, Zimbabwe, Malawi, Botswana, and South Africa, national trends varied between -4% in Zimbabwe, where it is policy to reduce the national herd by culling, to an annual increase of 5% per annum in Botswana. The Addo national park in South Africa with an increase of 3% is an example of recovery due to increased protection. The worst poaching in these countries occurred in Kaokoland, Namibia between 1977 and 1982, with an annual trend of -17%, but this small population did not affect the overall weighting. The regional weighted trend for well managed populations of South Africa, totalling approximately 108,000 elephants, was an increase of 0.7% per annum.

For the remaining Southern African countries where poaching is not well controlled, reliable data were only available for the Luangwa Valley in Zambia with an annual trend of -5% and from the informed guesses of Tello (pers comm) for Mozambique of -11.8%. The Luangwa Valley is relatively better protected than elsewhere, and the trend in the rest of Zambia, and in Angola and Mozambique is likely to be that described by Tello. The weighted mean of these samples was -8.1%.

East Africa, from a ten year comparison of elephant estimates, showed an annual rate of change -10.4% for Kenya, -7.2% for Tanzania and -7.8% for Uganda. The regional weighted trend was -8.1%, heavily weighted by the rate of decline in Selous, which with 55,000 elephants comprises roughly half of today's East African elephant sample.

Within East Africa populations some protected areas such as Lake Manyara remained stable. The trend in Mara Game Reserve was +4.5% with an influx of elephants fleeing poaching in the neighbouring Serengeti. Serengeti itself decreased at -18.4% per annum. Other protected populations decreased throughout the region, e.g. Tsavo - 11.5%, Murchison - 11.2%, Selous - 6.6%.

The most severely negative trends in East Africa in the last ten years, were in the East of Kenya of - 18% to - 21%. Garissa, Lamu, Tana River, Kilifi, Kwale, Isiolo and Samburu Districts have over 15 years lost betweenm 90% to 95% of their elephants. These are matched in neighbouring Somalia with a loss of 94%. If the Sudan national estimate for 1976 is compared with the projected number for today, the rate of change is - 12.5% annually, or a total loss of 77% over ten years.

In the northern non forested elephants habitats from Somalia to Senegal (Table 13, Page 39) survey data is fragmentary. In West African Roth as an informed guess suggests a trend of - 10% in Ivory Coast, and Dupuy's surveys of Niokola Koba in Senegal a trend of - 17%. Cobb, however, as an informed guess suggests that the Gourma population of Mali is at present stable. It is likely that most other West African elephant populations have trends similar to those of Ivory Coast and Senegal. The overall weighted mean annual change from this sample is - 17.8% per annum. These rates correspond with informants reports of heavy poaching (Douglas-Hamilton, 1987).

The Central African forests are lacking trend data. Barnes (Appendix II, Page 41) suggests that while elephants in Gabon have been stable or increasing this is unlikely to continue. Anecdotal reports from Cameroun, Congo, and Zaire suggest negative elephant trends, especially in the East of Zaire. John Hart, a scientist studying the ecology of Okapi in the remote Ituri forest in Zaire, has written:

"We have found a number of recently killed elephant skeletons, so many in fact that we are censuring them along our transects.... It is clear that the current elephant number must be a fraction of what this forest could support .... The carnage in recent years was incredible. The fact that elephant hunting may be reduced now is a function of reduced elephant numbers, not due to any change in policy";

It is probable that the rates of change in Eastern Zaire are similar to those of heavily poached areas elsewhere in the continent.

It is clear that the present continental offtake of elephants for ivory is unsustainable.

TABLE 12 Regional East African Trends.

	ESTIMATES 1973	1977	1987	% ANNUAL CHANGE 73-77	77-87	NUMBERS CHANGE 73-77	77-87	10 YEAR CHANGE 77-87	15 YEAR CHANGE 73-87	DATA QUALITY	SOURCE
KENYA SAMPLE											
DISTRICTS EXCLUDING PROTECTED AREAS											
GARISSA	14500	7092	678	-16.4%	-20.9%	-7408	-6414	-90%	-95%	1	1
LAMU	7000	3412	310	-16.4%	-21.3%	-3588	-3102	-91%	-96%	1	1
TANA RIVER	32000	6524	1152	-32.8%	-15.9%	-25476	-5372	-82%	-96%	1	1
KILIFI	10000	806	23	-5.2%	-29.9%	-194	-783	-97%	-98%	1	1
KWALE	2000	1420	182	-8.2%	-18.6%	-580	-1238	-87%	-91%	1	1
ISIOLO	2000	1275	154	-10.6%	-19.1%	-725	-1121	-88%	-92%	1	1
SAMBURU	9000	1318	427	-38.1%	-10.7%	-7682	-891	-68%	-95%	1	1
TURKANA	1500	1318	444	-3.2%	-10.3%	-182	-874	-66%	-70%	1	1
LAIKIPIA	1000	3060	2791	32.3%	-.9%	2060	-269	-9%	179%	1	1
NAROK	5000	1921	243	-21.3%	-18.7%	-3079	-1678	-87%	-95%	1	1
UNPROTECTED SUB TOTAL	75000	28146	6404	-21.7%	-13.8%	-46854	-21742	-77%	-91%		
PROTECTED AREAS											
MARA GR	720	710	1100	-.3%	4.5%	-10	390	55%	53%	1	2
AMBOSELI NP	550	450	680	-4.9%	4.2%	-100	230	51%	24%	1	3
MERU NP	1500	2000	427	7.5%	-14.3%	500	-1573	-79%	-72%	1	4
SAMBURU, BUFFALO SPRINGS NR	2500	531	632	-32.1%	1.8%	-1969	101	19%	-75%	1	4
MARSABIT NR	300	900	529	31.6%	-5.2%	600	-371	-41%	76%	1	4
MT KENYA NP	2500	3000	2000	4.7%	-4.0%	500	-1000	-33%	-20%	3	4
MT ELGON NP	500	1000	200	18.9%	-14.9%	500	-800	-80%	-60%	3	4
ABERDARES NP	3000	3000	2000	0.0%	-4.0%	0	-1000	-33%	-33%	3	4
TSAVO ECOSYSTEM	35000	19300	5700	-13.8%	-11.5%	-15700	-13600	-70%	-84%	1	5
'PROTECTED' AREAS SUB TOTAL	46570	30891	13268	-9.8%	-8.1%	-15679	-17623	-57%	-72%		
TANZANIA SAMPLE											
UNPROTECTED AREAS											
ARUSHA COMPLEX		16660	2146		-18.5%	16660	-14514	-87%		2	6
TABORA REGION		8399	1958		-13.6%	8399	-6441	-77%		2	7
KILOMBERO		5848	2230		-9.2%	5848	-3618	-62%		1	8
UNPROTECTED SUB TOTAL		30907	6334		-14.7%	30907	-24573	-80%			

	ESTIMATES			% ANNUAL CHANGE		NUMBERS CHANGE		10 YEAR CHANGE	15 YEAR CHANGE	DATA	SOURCE
	1973	1977	1987	73-77	77-87	73-77	77-87	77-87	73-87	QUALITY	
PROTECTED AREAS											
SELOUS GR AND MIKUMI NP		109000	55000		-6.6%	109000	-54000	-50%		1	9
RUAHA NP, RUNGWA GR, KIZIGO		43685	21986		-6.6%	43685	-21699	-50%		2	10
SERENGETI NP		3008	395		-18.4%	3008	-2613	-87%		1	11
MANYARA NP		453	434		-.4%	453	-19	-4%		1	12
TARANGIRE NP		3000	3000		0.0%	3000	0	0%		3	13
MKOMAZI GR		667	193		-11.6%	667	-474	-71%		2	14
PROTECTED SUB TOTAL		159813	81008		-6.6%	159813	-78805	-49%			
UGANDA SAMPLE											
PROTECTED AREAS											
KIDEPO NP	820	615	430	-6.9%	-3.5%	-205	-185	-30%	-48%	2	15
QUEEN ELIZABETH NP	3000	1200	700	-20.5%	-5.2%	-1800	-500	-42%	-77%	2	15
MURCHISON SOUTH NP	13800	2375	725	-35.6%	-11.2%	-11425	-1650	-69%	-95%	2	15
PROTECTED SUB TOTAL	17620	4190	1855	-30.2%	-7.8%	-13430	-2335	-56%	-89%		
EAST AFRICA TOTAL											
KENYA SAMPLE	121570	59037	19672	-16.5%	-10.4%	-62533	-39365	-67%	-84%		
TANZANIA SAMPLE		184872	87342		-7.2%	184872	-97530	-53%			
UGANDA SAMPLE	17620	4190	1855	-30.2%	-7.8%	-13430	-2335	-56%	-89%		
UNPROTECTED SAMPLE		59053	12738		-14.2%		-46315	-78%			
PROTECTED SAMPLE		194894	96131		-6.8%		-98763	-51%			
TOTAL SAMPLE		253947	108869		-8.1%		-145078	-57%			

SOURCES

1 JARMAN (1973), PEDEN (1983), OTTICHILO (1987)
2 DUBLIN AND DOUGLAS-HAMILTON (1987), DUBLIN (PERS COMM)
3 POOLE (PERS COMM), WESTERN (PERS COMM)
4 JARMAN (1973), HILLMAN (1977), AERSG (1987)
5 COBB (1976), OTTICHILO (1987)
6 ECOSYSTEMS (1980), EXTRAPOLATION THIS STUDY
7 ECOSYSTEMS (1979), EXTRAPOLATION THIS STUDY
8 RODGERS ET AL (PERS COMM), DOUGLAS-HAMILTON ET AL (1986)
9 DOUGLAS-HAMILTON ET AL (1986)
10 BARNES ET AL (1982), BORNER ET AL (1984), THIS STUDY
11 DUBLIN AND DOUGLAS-HAMILTON (1987), DUBLIN (PERS COMM)
12 DOUGLAS-HAMILTON (UNPUBLISHED DATA)
13 ECOSYSTEMS (1980) AND ASSUMED STABILITY
14 DOUGLAS-HAMILTON (UNPUBLISHED DATA) AND THIS STUDY
15 ELTRINGHAM AND MALPAS (1980), DOUGLAS-HAMILTON (1983a), SSEMWEZI (PERS COMM)

The trends shown in Tables 12 and 13 if extrapolated at a compound rate give a halving rate of 10 years for the "protected areas" and 5 years for the unprotected areas of East Africa. This assumes the offtake will decrease as elephants become fewer. If on the other hand the offtake were maintained at the average level of the last ten years, a decrease of 14,500 elephants per year, the East African elephants would be finished in eight years. This scenario is unlikely, but unless the factors which cause the decrease are altered the future rate of decrease will probably lie between the compound and the straight rates.

TABLE 13

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	ANNUAL CHANGE	DATA QUALITY	SOURCES
SOUTHERN AFRICAN SAMPLE															
MAJOR POACHING AREAS															
ZAMBIA: LUANGWA NP				33510								21900	-5.2%	1	1
MOCAMBIQUE: ELEPHANT RANGE									27150			18600	-11.8%	3	2
WEIGHTED SUB TOTAL												40500	-8.2%		
LITTLE POACHING AREAS															
BOTSWANA: SAMPLE ZONE												50400	5.0%	1	3
SOUTH AFRICA: KRUGER NP		7715									7617	7617	-.1%	1	4
ADDO NP		90								120	118	118	3.1%	1	5
MALAWI: ELEPHANT RANGE												2400	0.0%	2	6
ZIMBABWE: ELEPHANT RANGE						55000						43000	-4.0%	1	7
NAMIBIA: ELEPHANT RANGE												4900	0.0%	2	8
KAOKOLAND		250					36					36	-17.6%	2	9
WEIGHTED SUB TOTAL												108435	0.7%		
SOMALIA TO SENEGAL: NON FOREST SAMPLE															
SOMALIA: RANGELANDS					31774				8264			3000	-28.6%	1	10
SUDAN: SHAMBE CENSUS ZONE		1510			829							340	-13.9%	2	11
C.A.R: TREND SAMPLE ZONE			11174							617		400	-33.9%	1	12
CHAD: ZAKOUMA NP AND ZONE							8100				1087	660	-39.5%	2	13
ZAIRE: VIRUNGA NP (PLAINS)					751							400	-10.0%	3	14
GARAMBA NP AND ZONE	22670						7742				4352	3690	-15.2%	1	15
IVORY COAST: ELEPHANT RANGE												3800	-10.0%	3	16
MALI: GOURMA												500	0.0%	3	17
BOUCLE DE BAOULE NP		70										10	-17.7%	3	18
SENEGAL: NIOKOLA KOBA NP		350										50	-17.7%	2	19
												12850	-17.8%		
SUDAN	130000											30000	-12.5%		20

The trends for the Senegal to Somalia sample if extrapolated at a compound rate give a halving rate of four years. Mozambique and Zambia samples are similar to East Africa. Only the remainder of Southern Africa is stable.

TABLE 13

SOURCES

1 DOUGLAS-HAMILTON ET AL (1979), KAWECHE ET AL (1987)
2 TELLO (PERS COMM)
3 CALEF (PERS COMM)
4 HALL MARTIN (1981), BROOKS (PERS COMM)
5 PENZHORN ET AL (1974), HALL-MARTIN (PERS COMM)
6 BELL (1985), MPHANDE (PERS COMM)
7 CUMMING AND JACKSON (1984), AERSG (1987)
8 CITES QUOTA RETURNS 1987
9 OWEN SMITH (1983), CITES QUOTA RETURNS 1987
10 WATSON (1985)
11 HILLMAN ET AL (1981)
12 SPINAGE ET AL (1978), DOUGLAS-HAMILTON ET AL (1985)
13 BOUSQUET ET AL (1986)
14 MERTENS (1981), AVELING (PERS COMM)
15 SAVIDGE ET AL (1976), HILLMAN (PERS COMM)
16 ROTH ET AL (1984)
17 COBB (PERS COMM)
18 LA MARCHE (PERS COMM), DE BIE AND KESSLER (1983). VA
19 DU PUY (1977), HALL MARTIN (PERS COMM).
20 WATSON ET AL (1975), THIS STUDY

APPENDIX II

A Review of the Status of Elephants in the Rain Forests of Central Africa

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INTRODUCTION

Rain forest extends over 1.75 million square kilometres of equatorial Africa. It covers large parts of Cameroon, Central African Republic, Congo, Zaire, Equatorial Guinea, and Gabon. This huge area forms a large proportion of the total range of the African elephant *Loxodonta africana.*

Ivory from the rain forest accounts for about 60% of ivory exports from Africa. Yet there is very little information available on the numbers and trends of elephants in the rain forest zone. A census programme is now being planned, but it will be two or three years before the results are ready. In the meantime, this review provides a synthesis of the available information on the status of forest elephants in equatorial Africa. It updates the assessment made by Douglas-Hamilton in 1979.

This review covers only the rain forest block of central Africa and does not include the forest elephants of west Africa. It is based upon two years spent in the forests of Gabon (Barnes and Jensen, 1986) and upon an assessment of a collection of unpublished reports, letters, and questionnaire returns accumulated by Dr. Iain Douglas-Hamilton.

ELEPHANT ECOLOGY IN THE RAIN FOREST

It is not rainfall or soil or vegetation that determines elephant abundance in the rain forest, but man. Man destroys the forest, alters the forest, and hunts elephants for meat and ivory.

Except for parts of Cameroon, habitat loss caused by expanding human populations and the spread of agriculture does not yet seem to be an important threat to elephants. In general human densities and rates of population growth are low in the African rain forest. In addition, there is a drift of people to the towns, so the rural population may even be declining.

The preferred habitat for elephants---secondary forest---is created by man, for it grows up on abandoned villages and plantations. However the frequency with which elephants use a particular area of secondary forest depends upon the amount of human disturbance. Elephants avoid roads and villages and areas where there is regular hunting, even if it is only subsistence hunting for monkeys and antelopes (Barnes and Jensen, 1986).

Although they avoid villages, elephants do often come to raid plantations at night. Many crop-raiding elephants are shot each year, but this number accounts for only a small proportion of the total population and probably has very little effect upon the overall trend in elephant numbers.

Commercial activities such as forestry play a big role in changing the forest ecosystems. Sometimes elephants may benefit, while other times they may suffer. The disturbance caused by foresters and their machinery may drive elephants away from timber concessions. But after the foresters have moved on, elephants may return to take advantage of the secondary growth which appears in the gaps caused by selective logging and along forestry roads. But these roads also open up the area to poachers.

Industrial activities in remote forest, such as road and railway construction, mining, and oil production, can have a detrimental effect on elephant numbers. This is not because of the industrial installations themselves or their activities, which usually cover only a small area. It is because they bring in large numbers of workers and it is the uncontrolled poaching by the labour force which reduces the numbers of elephants. As roads and railways spread through the forest zone, opening up previously remote areas, it is inevitable that elephants will be driven out.

Ivory poaching has increased in the forest zone since the end of the colonial period. The increased availability of firearms and improvements in roads have made poaching easier. There are now large areas of forest in Cameroun, Congo, and Zaire where elephants are no longer found.

There are still some pigmy communities for whom elephant hunting is an important tradition. The numbers of elephants they kill, usually with spears, are small. In some areas the pigmies' way of life is changing rapidly. Instead of hunting small numbers of elephants for meat using traditional methods, they are now being given guns to hunt for ivory (Dodd, 1979).

What sort of elephant densities can one expect to find in rain forest? Preliminary results from an elephant census in Gabon (Barnes and Jensen, 1986) show that in large areas of secondary forest where there is no human activity densities may be as high as one elephant per km2. In primary forest with isolated patches of secondary forest where there is very little subsistence hunting the average density is about 0.4 per km2. In the same sort of forest where there is regular subsistence hunting the average density is about 0.1 per km2. But within these categories of forest the variation in elephant density is considerable. These figures show that rain forest can hold very large numbers of elephants.

SUMMARY OF THE STATUS OF ELEPHANTS IN EACH COUNTRY:

Cameroon:

Forest covers the southern two fifths of Cameroon. In the past elephants were found throughout this area. Ten years ago it was reported that elephants had disappeared from some areas where they used to occur and that in general they were decreasing in number (Ngog Nje, 1977).

The human density in the west and central parts of the rain forest area is about 30 per km2 (Barnes and Jensen, 1986), which is very high for rain forest in equatorial Africa. Here elephants are under considerable pressure from expanding settlements, forestry, and hunting. This is one area where loss of habitat due to an expanding human population is important. For example, in 1964, elephants were abundant on the slopes of Mount Cameroon (Douglas-Hamilton Pers. Comm.); now this area is densely settled and the elephants have gone. They have also disappeared from the Douala-Edea Reserve (Woodford, 1984, pers. comm.) and they are scarce within a radius of 100 km of Yaounde (Balinga, 1983, pers. comm.).

In the forests of south-eastern Cameroon the human population is low, about 4 per km2. However, commercial activities such as forestry are increasing and there are recent reports of very heavy hunting (Harrison, 1986, pers. comm.). Some of this is done by pigmies who are being commissioned to hunt for ivory with heavy rifles (Dodd, pers. comm.). It is feared that elephant numbers are falling rapidly (Harrison pers. comm.).

Congo:

The numbers of elephants in Congo were reduced during the colonial era, but even so elephants were to be found throughout the country during the 1950s (Nosso, 1977, IUCN Elephant Questionnaire reply). After independence, modern firearms became common. At the same time the road network was improved, providing access to remote parts of the country and allowing the forestry industry to expand. Inevitably the numbers of all wild animals, and especially elephants, decreased dramatically. Now elephants occur only in the forest. This covers the northern half of the country. Much of it is very remote with a sparse human population.

Ivory poaching is heavy and is said to be increasing in many parts of the forest zone. The construction of a road north and east of Ouesso will open up the remote forests of the far north to further poaching.

Large numbers of elephants still remain (Oko, 1983, pers. comm.). For example, there is a huge area of swamp forest in eastern Congo which must still harbour a large population. But it is clear that elephants are under considerable pressure in many parts of Congo. The authorities have expressed concern that elephants may disappear entirely (Nosso, 1981 pers. comm.).

Central African Republic:

The south west corner of CAR is covered by rain forest. Although elephants have been massacred outside the rain forest zone, large numbers remain within the forest. High densities have been reported around Bayanga. Richard Carroll and Michael Fay are making an ecological survey, including an elephant census, but I have not yet been able to see their reports.

Equatorial Guinea:

About half of Equatorial Guinea is covered by rain forest. Very little is known about this country, for it was closed off from the rest of the world during its civil war in the 1970s. Nothing is known about its elephants. But it is probable that they were hunted heavily during the turbulent seventies.

Gabon:

Eighty-five per cent of the surface area of Gabon is covered by forest. This is one of the most sparsely populated countries of Africa. There remain vast areas of uninhabited forest which support large numbers of elephants (Barnes and Jensen, 1986).

Poaching is widespread but on a small scale. It is probably too light to have any effect on elephant numbers. There is not yet any evidence of the heavy organised poaching that has been under way in Cameroon, Congo, and Zaire for so many years. But this lack of organised ivory poaching will not continue for much longer. Until 1985, Gabon was the richest country in sub-Saharan Africa (in 1983 its per capita GNP was $3,950 (The World Bank, 1986)), because of its oil wealth. The collapse of the price of oil caused a severe economic crisis and will have two important consequences for elephants. Firstly, Gabon will have to exploit its other natural resources, which means that mining and forestry will play a greater role in opening up remote areas of forest. Secondly, financial difficulties will encourage some entrepreneurs to turn to organising elephant poaching and to ivory trading. The result will be a rapid decline in the number of elephants.

Zaire:

Zaire is the second largest country in Africa. Rain forest covers nearly half of it --- about one million km2. This vast area once carried an enormous elephant population, perhaps the largest in Africa.

In the 1940s, elephants were found throughout the country and during the late 1940s and all through the 1950s an average of 4,600 crop-raiding elephants were shot each year (Rollais, 1979), without having any apparent effect on the population trend. But for the last 25 years elephants have been killed on a large scale. Zaire's huge area and its lack of communications make enforcement of the game laws almost impossible. It also suffered a long period of civil war during the 1960s when elephants were hunted very heavily as successive waves of rebels, mercenaries, soldiers, and poachers passed through.

There are many reports of large numbers of elephants being killed all through the 1970s. For example, the newspaper Elima wrote "...the exportation of ivory tusks has registered an alarming expansion. According to certain statistics, it can be concluded that more than 200 elephants per day are being killed." Another newspaper report described a concentration of about 50 poachers at a camp on the Tshuapa River. The poachers gathered there to sell meat and ivory to dealers who came upriver to meet them. Both the poachers and the ivory traffickers claimed to have good relations with the military and civil authorities of the region.

Zaire has an extensive system of large rivers which provide access to many parts of the rain forest zone. Poachers have taken full advantage of it. Large gangs of well-armed poachers have penetrated deep into the distant forests of Equateur and Kasai-Oriental using boats powered by outboard motors (Rollais, 1979).

Often soldiers were involved in poaching. Frequently, high-ranking government officials and officers of the Gendarmerie have connived in it. Some powerful figures high in the government are alleged to have been involved in ivory trafficking (Douglas-Hamilton, 1979).

Firearms used against elephants range from home-made guns to automatic weapons. Other methods have been described. For example, boards with nails have been left on elephant paths, immobilising elephants which were later finished off with spears or guns (Luketa Shimbi, 1979). Other poachers left papayas filled with poison (battery acid or insecticide) where elephants would find them.

There was a five-fold increase in the price of ivory in Zaire between 1973 and 1978 (Cutler, 1978). Zaire is a desperately poor country (in 1983 the per capita GNP was $170 (World Bank, 1986)). Thus it is no surprise that whole villages should have abandoned their normal farming activities in order to turn to full-time ivory poaching (Cutler, 1978, and Hudson pers. comm.).

In 1977, after banning all hunting and ivory trading, the government surveyed existing ivory stocks. The scale of the killing of the preceding years is reflected by the size of the stocks which, according to Cutler, numbered 1500 tons.

Most of the available reports refer to the 1970s. There is a little information about the elephant situation in the 1980s. It is almost certain that the killing has continued on the same scale as the 1970s. We know that in the savanna habitats of Zaire, elephants have continued to be slaughtered; for example, in Garamba N.P. elephant numbers fell by 64% between 1976 and 1983 (Hillman et al, 1983) Biologists report the absence of elephants from large areas of forest where they used to occur (Rollais, 1979). For example, elephants are no longer found within a large radius of Kisangani (Nicoll, 1987). "The carnage in recent years was incredible" in the Ituri Forest of eastern Zaire, according to one biologist (Hart, 1986). He has found a large number of elephant carcases and considers that in the Ituri Forest elephant densities are a fraction of what they must have been in the past.

CONCLUSION

At one time the rain forest zone of equatorial Africa must have held very large numbers of elephants. The ivory and slave trade in the eighteenth and nineteenth centuries depleted many areas, and numbers were further reduced during the early colonial period as roads and firearms spread through the forest zone (Douglas-Hamilton, 1979). After about 1920 some elephant populations may have recovered. But since independence in the early 1960s, all the rain forest countries except one have lost very large number of elephants. The one exception is Gabon, where high oil revenues and sparse human population have spared the forest from heavy exploitation. Gabon is also a stable peaceful country and, apart from shot-guns used for subsistence hunting and some heavy rifles, firearms are strictly controlled.

Although roads are extending into many remote areas of forest, and settlements usually spring up along the roads, there is little evidence yet to suggest that competition for space is a common reason for elephants being killed, except in parts of Cameroon. Nearly all the accounts either state explicitly or imply that ivory is the reason elephants are being killed.

All the accounts suggest a downward trend for the forest elephant populations of Cameroon, Congo, and Zaire. But these reports of poaching and changes in elephant abundance are usually based on impressions and informed guesses. They draw a picture of large numbers of people involved in poaching and of many elephants being killed. However, the number of elephants killed tells one nothing about the trend in elephant numbers, because one does not know the proportion of the population that has been killed. Although these are subjective observations, they do come from the best-informed people in each country and they are supported by the fact that elephants are no longer found in large areas of forest. Nevertheless, one must remember that the conclusion that elephants are declining in these countries is not based on any hard scientific data. For there are no data which could be used to estimate the trend of any elephant population in the rain forest. Requests by the countries of equatorial Africa for international aid for forest ecosystem conservation programmes in general, and elephant surveys in particular, should be treated with the greatest urgency.

APPENDIX III

Key to Vegetation Groupings

CATEGORY		WHITE'S VEGETATION CLASSES
A	Forest	1-5
B	Swamp Forest	8-9
C	Forest/Grassland	11-12
D	Coastal Mosaic	15-16
E	Montane	17-20, 65-66
F	Miombo Woodland	6, 25-28
G	Sudanian Woodland	29-30, 62-63
H	Woodland Mosaic	31-36, 22, 47
J	Secondary Wooded Grassland and Bushland	37, 43, 44.
K	Bushland/Thicket Mosaics	38-42, 45
L	Scrubland	24, 48-50
M	Semi-Desert	51-57
N	Grassland	58-61
O	Desert	67-74
P	Azonal Vegetation	64, 75-77
X	Mediterranean	10, 23, 78-80

APPENDIX IV

Protected Areas which have been Entered from Large Scale Maps.

BENIN:	Djouna (ZC), L'Atakora (ZC), Park W. (NP), Pendjari (NP), Pendjari (ZC).
BOTSWANA:	Chobe (NP), Chobe (FR), Kasane (FR), Kazuma (FR), Maikaelelo (FR), Moremi (WR), Nxai Pan, Sibuyu (FR).
BURKINA FASO:	Arli (NP), Arli (RP), Kourtiagou (RP), Pama (RP), Singou (RT).
CAMEROON:	Benoue (NP), Bouba Njida (NP), Campo (R), Dja (FR), Doula-Edea (NP), Faro (NP), Waza (NP).
CENTRAL AFRICAN REPUBLIC:	Bamingui-Bangoran (NP), Dzanga-Sangha (RF), Manovo-Gounda-Saint Floris.
CHAD:	Manda (NP), Salamat (MX), Siniaka Minia (NP), Zakouma (NP).
CONGO:	D'Ozala (NP), Lekoli-Pandaka (FR), Mboko (FR).
GHANA:	Ankasa (NP), Bia (NP).
IVORY COAST:	Comoe (NP), D'Azagny (NP), Tai Forest (NP), Haut Bandaama (RF), Marahoue (NP), Mont Peko (NP), Sangbe (NP).
KENYA:	Amboseli (NP), Buffalo Springs (NR), Kora (NR), Laikipia - Ol Ari Nyru, Mara (GR), Maralal (NS), Marsabit (NR), Meru (NP), Samburu (NR), Tsavo (NP).
MALAWI:	Kasungu (NP), Liwonde (NP), Majete (GR), Nkhotakota (GR), Nyika (NP), Vwaza Marsh (GR).
MALI:	Boucle du Baoule, Elephant Park (FR), Fina, Badinko.
MOZAMBIQUE:	Gorongoza (NP).
NAMIBIA:	Etosha (NP).
NIGERIA:	Borgu (GR), Kainji, Yankari (GR).
RWANDA:	Volcans (NP).
SENEGAL:	Niokolo Koba (NP).
SIERRA LEONE:	Gola (FR).
SOUTH AFRICA:	Addo (NP), Hluhluwe-Umfolozi (GR), Kruger (NP), Knysna (FR), Pilansberg (GR), Tembe Elephant Reserve (GR).
SUDAN:	Shambe (NP), Southern (NP).

TANZANIA:	Arusha (NP), Katavi (NP), Kilimanjaro (NP), Kisigo (GR), Manyara (NP), Mikumi (NP), Mkomazi (GR), Ngorongoro, Ruaha-Rungwa (NP), Selous (GR), Serengeti (NP), Tarangiri (NP), Ugalla (GCA).
UGANDA:	Bukimi, Karuma (GR), Kidepo (NP), Murchison (NP), Ruwenzori, Toro (GR).
ZAIRE:	Garamba (NP), Gwane, Kahozi-Biego, Maiko, Salonga, Virunga (NP).
ZAMBIA:	Chisomo (GMA), Luambe (NP), Lukusuzi (NP), Lumimba (GMA), Munyamadzi (GMA), Nsefu (NP), N. Luangwa (NP), S. Luangwa (NP), Sandwe (GMA).
ZIMBABWE:	Charara (SA), Chete (SA), Cheware (SA), Chimanimani (NP), Chimanimani Eland Santuary, Chipinga (SA), Chirisa (SA), Chizarira (NP), Dande (SA), Deka (SA), Doma (SA), Gonarezhou (NP), Inyanga (NP), Kazuma (FR), Kazuma Pan (NP), Lake Kyle (RP), Lake Mellwaine (RP), Lake Robertson, Mana Pools (NP), Manjirenji (RP), Matetsi (SA), Matusadona (NP), Motopos, Mt Selinda, Mushandike Sanctuary, Ngezi (RP), Nyajena-Bangala (RP), Sapi (SA), Tuli (SA), Umfuli, Urangwe (SA), Wankie (NP), Zambezi (NP).

APPENDIX V

Socio-Economic and Political Factor

Key Indicators 1985

COUNTRY	GDP Per Capita $	GDP Real Growth %	Reliability Of Military 1982 1 = High 5 = Low	Years At War 1945-82
Angola	921	n/a	3	22
Benin	230 (a)	9.7 (d)	n/a	2
Botswana	592	2.1	n/a	1
Burkina Faso	164 (a)	3.3 (a)	n/a	
Burundi	255 (a)	5.3 (a)	1	3
Cameroon	826	7	n/a	8
Central African Republic	152 (a)	-2.4 (a)	4	1
Chad	88 (a)	-2.1 (b)	4	18
Congo	1083 (a,e)	6.1 (a)	3	4
Equatorial Guinea	205 (a)	n/a	2	2
Ethiopa	149 (a)	4.3 (a)	2	15
Gabon	2955 (a)	1.9 (a)	n/a	1
Gambia	245	n/a	n/a	1
Ghana	2559 (b)	7.5	5	1
Guinea	343 (a)	3.8 (b)	n/a	1
Guinea Bissau	178 (a,e)	n/a	n/a	12
Ivory Coast	691	-3.9	n/a	4

COUNTRY	GDP Per Capita $	GDP Real Growth %	Reliability Of Military 1982 1 = High 5 = Low	Years At War 1945-82
Kenya	291	0.2	3	9
Lesotho	273 (a)	1 (b)	n/a	-
Liberia	389 (a)	2.0 (a)	3	-
Malawi	210 (a)	7.6	2	8
Mali	187 (a)	n/a	n/a	2
Mauritania	506 (a)	n/a	2	11
Mozambique	145 (a,e)	n/a	2	14
Namibia	1076 (a)	-5.4 (a)		
Niger	259	-0.5 (b)	n/a	-
Nigeria	739	-1.0	3	4
Rwanda	263 (b)	4.1 (b)	1	5
Senegal	407 (a)	n/a		
Sierra Leone	185 (a)	-1.8 (a)	3	-
Somalia	272 (a,e)	4.5 (a,e)	3	3
South Africa	2654	4.7	1	13
Sudan	298 (a)	-1 (a)	1	19
Swaziland	960 (a)	-0.5 (b)	n/a	-
Tanzania	237	-1.8 (a)	1	6
Togo	260 (a)	-7.9 (a)	n/a	-
Uganda	n/a	5.8	5	9
Zaire	327 (a)	-1.8 (b)	4	10
Zambia	460	-1.3	2	5
Zimbabwe	896 (b)	1.0	4	17

Notes:

(a) 1983
(b) 1982
(c) 1981
(d) 1980
(e) GNP
n/a Not available

Sources:

KIDRON, M and SMITH, D. (1983). The War Atlas: Armed Conflict - Armed Peace. Pan Books, London.

MIDDLE EAST REVIEW CO. LTD. Africa Review 1986 (10th ed).

APPENDIX VI

Table 11: Projected Elephant Numbers By Country, Habitat Type and Effective Protection.

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
ANGOLA			40.4283	.088
VEGETATION CATEGORY	A		.2447	.382
EFFECTIVE PROTECTION		5	.2447	.382
VEGETATION CATEGORY	C		5.7043	.066
EFFECTIVE PROTECTION		5	5.7043	.066
VEGETATION CATEGORY	D		.0709	.066
EFFECTIVE PROTECTION		5	.0709	.066
VEGETATION CATEGORY	F		5.7606	.070
EFFECTIVE PROTECTION		3	.7647	.181
" "		4	.1621	.037
" "		5	4.8418	.065
VEGETATION CATEGORY	G		3.0002	.146
EFFECTIVE PROTECTION		3	2.2068	.263
" "		5	.7934	.066
VEGETATION CATEGORY	H		23.0983	.103
EFFECTIVE PROTECTION		3	.2632	.144
" "		4	2.9654	.176
" "		5	19.8697	.097
VEGETATION CATEGORY	M		2.0333	.069
EFFECTIVE PROTECTION		3	.8165	.201
" "		4	1.0659	.103
" "		5	.1508	.010
VEGETATION CATEGORY	N		.0715	.009
EFFECTIVE PROTECTION		4	.0001	.103
" "		5	.0714	.009
VEGETATION CATEGORY	O		.0734	.095
EFFECTIVE PROTECTION		4	.0732	.103
" "		5	.0002	.004
VEGETATION CATEGORY	P		.3631	.099
EFFECTIVE PROTECTION		3	.0288	.238
" "		4	.2456	.164
" "		5	.0886	.043

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
BOTSWANA			58.0956	.419
VEGETATION CATEGORY	F		20.4184	.409
EFFECTIVE PROTECTION		1	.1414	.920
" "		2	.0008	.039
" "		3	8.0782	1.069
" "		4	.0031	.094
" "		5	12.1949	.289
VEGETATION CATEGORY	G		.0067	.039
EFFECTIVE PROTECTION		5	.0067	.039
VEGETATION CATEGORY	H		30.7963	.523
EFFECTIVE PROTECTION		1	.3342	.806
" "		3	11.9350	1.046
" "		5	18.5272	.394
VEGETATION CATEGORY	P		6.8742	.231
EFFECTIVE PROTECTION		3	.6333	.133
" "		4	.0173	.094
" "		5	6.2235	.251
CAMEROON:			58.3287	.231
VEGETATION CATEGORY	A		46.0252	.286
EFFECTIVE PROTECTION		2	.1711	.109
" "		3	3.6535	.268
" "		2	1.0133	.359
" "		5	41.1873	.288
VEGETATION CATEGORY	B		3.9452	.339
EFFECTIVE PROTECTION		3	.0114	.206
" "		4	.1783	.242
" "		5	3.7556	.347
VEGETATION CATEGORY	C		3.0634	.096
EFFECTIVE PROTECTION		3	.0148	.273
" "		4	1.2044	.174
" "		5	1.8442	.074
VEGETATION CATEGORY	E		.2734	.071
EFFECTIVE PROTECTION		2	.0337	.372
" "		4	.0135	.113
" "		5	.2261	.062
VEGETATION CATEGORY	F		3.0053	.113
EFFECTIVE PROTECTION		2	1.6367	.253
" "		5	1.3691	.068
VEGETATION CATEGORY	G		1.0784	.090
EFFECTIVE PROTECTION		3	.5149	.319
" "		4	.0097	.215
" "		5	.5538	.054

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
VEGETATION CATEGORY	P		.9373	.152
EFFECTIVE PROTECTION		2	.4876	.372
" "		3	.0999	.273
" "		4	.0269	.138
" "		5	.3228	.075
CENTRAL AFRICAN REPUBLIC			37.1863	.107
VEGETATION CATEGORY	A		5.4994	.462
EFFECTIVE PROTECTION		4	1.8930	.860
" "		5	3.6064	.372
VEGETATION CATEGORY	B		.8987	.840
EFFECTIVE PROTECTION		4	.8809	.860
" "		5	.0178	.389
VEGETATION CATEGORY	C		6.7942	.053
EFFECTIVE PROTECTION		4	.1222	.105
" "		5	6.6720	.053
VEGETATION CATEGORY	F		23.0057	.121
EFFECTIVE PROTECTION		3	.0076	.389
" "		4	5.8692	.120
" "		5	17.1289	.121
VEGETATION CATEGORY	G		.9883	.068
EFFECTIVE PROTECTION		4	.5160	.083
" "		5	.4723	.057
CHAD:			6.2670	.031
VEGETATION CATEGORY	F		1.2371	.092
EFFECTIVE PROTECTION		4	.0024	.063
" "		5	1.2346	.092
VEGETATION CATEGORY	G		5.0299	.029
EFFECTIVE PROTECTION		3	2.2550	.434
" "		4	.0781	.003
" "		5	2.6968	.019
VEGETATION CATEGORY	J		0.0	0.0
EFFECTIVE PROTECTION		5	0.0	0.0
VEGETATION CATEGORY	P		0.0	0.0
EFFECTIVE PROTECTION		5	0.0	0.0
CONGO:			73.2881	.343
VEGETATION CATEGORY	A		42.5618	.359
EFFECTIVE PROTECTION		3	1.5612	.340
" "		4	.0094	.859
" "		5	40.9912	.359
VEGETATION CATEGORY	B		29.3072	.384
EFFECTIVE PROTECTION		3	.0008	.389
" "		5	29.3065	.384

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
VEGETATION CATEGORY	C		1.4191	.075
EFFECTIVE PROTECTION		3	.2425	.263
" "		5	1.1766	.066
BENIN			2.2680	.111
VEGETATION CATEGORY	F		.3117	.194
EFFECTIVE PROTECTION		3	4,0860E-05	.180
" "		5	.3117	.194
VEGETATION CATEGORY	G		1.9563	.104
EFFECTIVE PROTECTION		2	.3800	.150
" "		3	1.0850	.110
" "		4	.0212	.222
" "		5	.4699	.076
EQ. GUINEA			5.4456	.233
VEGETATION CATEGORY	A		5.4456	.233
EFFECTIVE PROTECTION		3	.0198	.319
" "		4	.0475	.206
" "		5	5.3783	.233
ETHIOPIA:		62	9.2887	.067
VEGETATION CATEGORY	E		.8274	.035
EFFECTIVE PROTECTION		3	.2762	.240
" "		5	.5513	.024
VEGETATION CATEGORY	G		2.5368	.053
EFFECTIVE PROTECTION		3	.4423	.248
" "		4	.9129	.140
" "		5	1.1817	.030
VEGETATION CATEGORY	H		3.4506	.400
EFFECTIVE PROTECTION		4	.8967	.521
" "		5	2.5539	.370
VEGETATION CATEGORY	K		2.3979	.042
EFFECTIVE PROTECTION		3	1.1547	.227
" "		4	.2347	.155
" "		5	1.0086	.020
VEGETATION CATEGORY	N		0.0750	0.047
EFFECTIVE PROTECTION		5	0.0750	0.047
VEGETATION CATEGORY	P		0.0009	0.018
EFFECTIVE PROTECTION		5	0.0009	0.018

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
GABON:		74	74.3967	.299
VEGETATION CATEGORY	A		65.1615	.346
EFFECTIVE PROTECTION		3	.5192	.360
" "		4	3.7842	.388
" "		5	60.8581	.344
VEGETATION CATEGORY	B		3.8237	.382
EFFECTIVE PROTECTION		4	.1343	.390
" "		5	3.6893	.382
VEGETATION CATEGORY	C		5.2532	.108
EFFECTIVE PROTECTION		2	.9845	.372
" "		3	.4052	.273
" "		4	.1940	.174
" "		5	3.6694	.084
VEGETATION CATEGORY			.1584	.076
EFFECTIVE PROTECTION		5	.1584	.076
GHANA:			2.9651	.103
VEGETATION CATEGORY	A		.7036	.176
EFFECTIVE PROTECTION		3	.3634	.245
" "		5	.3402	.136
VEGETATION CATEGORY	C		1.3147	.284
EFFECTIVE PROTECTION		2	1.2737	.342
" "		5	.0410	.046
VEGETATION CATEGORY	F		.5455	.048
EFFECTIVE PROTECTION		3	.5454	.116
" "		5	8.4120E-05	.000
VEGETATION CATEGORY	G		.4013	.046
EFFECTIVE PROTECTION		3	.0016	.243
" "		4	2.8865E-07	.144
" "		5	.3997	.046
GUINEA:		90	.7573	.071
VEGETATION CATEGORY	A		.1496	.060
EFFECTIVE PROTECTION		5	.1496	.060
VEGETATION CATEGORY	C		.5590	.083
EFFECTIVE PROTECTION		2	4.4135E-05	.007
" "		4	.0850	.174
" "		5	.4739	.076
VEGETATION CATEGORY	F		.0181	.018
EFFECTIVE PROTECTION			.0181	.018
VEGETATION CATEGORY	G		.0306	.076
EFFECTIVE PROCTETION		5	.0306	.076

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
IVORY COAST:			3.7859	.075
VEGETATION CATEGORY A			2.2431	.086
EFFECTIVE PROTECTION		2	.5635	.140
" "		3	.2088	.140
" "		5	1.4707	.071
VEGETATION CATEGORY	B		.0621	.229
EFFECTIVE PROTECTION		3	.0341	.400
" "		5	.0279	.151
VEGETATION CATEGORY	C		.4449	.055
EFFECTIVE PROTECTION		2	.1470	.059
" "		3	.0310	.065
" "		5	.2669	.052
VEGETATION CATEGORY	F		1.0358	.064
EFFECTIVE PROTECTION		2	.6756	.070
" "		3	.0014	.068
" "		4	.0194	.070
" "		5	.3394	.055
KENYA:			20.8088	.050
VEGETATION CATEGORY	C		.0002	.005
EFFECTIVE PROTECTION		2	.0002	.300
" "		5	2.2494E-05	.001
VEGETATION CATEGORY	D		.5387	.019
EFFECTIVE PROTECTION		2	.0090	.021
" "		3	.0514	.057
		5	.4782	.018
VEGETATION CATEGORY	E		4.7589	.204
EFFECTIVE PROTECTION		1	.1726	.855
" "		2	4.0382	2.646
" "		3	.0107	.040
" "		4	0.0	0
" "		5	.5374	.025
VEGETATION CATEGORY	G		0.0	0
EFFECTIVE PROTECTION		5	0.0	0
VEGETATION CATEGORY	K		15.2359	.055
EFFECTIVE PROTECTION		1	1.0579	.393
" "		2	8.3367	.335
" "		3	.0982	.014
" "		4	.0013	.000
" "		5	5.7417	.024
VEGETATION CATEGORY	M		.2167	.003
EFFECTIVE PROTECTION		2	.0921	.053
" "		3	0.0	0
" "		4	0.0	0
" "		5	.1246	.002

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
VEGETATION CATEGORY	P		.0580	.014
EFFECTIVE PROTECTION		2	.0003	.021
" "		3	.0220	.071
" "		5	.0357	.009
LIBERIA:			3.9081	.230
VEGETATION CATEGORY	A		3.8605	.234
EFFECTIVE PROTECTION		2	.0795	.193
" "		3	.0713	.088
" "		4	.2614	.151
" "		5	3.4483	.254
VEGETATION CATEGORY	C		.0476	.099
EFFECTIVE PROTECTION		4	.0268	.164
" "		5	.0209	.065
MALAWI			2.7942	.149
VEGETATION CATEGORY	E		.0905	.028
EFFECTIVE PROTECTION		1	.0744	.030
" "		2	.0001	.314
" "		5	.0160	.020
VEGETATION CATEGORY	F		2.2317	.170
EFFECTIVE PROTECTION		1	.8261	.368
" "		2	.9305	.195
" "		3	.0024	.016
" "		5	.4727	.080
VEGETATION CATEGORY	G		.4534	.196
EFFECTIVE PROTECTION		1	.2380	.550
" "		2	.0471	.171
" "		3	.0981	.499
" "		5	.0702	.050
VEGETATION CATEGORY	P		.0186	.188
EFFECTIVE PROTECTION		2	.0178	.314
" "		5	.0008	.018
MALI:			.8956	.018
VEGETATION CATEGORY	F		.1265	.036
EFFECTIVE PROTECTION		5	.1265	.036
VEGETATION CATEGORY	G		.2410	.026
EFFECTIVE PROTECTION		3	.0087	.003
" "		4	.0038	.038
" "		5	.2286	.036
VEGETATION CATEGORY	J		.4656	.014
EFFECTIVE PROTECTION		4	.1547	.015
" "		5	.3108	.014
VEGETATION CATEGORY	P		.0625	.014
EFFECTIVE PROTECTION		4	.0067	.014
" "		5	.0558	.014

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
MAURITANIA:			.1045	.018
VEGETATION CATEGORY	J		.1045	.018
EFFECTIVE PROTECTION		5	.1045	.018
MOZAMBIQUE:			20.0124	.081
VEGETATION CATEGORY	D		6.5464	.096
EFFECTIVE PROTECTION		4	1.0859	.119
" "		5	5.4605	.091
VEGETATION CATEGORY	F		8.4082	.058
EFFECTIVE PROTECTION		1	.0172	.392
" "		2	.0252	.333
" "		3	.0487	.890
" "		4	.9765	.077
" "		5	7.3405	.056
VEGETATION CATEGORY	G		4.9530	.155
EFFECTIVE PROTECTION		1	.0796	.390
" "		3	.0418	.890
" "		4	1.6675	.425
" "		5	3.1641	.114
VEGETATION CATEGORY	P		.1045	.084
EFFECTIVE PROTECTION		4	.0309	.084
" "		5	.0736	.084
NAMIBIA:			4.9656	.024
VEGETATION CATEGORY	F		2.0714	.047
EFFECTIVE PROTECTION		1	1.7059	.109
" "		3	.0109	.079
" "		4	.0408	.094
" "		5	.3137	.011
VEGETATION CATEGORY	H		1.9100	.018
EFFECTIVE PROTECTION		1	.3134	.109
" "		3	.0010	.087
" "		4	.3662	.092
" "		5	1.2295	.012
VEGETATION CATEGORY	J		.0276	.014
EFFECTIVE PROTECTION		5	.0276	.014
VEGETATION CATEGORY	M		.1567	.005
EFFECTIVE PROTECTION		1	.0001	.001
" "		4	.0005	.002
" "		5	.1561	.005
VEGETATION CATEGORY	O		.1013	.007
EFFECTIVE PROTECTION		1	.0054	.003

COUNTRY	VEGETATION	PROTECTION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
EFFECTIVE PROTECTION		4	.0005	.007
" "		5	.0954	.007
VEGETATION CATEGORY	P		.6987	.096
EFFECTIVE PROTECTION		1	.4361	.109
" "		4	.1340	.094
" "		5	.1286	.069
NIGER:			.6091	.098
VEGETATION CATEGORY	G		.6091	.098
EFFECTIVE PROTECTION		3	.1035	.223
" "		4	.4525	.226
" "		5	.0531	.014
NIGERIA:			3.3454	.115
VEGETATION CATEGORY	A		.6085	.086
EFFECTIVE PROTECTION		2	0.0	0
" "		3	.0109	.206
" "		4	.4831	.101
" "		5	.1144	.053
VEGETATION CATEGORY	C		.3115	.069
EFFECTIVE PROTECTION		3	.0091	.263
" "		4	.0167	.164
" "		5	.2857	.066
VEGETATION CATEGORY	E		.0048	.066
EFFECTIVE PROTECTION		5	.0048	.066
VEGETATION CATEGORY	F		1.5030	.279
EFFECTIVE PROTECTION		3	1.5030	.280
" "		5	0.0	0
VEGETATION CATEGORY	G		.9125	.075
EFFECTIVE PROTECTION		3	.6290	.439
" "		5	.2835	.027
VEGETATION CATEGORY	P		.0051	.072
EFFECTIVE PROTECTION		2	.0005	.362
" "		5	.0046	.066
GUINEA BISSAU:			.0560	.137
VEGETATION CATEGORY	C		.0560	.137
EFFECTIVE PROTECTION		2	.0560	.137
VEGETATION CAGEGORY	P		3.9440E-06	.232
EFFECTIVE PROTECTION		5	3.9440E-06	.232

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
ZIMBABWE:			45.7751	.594
VEGETATION CATEGORY	F		31.2709	.542
EFFECTIVE PROTECTION		1	17.3100	.881
" "		2	4.0653	.812
" "		3	2.8605	.888
" "		5	7.0351	.235
VEGETATION CATEGORY	G		1.7556	.552
EFFECTIVE PROTECTION		3	1.6797	.890
" "		5	.0759	.059
VEGETATION CATEGORY	H		12.7485	.788
EFFECTIVE PROTECTION		1	10.8589	.896
" "		3	.0108	1.147
" "		4	1.8788	.465
RWANDA:			.0491	.017
VEGETATION CATEGORY	E		.0223	.067
EFFECTIVE PROTECTION		2	.0130	.152
" "		5	.0093	.038
VEGETATION CATEGORY	K		.0269	.011
EFFECTIVE PROTECTION		3	.0249	.010
" "		5	.0020	.099
SENEGAL:			.1460	.015
VEGETATION CATEGORY	C		.0418	.023
EFFECTIVE PROTECTION		2	.0073	.005
" "		4	.0032	.174
" "		5	.0313	.076
VEGETATION CATEGORY	G		.0995	.013
EFFECTIVE PROTECTION		2	.0342	.005
" "		5	.0653	.076
VEGETATION CATEGORY	J		.0048	.014
EFFECTIVE PROTECTION		5	.0048	.014
SIERRA LEONE:			.4065	.137
VEGETATION CATEGORY	A		.1084	.171
EFFECTIVE PROTECTION		2	.0802	.213
" "		4	0.0	0.
" "		5	.0282	.164
VEGETATION CATEGORY	B		.0010	.200
EFFECTIVE PROTECTION		2	9.0400E-05	.200
" "		5	.0010	.200
VEGETATION CAGEGORY	C		.2897	.130
EFFECTIVE PROTECTION		2	.0946	.362
" "		3	.0615	.263
" "		4	.0325	.164
" "		5	.1010	.066
VEGETATION CATEGORY	E		.0074	.082
EFFECTIVE PROTECTION		3	.0020	.263
" "		5	.0054	.066

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
SOMALIA:			4.4863	.080
VEGETATION CATEGORY	D		1.6661	.080
EFFECTIVE PROTECTION		3	.1206	.080
" "		4	.1843	.080
" "		5	1.3612	.080
VEGETATION CATEGORY	K		2.8202	.080
EFFECTIVE PROTECTION		3	.0591	.083
" "		4	.1897	.080
" "		5	2.5715	.080
SOUTH AFRICA:			9.0793	.217
VEGETATION CATEGORY	D		.1539	.283
EFFECTIVE PROTECTION		1	.1538	.284
" "		5	5.5004E-05	.048
VEGETATION CATEGORY	E		.0560	.047
EFFECTIVE PROTECTION		1	.0196	.084
" "		5	.0364	.038
VEGETATION CATEGORY	F		3.3038	.279
EFFECTIVE PROTECTION		1	3.0714	.390
" "		2	.2323	.058
VEGETATION CATEGORY	G		5.5332	.195
EFFECTIVE PROTECTION		1	4.9977	.352
" "		5	.5356	.038
VEGETATION CATEGORY	K		.0324	1.288
EFFECTIVE PROTECTION		1	.0323	1.389
" "		5	7.1451E-05	.038
SUDAN:			29.7603	.078
VEGETATION CATEGORY	C		1.7831	.118
EFFECTIVE PROTECTION		3	.2687	.257
" "		4	.2633	.195
" "		5	1.2511	.098
VEGETATION CATEGORY	E		.2730	.103
EFFECTIVE PROTECTION		3	.0278	.293
" "		4	.0865	.172
" "		5	.1588	.078
VEGETATION CATEGORY	F		15.7797	.117
EFFECTIVE PROTECTION		3	2.4481	.301
" "		4	6.8377	.200
" "		5	6.4939	.070
VEGETATION CATEGORY	G		3.1437	.075
EFFECTIVE PROTECTION		3	.5202	.287
" "		4	1.1413	.127
" "		5	1.4822	.048
VEGETATION CATEGORY	H		2.9754	.068
EFFECTIVE PROTECTION		4	1.6050	.100
" "		5	1.3704	.049

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS		ESTIMATE OF DENSITY
VEGETATION CATEGORY	J		.0001		.038
EFFECTIVE PROTECTION		5	.0001		.038
VEGETATION CATEGORY	K		1.6733		.061
EFFECTIVE PROTECTION		4	.3782		.154
" "		5	1.2951		.052
VEGETATION CATEGORY	M		.0006		.038
EFFECTIVE PROTECTION		5	.0006		.038
VEGETATION CATEGORY	N		2.0761		.029
EFFECTIVE PROTECTION		4	.5220		.047
" "		5	1.5541		.025
VEGETATION CATEGORY	P		2.0552		.049
EFFECTIVE PROTECTION		4	.7478		.074
" "		5	1.3174		.041
TANZANIA:			215	108.7797	.217
VEGETATION CATEGORY	B		0.0		0
EFFECTIVE PROTECTION		5	0.0		0
VEGETATION CATEGORY	C		.3649		.112
EFFECTIVE PROTECTION		3	.1446		.295
" "		5	.2204		.080
VEGETATION CATEGORY	D		7.8855		.223
EFFECTIVE PROTECTION		2	1.3323		.945
" "		3	2.5543		.315
" "		4	.0182		.197
" "		5	3.9807		.155
VEGETATION CATEGORY	E		.9192		.095
EFFECTIVE PROTECTION		2	.5516		.181
" "		3	.1665		.203
" "		5	.2010		.035
VEGETATION CATEGORY	F		71.8114		.255
EFFECTIVE PROTECTION		2	6.2758		.838
" "		3	43.7507		.933
" "		4	0.0013		.234
" "		5	21.7836		.096
VEGETATION CATEGORY	G		1.0139		.169
EFFECTIVE PROTECTION		3	.6126		.235
" "		5	.4011		.118
VEGETATION CATEGORY	H		.8432		.127
EFFECTIVE PROTECTION		3	.3454		.157
" "		5	.4978		.112
VEGETATION CATEGORY	K		22.5724		.177
EFFECTIVE PROTECTION		2	5.2756		.275
" "		3	11.2426		.842
" "		5	6.0542		.064

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
VEGETATION CATEGORY	M		0.0	0
EFFECTIVE PROTECTION		5	0.0	0
VEGETATION CATEGORY	N		1.0266	.062
EFFECTIVE PROTECTION		2	.7593	.112
" "		5	.2673	.027
VEGETATION CATEGORY	P		2.3426	.170
EFFECTIVE PROTECTION		2	.2596	3.717
" "		3	1.2643	.227
" "		5	.8188	.100
TOGO			.4007	.060
VEGETATION CATEGORY	F		.2247	.056
EFFECTIVE PROTECTION		1	.0847	.057
" "		5	.1401	.055
VEGETATION CATEGORY	G		.1760	.068
EFFECTIVE PROTECTION		3	.0114	.068
" "		5	.1646	.068
UGANDA:			2.6130	.167
VEGETATION CATEGORY	A		.1622	.115
EFFECTIVE PROTECTION		2	.0520	.127
" "		3	.0238	.125
" "		5	.0864	.106
VEGETATION CATEGORY	B		0.0	0
EFFECTIVE PROTECTION		5	0.0	0
VEGETATION CATEGORY	C		.8737	.172
EFFECTIVE PROTECTION		2	.6685	.244
" "		3	.0887	.146
" "		5	.1164	.068
VEGETATION CATEGORY	E		.2537	.080
EFFECTIVE PROTECTION		2	.0309	.236
" "		3	.0014	.133
" "		4	.0048	.080
" "		5	.2166	.073
VEGETATION CATEGORY	F		.0033	.192
EFFECTIVE PROTECTION		3	.0019	.353
" "		4	.0013	.115
VEGETATION CATEGORY	G		.5500	.229
EFFECTIVE PROTECTION		2	.5238	.278
" "		4	.0171	.212
" "		5	.0091	.021
VEGETATION CATEGORY	K		.7702	.217
EFFECTIVE PROTECTION		2	.6532	.347
" "		3	.0202	.104
" "		4	.0034	.115
" "		5	.0933	.065

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
UPPER VOLTA:			4.7561	.131
VEGETATION CATEGORY	F		.6626	.214
EFFECTIVE PROTECTION		3	.0747	.442
" "		4	.2843	.307
" "		5	.3036	.152
VEGETATION CATEGORY	G		3.4074	.138
EFFECTIVE PROTECTION		2	.0134	.150
" "		3	1.9311	.224
" "		4	.8978	.309
" "		5	.5651	.043
VEGETATION CATEGORY	J		.6861	.081
EFFECTIVE PROTECTION		4	.6565	.103
" "		5	.0296	.014
ZAIRE;			329.6511	.232
VEGETATION CATEGORY	A		212.8591	.352
EFFECTIVE PROTECTION		2	1.8930	.341
" "		3	10.6793	.389
" "		4	.0775	.128
" "		5	200.2093	.351
VEGETATION CATEGORY	B		79.8872	.341
EFFECTIVE PROTECTION		3	5.2472	.389
" "		4	.7776	.319
" "		5	73.8623	.339
VEGETATION CATEGORY	C		23.4922	.075
EFFECTIVE PROTECTION		3	5.6618	.697
" "		4	1.9077	.157
" "		5	15.9227	.054
VEGETATION CATEGORY	E		1.3086	.056
EFFECTIVE PROTECTION		2	.2174	.236
" "		4	.2250	.095
" "		5	.8662	.043
VEGETATION CATEGORY	F		7.6751	.048
EFFECTIVE PROTECTION		3	1.7359	.183
" "		5	5.9392	.040
VEGETATION CATEGORY	H		1.5886	.030
EFFECTIVE PROTECTION		3	.2168	.111
" "		5	1.3718	.027
VEGETATION CATEGORY	J		.5408	.077
EFFECTIVE PROTECTION		3	.2041	.252
" "		5	.3367	.055
VEGETATION CATEGORY	K		.3932	.106
EFFECTIVE PROTECTION		2	.0065	.354
" "		4	.3394	.127
" "		5	.0473	.047

COUNTRY	VEGETA-TION	PROTEC-TION	ESTIMATES OF 1000'S OF ELEPHANTS	ESTIMATE OF DENSITY
VEGETATION CATEGORY	N		1.5572	.082
EFFECTIVE PROTECTION		3	.6661	.246
" "		5	.8911	.055
VEGETATION CATEGORY	P		.3490	.121
EFFECTIVE PROTECTION		3	.2445	.252
" "		5	.1045	.055
ZAMBIA:			54.6990	.228
VEGETATION CATEGORY	E		.0008	.045
EFFECTIVE PROTECTION		1	.0002	.030
" "		2	.0004	.314
" "		5	.0002	.018
VEGETATION CATEGORY	F		45.1695	.226
EFFECTIVE PROTECTION		1	1.7441	.984
" "		2	24.9599	.773
" "		3	13.1852	.159
" "		4	.2835	.144
" "		5	4.9968	.062
VEGETATION CATEGORY	G		.2374	.073
EFFECTIVE PROTECTION		2	.0245	.106
" "		3	.1324	.066
" "		5	.0805	.080
VEGETATION CATEGORY	H		4.0265	.454
EFFECTIVE PROTECTION		3	3.9241	.478
" "		4	.0081	.312
" "		5	.0944	.150
VEGETATION CATEGORY	K		1.1232	.233
EFFECTIVE PROTECTION		3	1.0322	.281
" "		5	.0910	.080
VEGETATION CATEGORY	N		1.7870	.249
EFFECTIVE PROTECTION		3	1.6778	.363
" "		4	.1056	.045
" "		5	.0036	.018
VEGETATION CATEGORY	P		2.3547	.149
EFFECTIVE PROTECTION		2	.5800	.111
" "		3	1.4350	.276
" "		4	.1495	.094
" "		5	.1901	.050

Total Cases = 9250

APPENDIX VII

Elephant Input Data

TYPE is keyed as follows:

AS	Aerial Sample survey
AT	Aerial Total Count
AC	Aerial Count unspecified
ASP	Aerial Sample survey preliminary analysis
ASS	Aerial Single Strip transect
ATO	Aerial Total Count out of date
ASO	Aerial Sample survey out of date
ACO	Aerial Cound unspecified out of date
GC	Ground Count
DC	Dropping Count
IG	Informed Guess

DATA QUALITY is keyed from with 1 as best, and 3 as worst.

CENTRAL AFRICA

CAMEROON

	TYPE	DATA QUALITY	ELEPHANTS NUMBER OR DENSITY
VAN LAVIEREN (1977), AERSG (1987)			
WAZA NP	ASO	3	600
WOODFORD (1984)			
BENOUE NP	IG	3	200
BOUBA NJIDA NP	IG	3	200

CENTRAL AFRICAN REPUBLIC

	TYPE	DATA QUALITY	ELEPHANTS NUMBER OR DENSITY
CARROLL (1986)			
DZANGA-SANGHA, BAYANGA	DC	2	2855

High density with possible immigration due to safety offered by forestry company.

	TYPE	DATA QUALITY	ELEPHANTS NUMBER OR DENSITY
DOUGLAS-HAMILTON ET AL (1985)			
MANOVO-GOUNDA-ST FLORIS NP CENSUS ZONE	AS	1	2701
BAMINGUI-BANGORAN NP CENSUS ZONE	AS	1	1607

A single crew one-off aerial census. One density should be used for the whole park since the confidence limits are high. No update applied as the survey is recent, although trend is down.

	TYPE	DATA QUALITY	ELEPHANTS NUMBER OR DENSITY
DOUGLAS-HAMILTON UNPUBLISHED DATA.			
CHINKO	ASS	2	.08 km2
RAFAI-BANGASSOU	ASS	2	0.00 km2

Single strip transects .25 km by 204, and .21 km by 80 km.

CHAD

BOUSQUET (1986) SURVEY			
AOUK DC	AS	1	0
BAHR SALAMAT R DE F	AS	1	0
MANDA NP	AS	2	350
SINIAKA-NINIA R DE F	AS	1	0
ZAKOUMA NP	AS	1	1077

GABON

BARNES AND JENSEN (1986)			
NE RANGE	DC	2	21500

ZAIRE

AVELING (1987) PERS COMM			
VIRUNGA NP LAKE KIBUGA	IG	2	0
VIRUNGA NP MURAMBA	IG	2	40
VIRUNGA NP NORTH	IG	2	0
VIRUNGA NP TSHIABERIMU	IG	2	15
VIRUNGA NP VOLCAN	IG	3	50
MAKABUSA (1987) PERS COMM			
VIRUNGA NP SOUTH	IG	3	95
MERTENS (1981) AND AVELING (1987) PERS COMM			
VIRUNGA NP PLAINS	ASO	2	400
BIHINI (1987, PERS COMM)			
BUSHIMAIE	IG	3	120
DOUGLAS-HAMILTON UNPUBLISHED DATA.			
BILI-UELE	ASS	2	.24 km2
MBOMOU RIVER	ASS	2	0.00 km2
Single strip transects .21 km by 306 km and .25 km by 211 km.			
HILLMAN (PERS COMM)			
GARAMBA NP NORTH	AS	1	44
GARAMBA NP SOUTH	AS	1	3899
GARAMBA OUT NE	AS	1	0
GARAMBA OUT S	AS	1	0
GARAMBA OUT W	AS	1	13

EAST AFRICA

KENYA

AERSG (1987)			
ABERDARES NP	IG	3	2000

MT KENYA NP	IG	3	2000
BRETT (1987, PERS COMM)			
OL ARI NYIRO RANCH	IG	2	300
DUBLIN (1987) PERS COMM			
MARA GAME RESERVE	AT	1	1134
Numbers recently increased by immigration from Serengeti (DUBLIN AND DOUGLAS-HAMILTON).			
DUBLIN (1987) PERS COMM			
MARA GAME RESERVE OUT E	AT	1	32
MARA GAME RESERVE OUT N	AT	1	7
OTTICHILO (1987, PERS COMM)			
BARINGO DISTRICT	ASP	2	200
BONI FOREST NR	ASP	2	62
BUFFALO SPRINGS NR	ASP	2	315
GARISSA DISTRICT	ASP	2	1000
ISIOLO DISTRICT	ASP	2	77
KAJIADO DISTRICT	ASP	2	0
KILIFI DISTRICT	ASP	2	91
KITUI DISTRICT	ASP	2	250
KORA GR	ASP	2	500
KWALE DISTRICT	ASP	2	245
LAIKIPIA DISTRICT	ASP	2	1500
LAMU DISTRICT	ASP	2	570
MACHOKOS	ASP	2	51
MARSABIT NR	ASP	2	530
MERU NP	ASP	2	430
NAROK DISTRICT	ASP	2	166
RAHOLI NR	ASP	2	0
SAMBURU DISTRICT	ASP	2	430
SAMBURU NR	ASP	2	315
TAITA TAVETA DISTRICT	ASP	2	1900
TANA RIVER DISTRICT	ASP	2	1000
TSAVO EAST NP N	ASP	2	400
TSAVO EAST NP S	ASP	2	2600
TSAVO WEST NP	ASP	2	2400
TURKANA DISTRICT	ASP	2	0
TURKANA POKOT SPECIAL AREA	ASP	2	50
WEST POKOT DISTRICT	ASP	2	0
DODORI NR	ASP	2	64

Preliminary analysis of KREMU raw data, without any correction for bias. Estimates with wide variation in successive surveys are averaged for last five years and rounded. This may mask some negative trend. These totals may vary slightly from those in Appendix I, due to differences in correction of strip width sampling intensity. Poaching reported current in Mathews range, Kora and Galana ranch (Evans, pers comm; Adamson, pers comm; Prettejohn, pers comm).

POOLE AND WESTERN (AERSG 1987)			
AMBOSELI NP	ASP	1	680
AMBOSELI NP OUT	ASP	1	120

RWANDA

MONFORT (1983, PERS COMM)			
AKAGERA	GC	2	25

SOMALIA

WATSON, (1985)			
SOMALI RANGE	ASO	2	4474

Updated by trend based on carcasses seen.

SUDAN

BOITANI (1981)			
SOUTHERN NP IN C	ASO	3	2586
SOUTHERN NP IN E	ASO	3	1661
SOUTHERN NP IN W	ASO	3	1406
SOUTHERN NP OUT E	ASO	3	0
SOUTHERN NP OUT N	ASO	3	566
SOUTHERN NP OUT S	ASO	3	1096
SOUTHERN NP OUT W	ASO	3	643

Updated at 9% compound drop per annum based on poaching levels.

ECOSYSTEMS (1981)			
JONGLEI ZONE E	ASO	3	0
JONGLEI ZONE N	ASO	3	651
JONGLEI ZONE S	ASO	3	674
JONGLEI ZONE W	ASO	3	54

Subdivided into natural groups and updated at -9% per annum based on poaching levels.

HILLMAN ET AL (1981)			
SHAMBE NP ZONE	ASO	3	57

Area cut by Jonglei census. Remaining number updated by 9% compound drop per annum based on poaching levels.

TANZANIA

BORNER (1987) QUESTIONNAIRE REPLY			
BURIGI	IG	3	100
ARUSHA NAT PARK	IG	3	85

BORNER AND SEVERRE (1984)			
RUAHA NP	ASO	3	13700
RUAHA OUT E	ASO	3	0
RUNNGWA GR	ASO	3	8400

Seasons averaged then updated by 8.5% compound drop per annum. Eastern area outside park with no elephants taken as a seperated zone.

1988

DOUGLAS-HAMILTON (1987)

MARANG FOREST	IG	3	200
NGORONGORO FOREST	IG	3	300

DOUGLAS-HAMILTON (UNPUBLISHED DATA)

MKOMAZI	ASO	3	193	93

Updated from neighbouring Tsavo trend of -11. % pa compounded.

DOUGLAS-HAMILTON (1985, UNPUBLISHED DATA)

MANYARA NP	ATO	1	434

DOUGLAS-HAMILTON ET AL (1986)

KILOMBERO VALLEY	AS	1	2230
MIKUMI NORTH	AS	1	1776
MIKUMI SOUTH	AS	1	310
SELOUS GR CN	AS	1	21072
SELOUS GR NE	AS	1	2217
SELOUS GR SW	AS	1	18477
SELOUS OUT N	AS	1	0
SELOUS OUT NE	AS	1	710
SELOUS OUT NW	AS	1	0
SELOUS OUT S	AS	1	3978
SELOUS OUT SE	AS	1	2774
SELOUS OUT SW	AS	1	2617
SELOUS OUT W	AS	1	2235

Two planes were used with no significant difference between observers or crews. Earlier counts of sub-areas, (1976, 1979, 1981) showed little seasonal variation in distribution. High carcass ratio confirms downward trend since 1976. Elephant and rhino have decreased due to trophy poaching, while another main species, the buffalo has increased.

ECOSYSTEMS (1977)

KATAVI	ASO	1	407
RUKWA CENSUS ZON	ASO	2	606
RUKWA REMAINDER	ASO	2	1674

The estimate was updated by -7.7% pa straight rate.

ECOSYSTEMS (1979)

TABORA GOMBE	ASO	2	17
TABORA INYONGA	ASO	2	222
TABORA KIGOZI	ASO	2	838
TABORA LUGANZO	ASO	2	0
TABORA NORTH	ASO	2	0
TABORA SOUTH	ASO	2	585

TABORA UGALLA	ASO	2	65
TABORA UGUNDA	ASO	2	276

The estimate was updated as recommended by the AERSG (1987) meeting at -7.7% pa. at a straight rate.

ECOSYSTEMS (1980)

ARUSHA ENDULEN	ASO	2	178
ARUSHA HANANG	ASO	2	223
ARUSHA LOLIONDO			
ARUSHA MASAI STEPPE	ASO	2	2010
ARUSHA NGORONGORO CONS. AREA (NON FOREST)	ASO	2	219
ARUSHA REMAINDER	ASO	2	0
ARUSHA TARANGIRE	ASO	2	3000
ARUSHA YAIDA	ASO	2	384

The estimate was updated as recommended by the AESRG 1987 meeting at -8.6% pa.

POOLE AND WESTERN (1987, PERS COMM)

KILIMANJARO	IG	3	1000

SERENGETI WILDLIFE RESEARCH INSTITUTE (1986) Unpublished Data.

SERENGETI NP EAST	AT	1	395
SERENGETI NP WEST	AT	1	0

Data was compiled from original survey maps. No elephants were found in the west so the census zone was subdivided into east and west blocks.

UGANDA

DOUGLAS-HAMILTON (1983)

KIDEPO	ATO	2	428

Unconfirmed report of 700 seen in 1986 (EVANS, Pers Comm). Present numbers are uncertain since no counts made since 1982, and elephants are highly mobile, but trend is probably downwards.

MURCHISON NORTH ONLY	ATO	2	700

Negative trend assumed since 1982 census result of 928 elephants, on account of recent civil war and proliferation of arms.

HOWARD, P., (1986) PERS COMM

BWINDI	IG	2	18

Sixty days in the field 83/84, with Butynski.

ITWARA	IG	2	6

Thirty days foot recce.

KALINZU	IG	2	0

Adjoins Q.E., only old dung seen.

KASYHOHA-KITOMI	IG	2	20

Twenty days foot recce. One elephant shot in 1985.

MT ELGON	IG	2	100

Twenty days foot recce.
Elephants also found in Bukwa, Amanang and Suam valleys int the north east.

MURCHISON NP SOUTH AND BUDONGO FOREST	IG	3	500

Has talked with local forestry officials in the area.

RWENZORI MTS.	IG	2	100

Elephants only found in the south of Mubuku Valley, in the Bamboo zone.

SEMLIKI	IG	2	30

Twenty days foot recce. Elephants restricted to eastern one third of the range.

SSEMWEZI (1987)

QUEEN ELIZABETH NP	ATO	2	700

Immigration reported from Zaire since 1982 Census of 420 elephants.

STRUHSAKER (1980) PERS COMM

KIBALE	IG	2	100

Informant has lived and worked in the forest for nearly twenty years.

SOUTHERN AFRICA

BOTSWANA

CALEF (1987) QUESTIONNAIRE REPLY

BLOCK A	AS	1	1100
BLOCK B	AS	1	1118
BLOCK C/D	AS	1	22000
BLOCK F	AS	1	1520
BLOCK G	AS	1	8400
BLOCK H	AS	1	5760
BLOCK I	AS	1	480

BOTSWANA AND ZIMBABWE

CUMMING (1987, PERS COMM)

TULI BLOCK	IG	2	600

MALAWI

MARTIN R (BELL, 1985)

MANGOCHI NAMIZUMI	IG	32	100
TUMA	IG	3	50
LIWONDE NP	AC	1	.55
MAJETE GR	AC	1	.29
NKHOTAKOTA GR	DC	2	.22
NYIKA NP	DC	2	.03
PHIRILONGWE FR	DC	2	.5
KASUNGU NP	ASO	2	.38

MPHANDE, J.B. (1987)

VWAZA MARSH GR	DC	2	250

MOZAMBIQUE

TELLO PERS.COMM. (1987, AERSG)

RUVUMA SOUTH	IG	3	1000

RUVUMA-LUGENDA	IG	3	1000
LUGENDA	IG	3	6000
GILE	IG	3	100
ZUMBO-FINGOE	IG	3	100
MESSENGUEZI-CHIOCO	IG	3	250
FURANCUNGO	IG	3	50
MORRUMBALA	IG	3	20
MADZUIRE	IG	3	1000
BLOCK 2	IG	3	2000
EMOFAUNA CENTRAL AREA	IG	3	750
GORONGOZA NP	IG	3	2000
CHIRAPE	IG	3	500
CHITANGA	IG	3	300
TESSOLO AND SOUTH	IG	3	1000
ZINAVE NP	IG	3	400
EMOFAUNA SOUTH AREA	IG	3	50
MAPUTO NP	IG	3	1000

Estimate for Maputo national park looks high.

NAMIBIA

CITES IVORY EXPORT QUOTA FORM Q1 (1987)

BOESMANLAND	IG	3	385
DAMARALAND	IG	3	247
ETOSHA NP	AC	1	2464
KAOKOLAND	IG	2	36
OOS CAPRIVI	IG	3	878
WES CAPRIVI	IG	3	560
KAVANGO	IG	3	377

Zones are based on Districts and Parks cut by elephant range.

SOUTH AFRICA

HLUHLUWE-UMFOLOZI GR	GC	1	46

BROOKS (1987) QUESTIONNAIRE REPLY

PILANSESBERG GR	GC	1	45
TEMBE GR	IG	2	80

HALL-MARTIN (1986), IN BROOKS (1987)

ADDO NP	GC	1	118
KRUGER NP	AT	1	7617

HALL-MARTIN (1981)

KNYSNA FR	GC	1	3

ZAMBIA

KAWECHE ET AL (1987)

CORRIDOR	ASO	2	1200
LUAMBE NP	AS	1	2864
LUPANDE GMA	AS	1	2400
N. LUANGWA NP	AS	1	5282
S. LUANGWA NP	AS	1	15375

LEWIS AND AERSG (1987)

ISANGANO NP	IG	3	100
LIUWA PLAIN NP	IG	3	175
LUKUSUZI NP	IG	3	800
LUMIMBA GMA	IG	2	100
LUNGA LUSWISHI GMA	IG	3	50
MULOBESI GMA	IG	3	500
MUMBWA GMA	IG	3	175
MUSALANGU GMA	IG	3	250
NSUMBU NP	IG	3	600
SANDWE GMA	IG	3	50
SICHIFULA GMA	IG	3	500
SIMOMA NGWEZI	IG	3	2500
W PITAUKE GMA	IG	3	50
CHISOMO GMA	IG	3	50
LOWER ZAMBESI	IG	2	1.0
KAFUE NP	AR	3	2500

Updated by Southern group of AESRG from MARTIN (1985) according to severity of poaching.

ZIMBABWE

CUMMING (1987 PERS COMM)

HWANGE NP	AS	1	13000
MATETSI COMPLEX	AS	1	3763
TJOLOTJO (SE OF HWANGE)	IG	2	500
CHETE SA	AS	1	800
CHIRISA NP	AS	1	1500
CHIZARIRA NP	AS	1	2000
MATUSADONA NP	AS	1	1286
SEBUNGWE REMAINDER	AS	1	3000
ZAMBESI VALLEY COMPLEX	AS	1	11260
DANDE SA	IG	2	1400
GONA RE ZHOU NP	AS	1	4451

WEST AFRICA

BENIN

BOUSQUET ET AL (1981)

L'ATAKORA	ASO	3	0.00
PARK W	ASO	3	.11
PENDJARI NP	ASO	3	.15
PENDJARI ZC	ASO	3	.18
DJONA	ASO	3	.11

Updated by -5% pa compounded, based on moderate reported poaching rate. Rating is dropped to 3 as survey is old and extrapolation uncertain.

BURKINA FASA

BOUSQUET ET AL (1981)			
ARLI PARC NATIONAL	ASO	3	0.00
ARLI RESERVE PARTIELLE	ASO	3	0.00
KOURTIAGOU	ASO	3	0.00
OUEST PAMA	ASO	3	.024
PAMA RESERVE PARTIELLE	ASO	3	.41
SINGOU NORTH	ASO	3	0.00
SINGOU R.T	ASO	3	.42
TAPOADJER	ASO	3	0.00
W PARK	ASO	3	.19

GHANA

MERZ (1986, BASED ON SHORT, 1983)			
BIA NP	IG	3	265

GUINNEA BISSAU

CHARDONNET (1986, PERS COMM)			
RANGES	IG	3	40

IVORY COAST

ROTH ET AL (1984)			
ROTH No.			
1 MT. GBANDEE AND AREA	IG	3	.02
2 NON CLASSE	IG	3	.02
3 NYANGBOUE AND AREA	IG	3	.04
4 FOUMBOU AND AREA	IG	3	.03
5 NON CLASSE	IG	3	.02
6 HAUT BANDAAMA AND AREA	IG	3	.04
7 SILUE	IG	3	.02
8 LOHO AND AREA	IG	3	.015
9 COMOE AND AREA	ASO	3	.07
10 NON CLASSE	IG	3	7
11 KEREGBO AND AREA	IG	3	.03
12 BESSE BOKA AND AREA	IG	3	.04
13 KOUNOUMOU AND AREA	IG	3	.03
14 MARAHOUE	IG	3	.09
15 SASSANDRA AND AREA	IG	3	.05

16 NON CLASSE	IG	3	.05
17 DUEKOUE	IG	3	.05
18 SANGBE AND AREA	IG	3	.02
19 MONT PEKO	IG	3	.04
20 NON CLASSE	IG	3	15
21 TAI FOREST NP	DCO	3	.14
22 NON CLASSE	IG	3	.05
23 NON CLASSE	IG	3	.02
24 GOIN AND AREA	IG	3	.04
25 CAVALLY MT. SAINTE	IG	3	.09
26 SCIO AND AREA	IG	3	.02
27 NON CLASSE	IG	3	.03
28 NON CLASSE	IG	3	.05
29 MONOGAGA	IG	3	.04
30 NON CLASSE	IG	3	.04
31 NIEGRE AND AREA	IG	3	.05
32 DASSIEKRO AND AREA	IG	3	.06
33 DAVO AND AREA	IG	3	.03
34 BAGBO	IG	3	.09
35 NON CLASSE	IG	3	.04
36 GO	IG	3	.04
37 MOPRI AND AREA	IG	3	.04
38 D'AZAGNY NP	AT	1	80

Azagny was assumed stable, but since this data entry Hall-Martin has written to say Azagny herd has decreased by 20% over seven years probably due to poaching by rangers.

39 IROBO AND AREA	IG	3	.05
40 NON CLASSE	IG	3	.05
41 YAYA AND AREA	IG	3	.06
42 MANZAN AND AREA	IG	3	.09
43 BOSSEMATIE AND AREA	IG	3	.06
44 DJAMBAMKROU AND AREA	IG	3	.07
45 NON CLASSE	IG	3	.15
46 NON CLASSE	IG	3	.15

All Ivory Coast estimates have been dropped by 10% pa compounded since Roth et al's estimates, except Azagny NP which was kept stable.

<u>MALI</u>

DE BIE AND KESSLER (1983), COBB (PERS COMM).
BOUCLE DU BAOULE NP CENSUS ZONE. AS 2 6
The range is recorded from tracks seen by Watson, the survey consultant. Van Wijngaarden estimates 6 elephants, later amended to ten by Cobb at AERSG (1987).

LAMARCHE (1981), COBB (PERS COMM).
GOURMA IG 3 550
Cobb believes this population is still stable. No systematic census has ever been undertaken. Population is said to be highly mobile and therefore difficult to count.

NIGERIA

GREEN (1985)			
YANKARI NP	IG	2	350
MILLIGAN (1978)			
BORGU GR KAINJI NP	ARO	3	750

SENEGAL

FALL (1987) QUESTIONNAIRE REPLY			
NIOKOLA KOBA	IG	3	50

SIERRA LEONE

MERZ, G. (1983)			
GOLA EAST	DC	2	45
6 killed in 1981 3 more in 1982 from which a trend of - 6% was calculated.			
GOLA NORTH	DC	2	50
Less killing than GOLA EAST; last poaching recorded in 1972.			

TOGO

DIRECTION DE FORET ET CHASSE, TOGO (1987) QUESTIONNAIRE REPLY			
SOUTH ZONE	IG	3	150
NORTH ZONE	IG	3	250

APPENDIX VIII

Comparison of Continental Estimates

		PREVIOUS STUDIES				THIS STUDY		
		1979 (1)	1981 (2)	1985 (3)	AERSG 1987	GIS 1987	% PROJECTED	% PROTECTED.
CENTRAL AFRICA	CAMEROON	16200	5000	12400	21200	58328	98%	16%
	CAR	63000	31000	19500	19000	37186	81%	25%
	CHAD	15000	-	2500	3100	6267	67%	37%
	CONGO	10800	10800	59000	61000	73278	100%	2%
	EQUATORIAL GUINEA	1300	-	1800	500	5445	100%	0%
	GABON	13400	13400	48000	76000	74396	73%	8%
	ZAIRE	377700	376000	523000	195000	329651	98%	9%
EAST AFRICA	ETHIOPIA	900	-	9000	6650	9288	100%	42%
	KENYA	65000	65056	28000	23000	20809	0%	67%
	RWANDA	150	150	100	50	48	23%	77%
	SOMALIA	24300	24323	8600	6000	4482	0%	12%
	SUDAN	134000	133722	32300	40000	29760	71%	50%
	TANZANIA	316300	203900	216000	85000	108779	14%	69%
	UGANDA	6000	2320	2000	2300	2611	5%	80%
SOUTHERN AFRICA	ANGOLA	12400	12400	12400	12400	40426	100%	21%
	BOTSWANA	20000	20000	45300	51000	58096	12%	36%
	MALAWI	4500	4500	2400	2400	2794	16%	80%
	MOZAMBIQUE	54800	54800	24700	18600	20013	1%	20%
	NAMIBIA	2700	2300	2000	5000	4963	1%	61%
	SOUTH AFRICA	7800	8000	8300	8200	9075	11%	91%
	ZAMBIA	150000	160000	58000	41000	54699	30%	90%
	ZIMBABWE	30000	47000	47000	43000	45774	3%	80%
WEST AFRICA	BENIN	900	1250	2300	2100	2267	34%	66%
	BURKINA FASA	1700	3500	3500	3900	4756	54%	81%
	GHANA	3500	970	1000	1100	2964	88%	74%
	GUI BISSAU	-	-	-	20	56	29%	0%
	GUINEA	300	800	800	300	757	100%	11%
	IVORY C	4000	4800	4800	3300	3785	2%	44%
	LIBERIA	900	2000	800	650	3901	100%	11%
	MALI	1000	780	700	600	896	45%	19%
	MAURITANIA	160	40	0	20	105	100%	0%
	NIGER	1500	800	800	800	609	19%	91%
	NIGERIA	2300	1820	1500	3100	3345	45%	79%
	SENEGAL	450	200	100	50	142	71%	29%
	SIERRA LEONE	300	500	500	250	405	73%	67%
	TOGO	80	150	100	100	400	0%	24%

SOURCES; (1) DOUGLAS-HAMILTON (1979), (2) CUMMING AND JACKSON (1984), (3) MARTIN (1985), AERSG 1987, THIS STUDY

Some changes reflect real trends (Sudan, Kenya) others are corrections of wrong information (Malawi, Gabon) or a combination of both factors (Botswana) and some are affected by inflated projections (Central African countries, Angola). GIS projections can be used as maximum estimates. The percentage of the current GIS estimate which is projected is given. The percentage of elephants living in protected areas, nominal or otherwise, is also given.

REFERENCES AND SELECT BIBLIOGRAPHY

AERSG (1985). Minutes of a Meeting in Victoria Falls, Zimbabwe. Typescript 33 pp.

AERSG (1987). Proceedings of meeting at Nyeri, including review of elephant data, Kenya.

AFOLOYAN, T.A. (1975). Effects of elephants activities on forest plantations in Kilimanjaro Forest Game Reserve in northern Tanzania. Oikos 26 (3): 405-410.

ANON. (1978). "How many are we in Cameroon?".

BARNES, R.F.W. and DOUGLAS-HAMILTON, I. (1982). The numbers and distribution patterns of large mammals in the Ruaha-Rungwa area of southern Tanzania. Journal of Applied Ecology. 19: 411-425.

BARNES, R.F.W. and JENSEN, K.L. (1986). Forest Elephant Survey Progress Report 1985-1986. Typescript 30 pp.

BARNES, R.F.W. and JENSEN, K.L. (1986). Forest Elephant Survey: Progress Report for Second Half of 1986. Typescript 13 pp.

BARNES, R.F.W. and JENSEN, K.L. (1987). Forest Elephant Survey Progress Report 1986-1987.

BELL, R.H.V. (1984). Letter to the Editor. Swara 7(1): 40

BOITANI, L. (1981). The Southern National Park, a master plan. Prepared for Istituto di Zoologia, Facolta di Scienze dell'Universita di Roma-Italy. Report typescript 221 pp. plus maps.

BORNER, M. (1983). The Selous Survey. African Elephant and Rhino Specialist Group Newsletter (1).

BORNER, M. and SEVERRE, E. (1984). The Ruaha Elephants. Report from the Ministry of Lands, Natural Resources and Tourism, Tanzania.

BORNER, M. and SEVERRE, E. (1985). Rhino and Elephant poaching in the Selous Game Reserve. Serengeti Wildlife Research and Frankfurt Zoological Society. Report typescript 10 pp.

BOURLIERE, F. and VERSCHUREN, J. (1960). Introduction a l'ecologie des Ongules du Parc National Albert. Vol I. Institut des Parcs Nationaux du Congo Belge. Typescript 158 pp.

BOUSQUET, B. (1986). Projet de Conservation du Patrimoine Naturel en Zone Sud, Republique du Chad. Ministere du Tourisme et de l'Enviroment. Societe D'eco Amenagement raport aux Commission des Communautes Europeenes.

BOUSQUET, B. and SZANIAWSKI, A. (1981). Benin et Haute Volta. Resultats des Recensements Aeriens de Grands Mammiferes dans la region Pendjarie et Mekrou. FO:DP/UPV/78/008 DP/BEN/77/011. Document de Terrain No.4. Report typescript 59 pp.

BRYDEN, H.A. (1903). The Decline and Fall of the South African Elephant. Fortnightly Review (N.S.) 79: 100-108.

BUNDERSON, W.T. (1977). Interim Report on Numbers Distributions and Densities of Large Wild and Domestic Animals in Southern Garissa and Lamu Districts, Kenya.

BURRILL, A., DOUGLAS-HAMILTON, I. and MACKINNON, J. (1987). Protected Areas as Refuges for Elephants. (Part of MacKinnon Report to IUCN on Protected Areas in the Afrotropical Realm - in Press).

BUSS, I.O. and SAVIDGE, J.M. (1966). Change in Population Number and Reproduction rate of Elephants in Uganda. Journal of Wildlife Management, 30(4): 791-809.

CAUGHLEY, G. (1977). Sampling in Aerial Survey. Journal of Wildlife Management. 41(4): 605-615.

CAUGHLEY, G. and GODDARD, J. (1975). Abundance and distribution of elephants in the Luangwa Valley, Zambia. East African Wildlife Journal. (13): 39-48.

CITES. (1987). Namibia Estimate of Ivory Production and Export Quota. Form Q1.

COBB, S.M. (1976). The distribution and abundance of the large herbivore community of Tsavo National Park, Kenya. D.Phil.Thesis. University of Oxford.

CRAVEN, D. (1984). Damaraland and Kaokoland - Where to Now? Namibia Wildlife Trust Newsletter. Winter 1984.

CUMMING, D.H.M. and JACKSON, P. (1984). The Status and Conservation of Africa's Elephants and Rhinos. Proceedings of the joint meeting o IUCN/SSC African Elephant and African Rhino Specialist Groups at Hwange Safari Lodge Aug. 1981.

CUTLER. (1978). The killing of elephants in Zaire. Diplomatic telegram to the U.S. State Department.

DE BIE, S. and KESSLER, J.J. (1983). An aerial resource inventory of the national park Boucle du Baoule. Department of Nature Conservation, Agricultural University, Wageningen, the Netherlands.

DOMMISSE, E.J. (1851). The Kynsa Ekephants - Historical Sketch of a World Famous Herd. African Wildlife 5 (3): 195 - 200.

DOUGLAS-HAMILTON, I. (1972). On the Ecology and Behaviour of the African Elephant, D.Phil. thesis, Oxford.

DOUGLAS-HAMILTON, I. (1976). 80,000 Elephants Alive and Well in Selous. Africana 6 (3): 18-19.

DOUGLAS-HAMILTON, I. (1977-1979). The African Elephant Survey and Conservation Programme Annual Reports to WWF/NYZS/IUCN. Typscript

DOUGLAS-HAMILTON, I. (1977-1979). The African Elephant Survey and Conservation Programm. Annual Report summaries in WWF Yearbooks.

DOUGLAS-HAMILTON, I. (1978). Mkomazi Aerial Survey. Unpublished.

DOUGLAS-HAMILTON, I. (1979a). The African Elephant Action Plan. Typescript report for the IUCN/WWF/NYZS Elephant Survey and Conservation Programme.

DOUGLAS-HAMILTON, I. (1979b). African Elephant Ivory Trade - Final Report to US Fish and Wildlife Service. Typescript 105 pp.

DOUGLAS-HAMILTON, I. (1979c). Why Resurrect the Dead Elephant Issue? Africana, 6(11): 3-4.

DOUGLAS-HAMILTON, I. (1980-1982). African Elephant Coordination Office. Annual Report summaries WWF Yearbooks.

DOUGLAS-HAMILTON, I. (1982). Aerial Survey of Kidepo. Unpublished.

DOUGLAS-HAMILTON, I. (1983a). Back from the Brink. AERSG Newsletter (1): 13.

DOUGLAS-HAMILTON, I. (1983b). Elephants Hit by African Arms Race. Pachyderm (2): 11-3.

DOUGLAS-HAMILTON, I. (1984a). Trends in Key African Elephant Populations. Pachyderm (4): 7-9.

DOUGLAS-HAMILTON, I. (1984b). Elephant and rhino populations trends in Selous, Tanzania. Pachyderm (4): 18.

DOUGLAS-HAMILTON, I. (1984c). Another Look at the Ivory Trade. African Wildlife Foundation newsletter.

DOUGLAS-HAMILTON, I. (1985). Manyara Aerial Survey. Unpublished.

DOUGLAS-HAMILTON, I. (1987). African Elephant Population Study. Pachyderm (8): 1-10.

DOUGLAS-HAMILTON, I. (1987). African Elephants Population Trends and Their Causes. Oryx, 21: 11-4.

DOUGLAS-HAMILTON, I. and BURRIL, A. (In Press). Using Elephant Carcass Ratios to Determine Trends. In Proceedings of the International Symposium on African Wildlife, Kampala, Dec. 1986. African Journal of Ecology.

DOUGLAS-HAMILTON, I., FROMENT, J.M., DOUNGOUBE, G. and ROOT, J. (1985). Amenagement Faune Republique Centrafricaine. Recensement aerien de la faune dans la zone nord de la Republique Centrafricaine. FO: CAF/78/006 Document de travail 5. FAO, Rome.

DOUGLAS-HAMILTON, I., HILLMAN, A.K.K., HOLT, P. and ANSELL, P. (1979). Luangwa Valley. IUCN/NYZS,WWF Elephant, Rhino and Wildlife Survey. Typescript.

DOUGLAS-HAMILTON, I., HIRJI, K., MBANO, B., OLIVIER, R., TARIMO, E. and de BUTTS, H. (1986). Aerial Census of Wildlife in the Selous Game Reserve, Tanzania. World Wildlife Fund Project 3173 Report. Typescript 104 pp.

DOUGLAS-HAMILTON, I., MALPAS, R., EDROMA, E., HOLT, P., LAKER-AJOK, G. and WEYERHAEUSER, R. (1980). Rwenzori National Park and Kabalega National Park aerial counts. IUCN Progress Report. Uganda Elephant Survey. Uganda Institute of Ecology.

DOUGLAS-HAMILTON, O. (1980). Africa's Elephants - Can they survive? National Geographic Magazine, 18(5): 568-603.

DUBLIN, H. and DOUGLAS-HAMILTON, I., (1986). Current Status and Past Trends of Elephants in the Serengeti and Mara ecosystems. African Wildlife Journal (in Press).

DUPUY, A. (1967-1982). Aerial survey reports of Niokobola National Park.

ECOSYSTEMS (1977-80). Aerial survey reports in Tanzania.

ECOSYSTEMS (1981). Aerial Survey Report of Jonglei Land Area, Sudan. (Exact title unknown).

EDROMA, E.L. (1975). Wildlife Count in a Uganda National Park (Kidepo). Oryx XIII (2): 176-178.

ELIMA. (1978). Editorial, 31 July.

ELTRINGHAM, S.K. (1977). The numbers and distribution of elephant Loxodonta africana in the Rwenzori National Park and Ohambwa Game Reserve, Uganda. East African Wildlife Journal 15: 19-39.

ELTRINGHAM, S.K. (1980). Wildlife Research Program. UNEP FP/1110-79-01. Typescript 132 pp.

ELTRINGHAM, S.K. (1987). Review of Elephant Problems. In Proceedings of the International Symposium on African Wildlife, Kampala, Dec. 1986. African Journal of Ecology (in Press). (Exact title unknown).

ELTRINGHAM, S.K. and MALPAS, R.C. (1980). The decline in elephant numbers in Rwenzori and Kabalega Falls National Parks, Uganda. African Journal of Ecology, 18: 73-86.

FEDERAL REGISTER. (1978). Listing of the African Elephant as a Threatened Species. Federal Register 43 (93):20499-20504.

FIELD, C.R. (1971). Elephant ecology in the Queen Elizabeth National Park, Uganda. East Arfican Wildlife Journal. 9: 99-123.

FROMENT, J-M. (1985). Exploitation des elephants en Republique Centrafricaine. Document de terrain No. 1, CAF/78/006, FAO (in Press).

HAIGH, J., PARKER, I.S.C., PARKINSON, D. and ARCHER T. (1979). An Elephant Extermination. Environmental Conservation 6 (4): 305-310.

HART, J. (1986). Letter to Dr R. Barnes.

HALL-MARTIN, A. (1980). Elephant Survivors. Oryx, 15 (4): 355-362.

HALL-MARTIN, A. (1981). Conservation and Management of elephants in the Kruger National Park, South Africa. IUCN/SSC AERSG proceedings at Hwange Safari Lodge, Zimbabwe.

HILLMAN, A.K.K., BORNER, M., OYISENZOO, M., RODGERS, P. and SMITH, F. (1983). Aerial Census of the Garamba National Park, Zaire, with emphasis on the Northern White Rhino and Elephants. Typescript.

HILLMAN, A.K.K., SNYDER, P.M., TEAR, T. and SOMMERLATTE, M. (1981). An Aerial Reconnaissance of the Shambe Area, Southern Sudan. Typescript.

IUCN African Elephant Questionnaire Replies, or pers. comm. (available in Douglas-Hamilton archives, Nairobi).

1969 MCCABE,D.H.; VESEY-FITZGERALD, D.

1970 BREITENBACH.;

1976 ABEL, N.; ANNA, M.; BALINGA, V.S.; BOUSQUET, B.; CAUGHLEY, G.; DE SCHRYVER, A.; DU PUY, A.R.; FAGOTTO, F.; GRAHAM, A.; HALL-MARTIN, A.; JOUBERT, E.; JOUBERT, S.; LEUTHOLD, W.; MERZ, A.; RODGERS, W.A.; SPINAGE, C.; SOMMERLATTE, M.W.L.; SIKES, S.K.; WALKER, C.

1977 ALLAWAY, J.; ARENSEN, J.; BOUSQUET, B.; BOY; COLQUHOUN, I.R.; ERICKSON; GARTLAN.; GREEN, A.; HALL, P.; JEFFREY, S.M.; LA MARCHE, B.; MARSHALL; MARTIN, C.; MERZ, A.; N'SOSSO, D.; ODENDAAL, P.B.;

SOMMERLATTE, M.W.L.; VAN LAVIEREN; VON DER BECKE, J.P.; WOOD, J.T.; WOODLEY, W.

1978 BALINGA, V.S.; BUNDERSON, V.L.; LA MARCHE, B.; MILLIGAN; PARRY, D.; ROTH, H.H.; ROTTCHER, D.; SAYER, J.A.; SOMMMERLATTE, M.W.L.; WALKER, C.

1979 BECKER, P.; CAUGHLEY, G.; CONDY, J.B.; DODD, R.; FEIKA, M.B.D.; HUNTLEY, B.J.; KIDANE, A.; KILLE, M.E.; MINGA, H.; OMAR, H.S.; ROTH, H.H.; PATTERSON, L.; PELIZZOLI, A.; REOYO, M.T.; ROLLAIS, G.; SACKEY, V.; SNYDER, P.; SOMMERLATTE, M.W.L.; THOMAS, T.D.; VERSCHUREN, J.; WATSON, R.M.; WILLIAMSON, D.; WOOD, J.T.

1980 MINGA, H.; ROTH, H.H.; STRUHSAKER, T.; LA MARCHE, B.

1981 ASIBEY, E.A.O.; CHILD, G.; CUMMING, D.; GRETTENBERGER, J.G.; HALL-MARTIN, A.; KAWECHE; LA MARCHE, B.; MC SHANE, J.O.; MILLIGAN, K.; MINGA, H.; N'SOSSO, D.; NEWBY, J.E.; REOYO, M.T.; RODGERS, W.A.; ROTH, H.H.; TAYLOR, R.D.; WALKER, C.

1982 COBB, S.; MERZ, G.; TELLO, T.L.P.

1983 ALLO; BALINGA, V.S.; DE PATOUL, D,; DUNCAN, P.; DU PUY, A.R.; MELTON, D.A.; MONTFORT, N.; MOROKA, D.N.; NAZINGA GAME REANCH; NEWBY, J.E.; NGOG NJE.; OKO, R.A.; PARRY, D.; PEAL, A.L.; SPINAGE, C.

1984 BUNDERSON, W.T.; HALL-MARTIN, A.; HURT, R.; PELIZZOLI, A.; SMITH, K.; SPINAGE, C.; TELLO, J.; VAN WIJNGAARDEN, W.; WATSON, R.M.; WOODFORD, M.H.

1985 CARROLL, R.W.; DOUGLAS-HAMILTON, I.; DUNCAN, P.; GREEN, A.; LE FOL, A.; LWEZAULA,F; MOUSIST, A.

1986 BROOKS, P.M.; CARROLL, R.W.; CHARDONNET, P.; HALL-MARTIN, A.; HARRISON, M.D.; HART, J AND T.; HOWARD, P.C.; HOWITT, F.; ROOT, J.; TRENCHARD P.;

1987 ADAMSON, G.; AVELING, C.; BARNES, R.F.W.; BIHINI WON WA MUSITI.; BORNER, M,; BRETT, R.; BROOKS, P.M.; CALEF, G.; COBB, S.M.; CUMMING, D.; DIRECTION DES FORETS, DES CHASSES ET DE L'ENVIRONNEMENT DE TOGO.; DOUGLAS-HAMILTON, I.; DUBLIN, H.; EVANS, S; FALL; HILLMAN, A.K.K.; HUDSON, P.J.; LEWIS, D.; MARTIN, R.; MERZ, G.; MPHANDE, J.N.B.; MOSS, C.; NEWBY, J.E.; NICOLL, M.; POOLE, J.; PRETTEJOHN, M.; SSEMWEZI, P.; TELLO, J.; WESTERN, D.; WOODLEY, W.

IUCN (1980). Minutes of the African Elephant Specialist Group Meeting, Nairobi May 1980. Typescript.

IUCN/WWF. (1980). Statement on the African Elephant Ivory Trade. IUCN Bulletin Sept./Oct.

IUCN/WWF/UNEP. (1982). Elephants and Rhinos in Africa - A Time for Decision.

JARMAN, P.J. (1973). Editor of Game Department Seminar. Elephant Discussion Group. Nairobi University September 17th, 1973.

KAWECHE, G., MUNYENYEMBE, F., MWIMA, H., LUNGU F.B. and BELL, R.H.V. (1987). Aerial Census of Elephant in the Luangwa Valley. LIRDP Report No. 1. Typescript.

KIDRON, M. and SMITH, D. (1983). The War Atlas: Armed Conflict - Armed peace. Pan Books, London.

LAMPREY, H.F. (1964). Esimation of the large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika. East African Wildlife Journal, 2: 1-46.

LAWS, R.M., PARKER, I.S.C. and JOHNSTONE, R.C.B. (1970). Elephants and Habitats in North Bunyoro, Uganda. East African Wildlife Journal 8: 163-180.

LINDSAY, K. (1986). Trading elephants for ivory. New Scientist 112 (1533).

LOEVINSOHN, M.E., SPINAGE, C.A. and NDOUTE, J. (1979). Etudes Preliminaires pour l'Amenagement de la Faune en Zone Nord, Empire Centrafricaine. Analyse des resultats des survol aerien 1978. FAO: CAF/72/010. Document de Travail No. 10.

MACKINNON J. and K. (In Press). Review of Protected Areas in the Afrotropical Realm.

MARTIN, R. (1985). Establishment of African Ivory Export Quotas and Associated Control Procedures. A report to the CITES secretariat. Typescript 112 pp.

MELTON, D.A. (1985). The status of elephants in Northern Botswana. Biological Conservation, 31: 317-333.

MERTENS, H. (1983). Recensement Aeriens des Principaux Ongules du Parc National des Virunga, Zaire. Rev. Ecol. (Terre Vie). 38: 52-64.

MERZ, G. (1986). The Status of the Forest Elephant, Loxodonta africana cyclotis, Matschie, 1900, in the Gola Forest Reserve, Sierra Leone. Biological Conservation (36):83-94.

MIDDLE EAST REVIEW CO. LTD. (1986). Africa Review 1986 (10th edition).

MULDER, M.B.and CARO, T. (1980). Slaughter of the Elephants. New Scientist. July: 32-34.

NGOG NJE, J. (1977). The Status of Elephants in Cameroon. Typescript 2 pp. and map.

NORTON-GRIFFITHS, M. (1976). The Numbers and Distribution of Large Mammals in Ruaha Natinal Park, Tanzania. East African Wildlife Journal (11): 135-149.

OAU. Tsetse Fly Map

OLIVIER, R.C.D. (1983). The Gourma Elephants of Mali. A Challenge for the integrated management of Sahelian Rangeland. Report to UNEP. Typescript, 125 pp.

OMAR, H.S. (1981). Save the elephants from extinction in Somalia. Somalia Range Bulletin, 12: 67-70.

OTTICHILO, W.K. (1982-1987). Report to UNEP/WWF/ELSA. Elephant population study.

OTTICHILO, W.K. (1986). Population estimates and distribution patterns of elephant in the Tsavo ecosystem, Kenya, in 1980. African Journal of Ecology, 24: 53-57.

OWEN-SMITH, G. (1984). Namibia's most valuable resource. Quagga, 7. Spring 1984.

PARKER, I.S.C. (1979). The Ivory Trade. Typescript report to Douglas-Hamilton, I., on behalf of the U.S. Fish and Wildlife Service.

PARRY, D. (1983). Slaughterhouse of the Giants. Quagga (3): 32-33.

PATTERSON, L. (1985). Aerial monitoring of major wildlife species in northern Botswana. Third survey. Kalahari Conservation Society.

PEDEN, D. G. (1984). Livestock and Wildlife Population Inventories by District in Kenya 1977-1983. KREMU Technical Report No. 102.

PIENAAR, U. DE. V. (1963). Large Mammals of the Kurger National Park - Their Distribution and Present Day Status. Koedoe (6): 1-50.

PIENAAR, U. DE. V., VAN WYK, P. and Fairall, N. (1966). An Aerial Census of Elephant and Buffalo in the Kruger National Park, and the Implication Thereof on Intended Management Schemes. Koedoe (9): 40-107.

PENZHORN, B.L., ROBBERTSE, P.J. and OLIVIER, M.C. (1974). The influence of the African elephant on the vegetation of the Addo National Park. Koedoe 17: 137-158.

PILGRAM, T. and WESTERN, D. (1984). Managing elephant populations for ivory production. Pachyderm, (4): 9-11.

PITMAN, C.R.S. (1934). A Report on a Faunal Survey of Northern Rhodesia with special reference to game, elephant control and national parks. Livingstone.

REDMOND, I. (1986). Islands of Elephants. BBC Wildlife, 4 (11) November 1986.

REOYO, M.T. (1979). Le Parc National de Zakouma "en peril"; Destruction systematique des animaux par des militaires. Typescript 6 pp.

RICCIUTI, E. (1979). Ivory Wars. Animal Kingdom. 83 (1): 6-58.

ROLLAIS, G. (1979). Note sur la Situation de l'Elephant en Republique du Zaire. Typescript.

ROSS, I.C., FIELD, C.R. and HARRINGTON, G.N. (1976). The Savanna Ecology of Kidepo Valley National Park. Part III Animal Populations and Park Management Reccomendations. East African Wildlife Journal 7: 171-174.

ROTH, H.H. and DOUGLAS-HAMILTON, I. (1987). Distribution and Status of West African Elephants. Manuscript in prep.

ROTH, H.H. and MERZ, G. (1983). Conservation of Elephants in Sierra Leone. Final Report IUCN/WWF. Typescript 48 pp.

ROTH, H.H., MERZ, G. and STEINHAUER, B. (1984). Repartition et Statue des grandes mammiferes en Cote d'Ivoire. Mammalia, 48(2): 207-226.

SALONGO. (1978). 3 April.

SAVIDGE, J.M., WOODFORD, M.H. and CROZE, H. (1976). Report on a mission to Zaire. FAO (KEN/71/526-ZAI/70/001).

SHIMBI, L. (1979). Les braconniers - sont-ils les seuls responsables de l'abattage d'elephants dans la cuvette centrale? Typescript.

SHORTRIDGE. (1934). Order Probiscidea, Family Elephantidae. Mammals of South West Africa. Heinemann Publishers.

SPINAGE, C.A. (1973). A review of ivory exploitation and elephants population trends in Africa. East African Wildlife Journal 11: 281-289.

SPINAGE, C.A. (1985). The Elephants of Burkina-Faso, West Africa. Pachyderm (5): 2-5.

SPINAGE, C.A. and GUINNESS, F. (1971). Tree survival in the absence of elephant in Akagera National Park, Rwanda. Journal of Applied Ecology 8: 723-725.

SPINAGE, C.A., LOEVINSOHN, M.E. and NDOUTE, J. (1977). Etudes Preliminaires pour l'Amenagement de la Faune en Zone Nord, Empire Centrafricaine. FAO: CAF/72/010 - Document de Travail No. 8.

STELFOX, J.G., KUFAFWA, J.W. and OTTICHILO, W.K., (1981). Distributions and Population Trends of Elephants and Rhinoceros in Kenya; 1977-1981. KREMU, Technical Report No. 43. Ministry of Tourism and Wildlife, Kenya.

SWYNNERTON, C.M.F (1923). Report on the control of elephants in Uganda. Entebbe.

TALBOT and STEWART (1964). First Wildlfe Census of the Entire Serengeti Mara Region. Journal of Wildlife Management. 28 (4): 815-827.

TELEKI, G. (1980). Status of the elephant (Loxodonta africana) in Sierra Leone. A preliminary report on distributions. Transcript 5 pp.

UNEP/FAO Database.

VAN WYK, P. and FAIRALL, N. (1969). The influence of the African elephant on the vegetation of the Kruger National Park with special reference to the tree and shrub strata. Koedoe 12: 57-89.

VERSCHUREN, J. (1981). Senegal's Disappearing Elephants. Oryx 16: 118-119.

VERSCHUREN, J. (1982). Hope for Liberia. Oryx 16(5): 421-427.

WATSON, R.M. (1985). Report on a Statistical Analysis of the Shirre Company Ivory. Typescript.

WATSON, R.M., THACKWAY, R.M., TIPPETT, C.I. and SCHOLES, V.A.D. (1976). Sudan National Livestock Census & Resource Inventory. Typescript 20 volumes.

WATSON, R.M. and TURNER, M.I.M. (1965). A Count of the Large Mammals of the Lake Manyara National Park: Results and Discussions. East African Wildlife Journal, III, 95-98.

WCMD. (1976) Unpublished count.

WELLS, M. and DOUGLAS-HAMILTON, I. (1986). Analysis of tusks from the Central African Republic. Pachyderm (6): 16-17.

WESTERN, D. (1986). An African Odyssey to save the Elephant. Discover Magazine, October 1986.

WETMORE, S.P., DIRSCHL, H.J. and MBUGUA, S.W. (1977). A comparison of six aerial censuses of Meru National Park and Bisanadi Conservation Area. Aerial Survey Technical Report Series (2).

WEYERHAEUSER, R. (1982). On the ecology of the Lake Manyara elephants. Msc. thesis. Yale University.

WHITE, F. (1981). UNESCO/AETFAT/UNSO Vegetation Map of Africa. Scale 1:5 000 000. UNESCO.

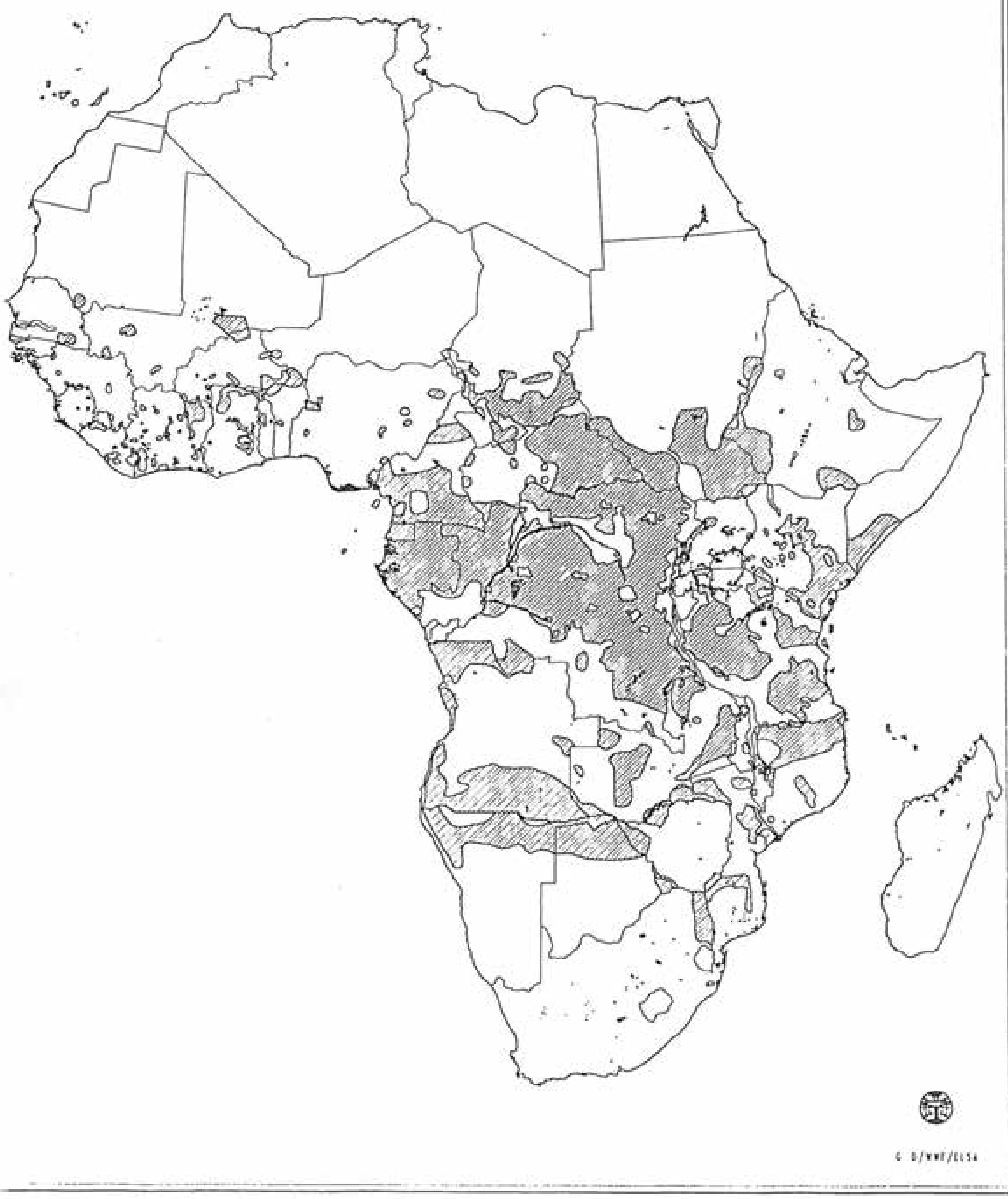
WILLIAMSON, B.R. (1975). The Seasonal Distribution of Elephant in Wankie National Park. Arnoldia 7 (11).

WORK, D.R. (1983). Chobe Elephant Survey Interim report. Typescript 7 pp. plus map.

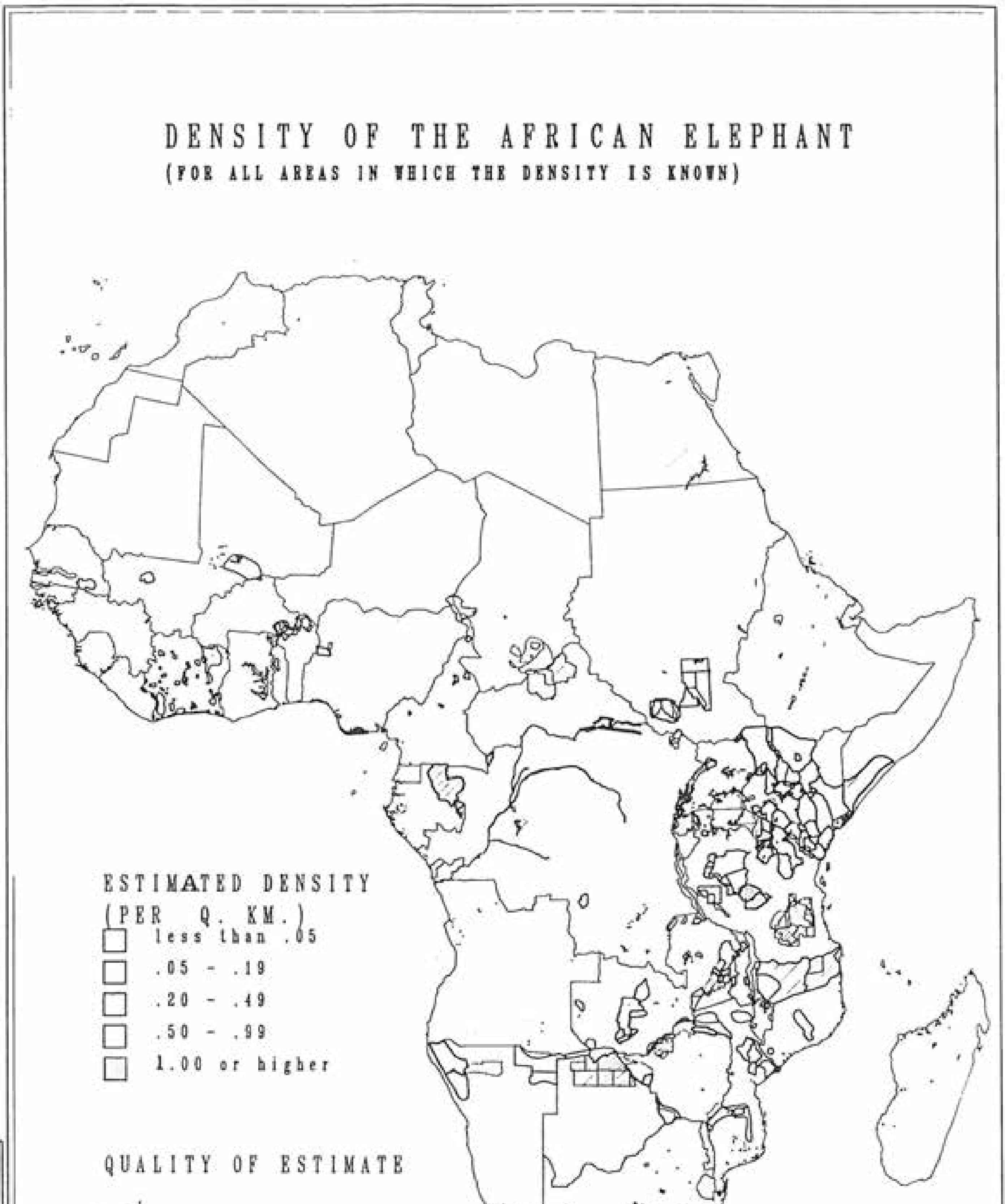
WORLD BANK. (1986). Population Growth and Policies in Sub-Saharan Africa. The World Bank. Washington D.C.

MAP 1

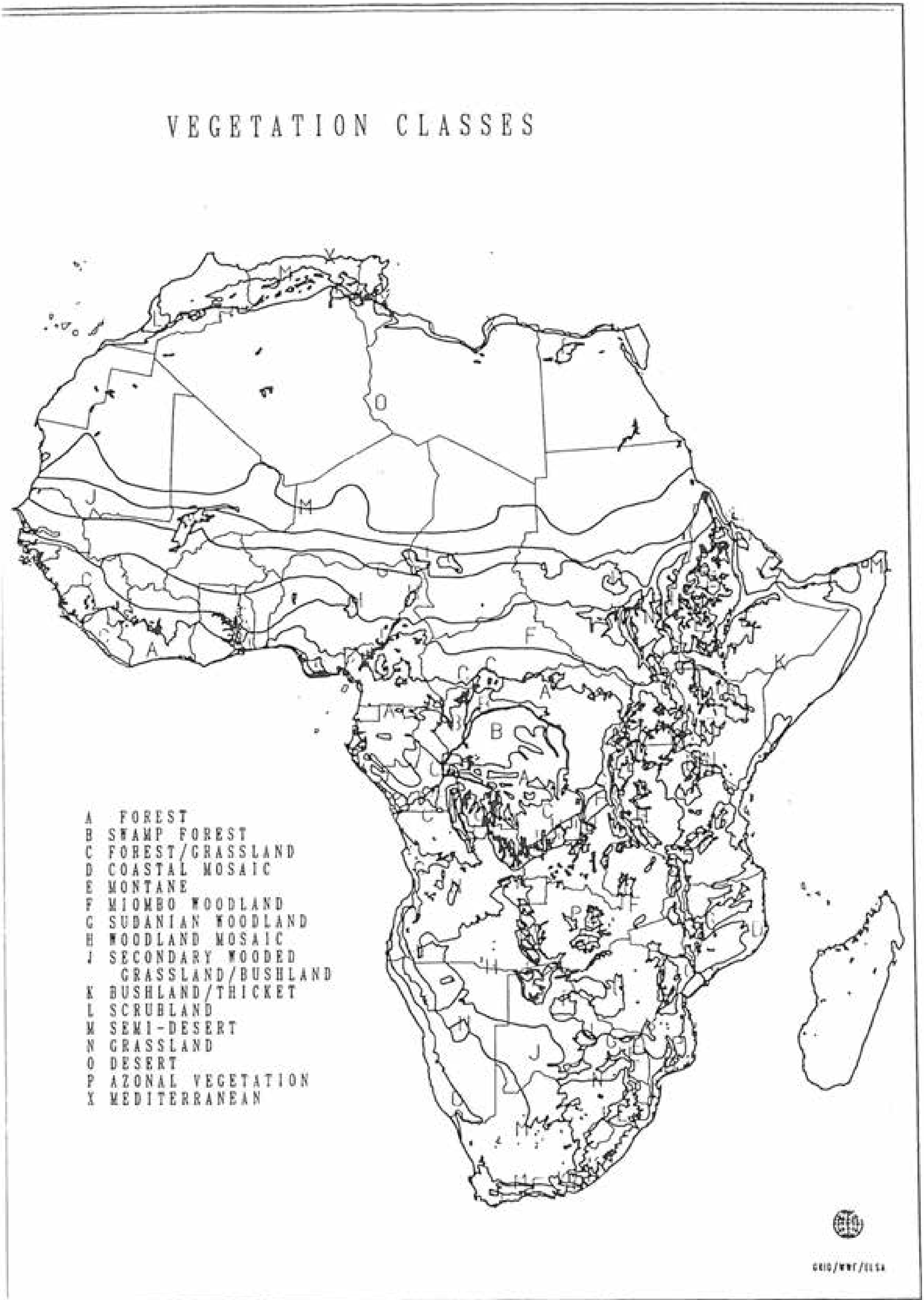
RANGE OF THE AFRICAN ELEPHANT



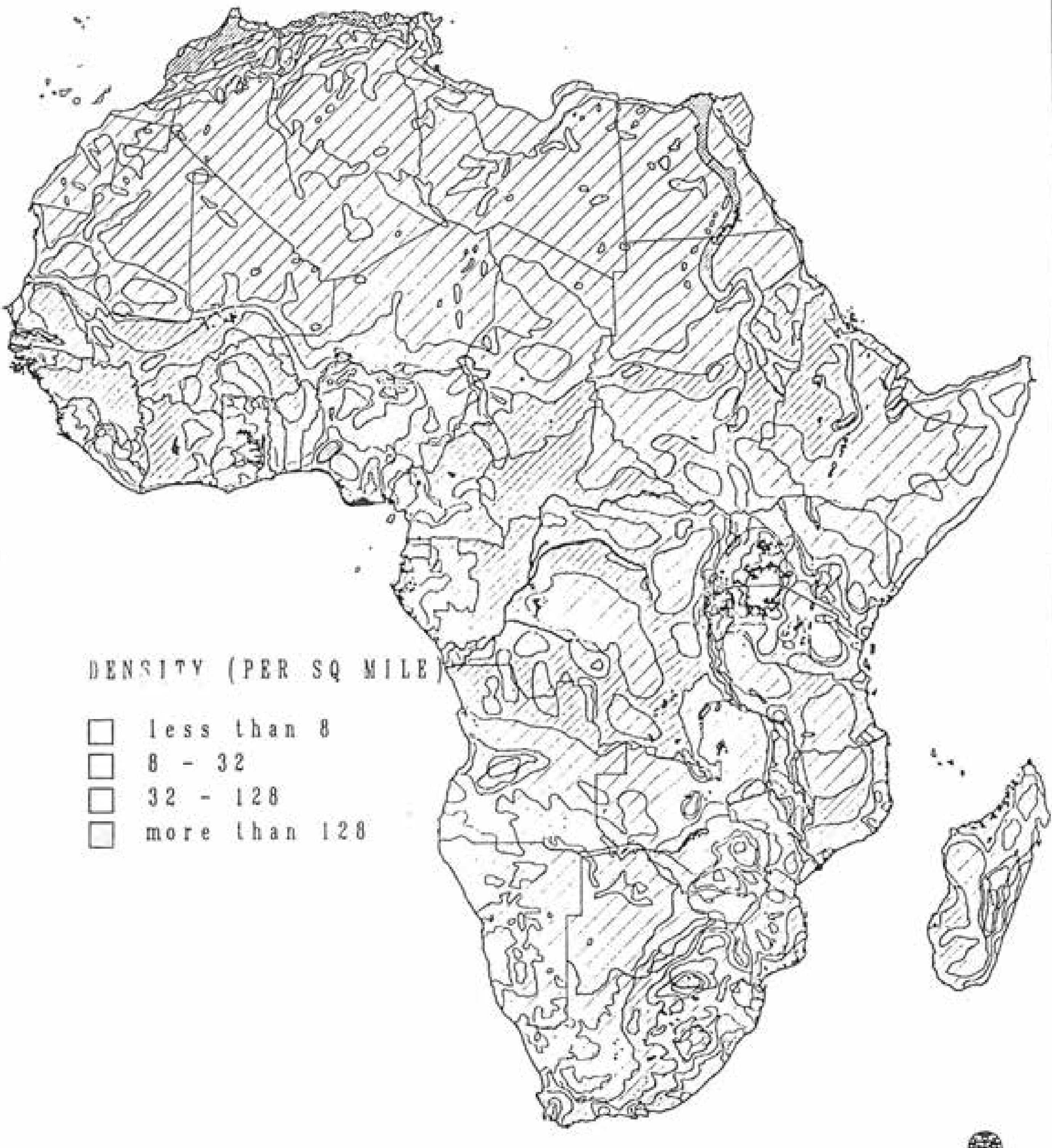
MAP 2


DENSITY OF THE AFRICAN ELEPHANT
(FOR ALL AREAS IN WHICH THE DENSITY IS KNOWN)
ESTIMATED DENSITY
(PER Q. KM.)
less than .05
.05 - .19
.20 - .49
.50 - .99
1.00 or higher
QUALITY OF ESTIMATE
1
2
3

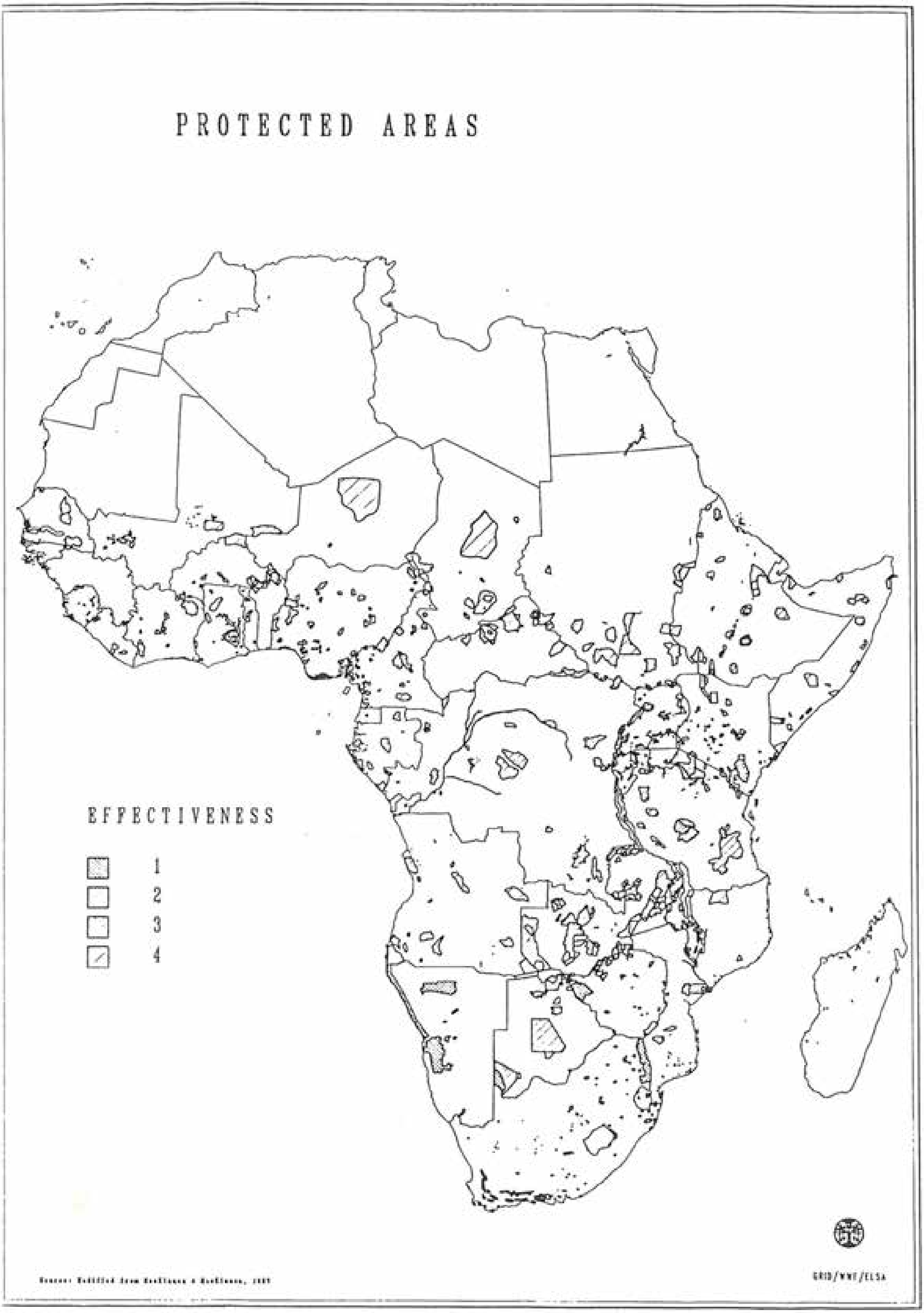
MAP 3

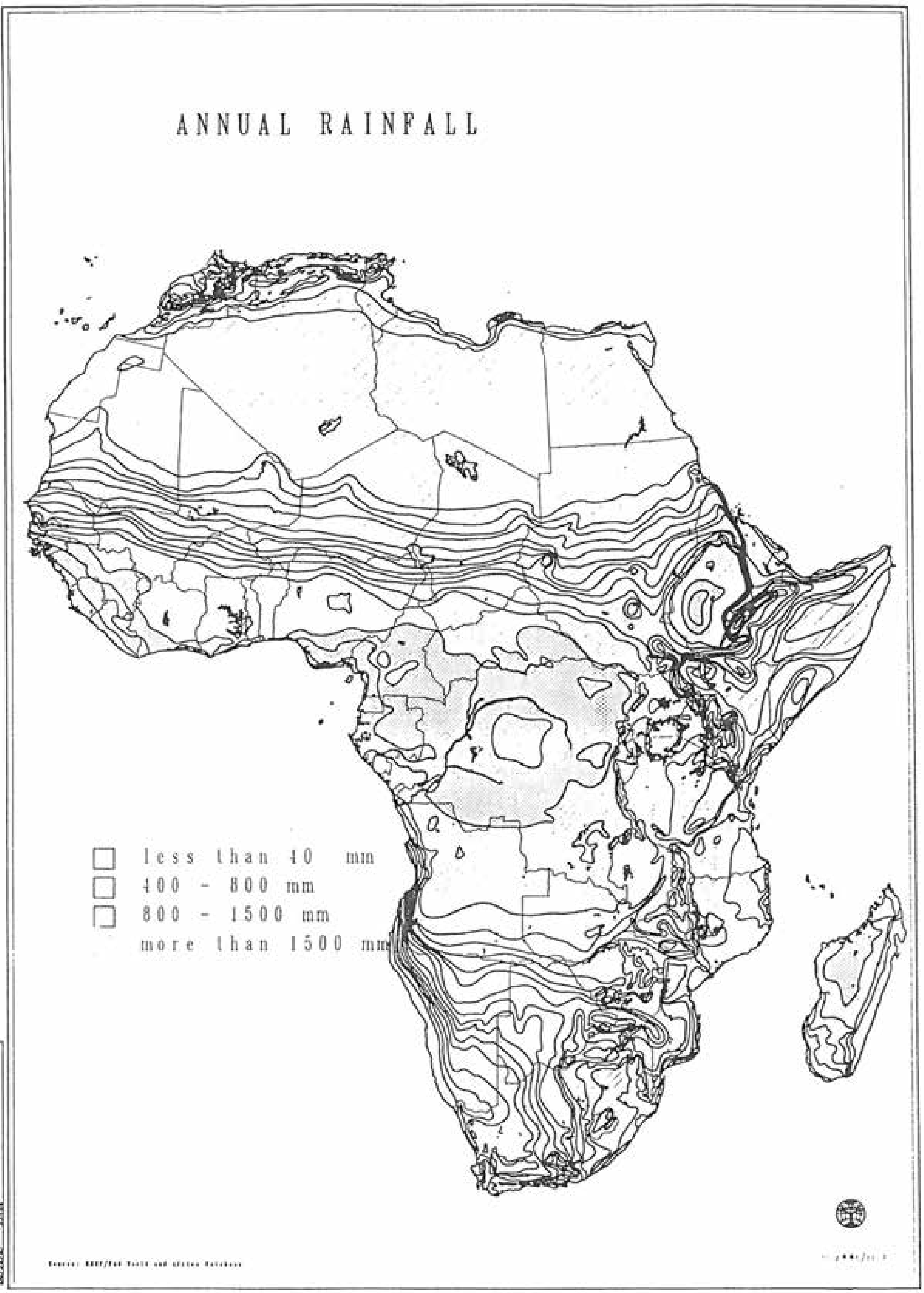

VEGETATION CLASSES
A FOREST
B SWAMP FOREST
C FOREST/GRASSLAND
D COASTAL MOSAIC
E MONTANE
F MIOMBO WOODLAND
G SUDANIAN WOODLAND
H WOODLAND MOSAIC
J SECONDARY WOODED GRASSLAND/BUSHLAND
K BUSHLAND/THICKET
L SCRUBLAND
M SEMI-DESERT
N GRASSLAND
O DESERT
P AZONAL VEGETATION
X MEDITERRANEAN

HUMAN POPULATION



MAP 5

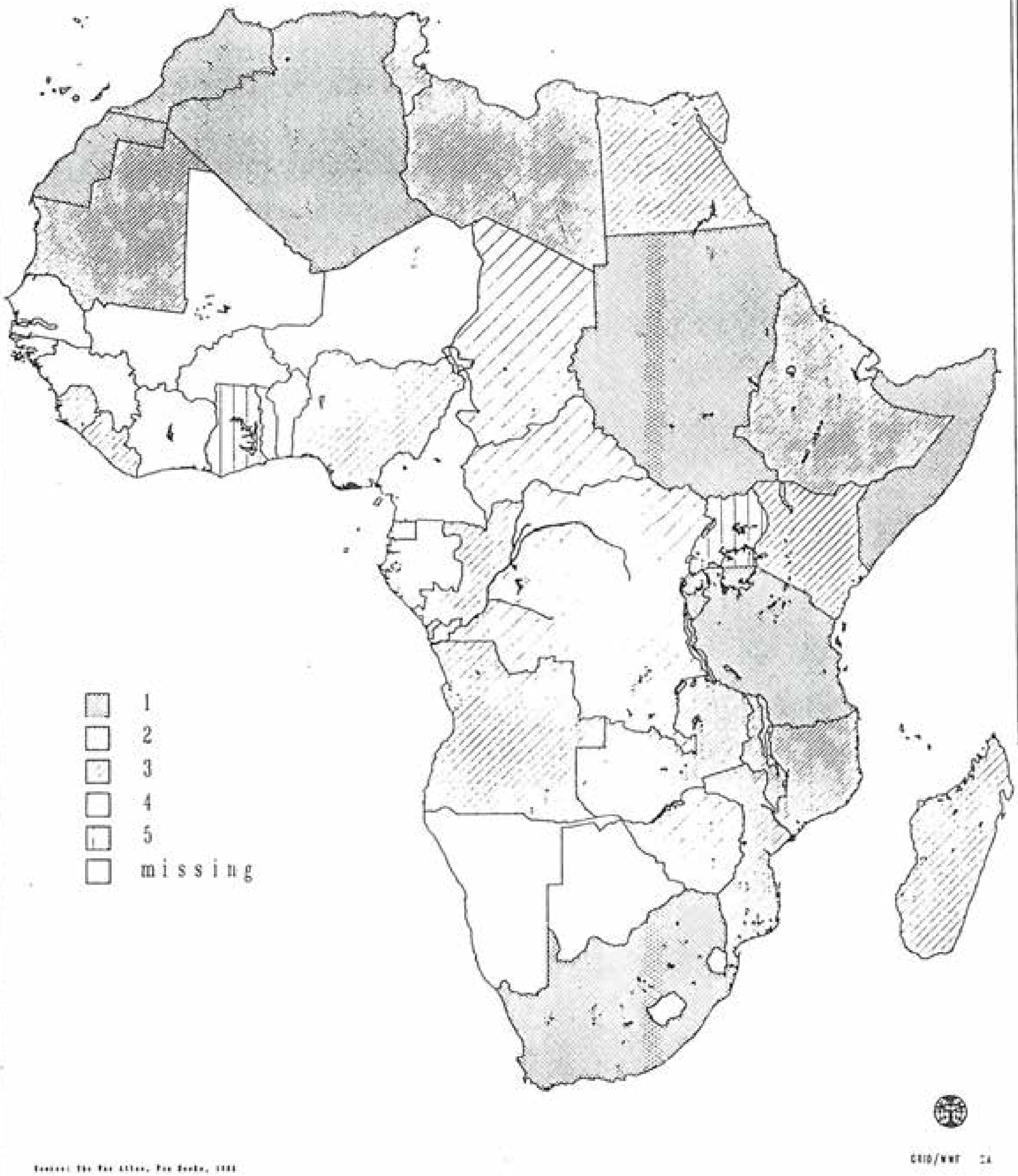



ANNUAL RAINFALL
less than 40 mm
400 - 800 mm
800 - 1500 mm
more than 1500 mm

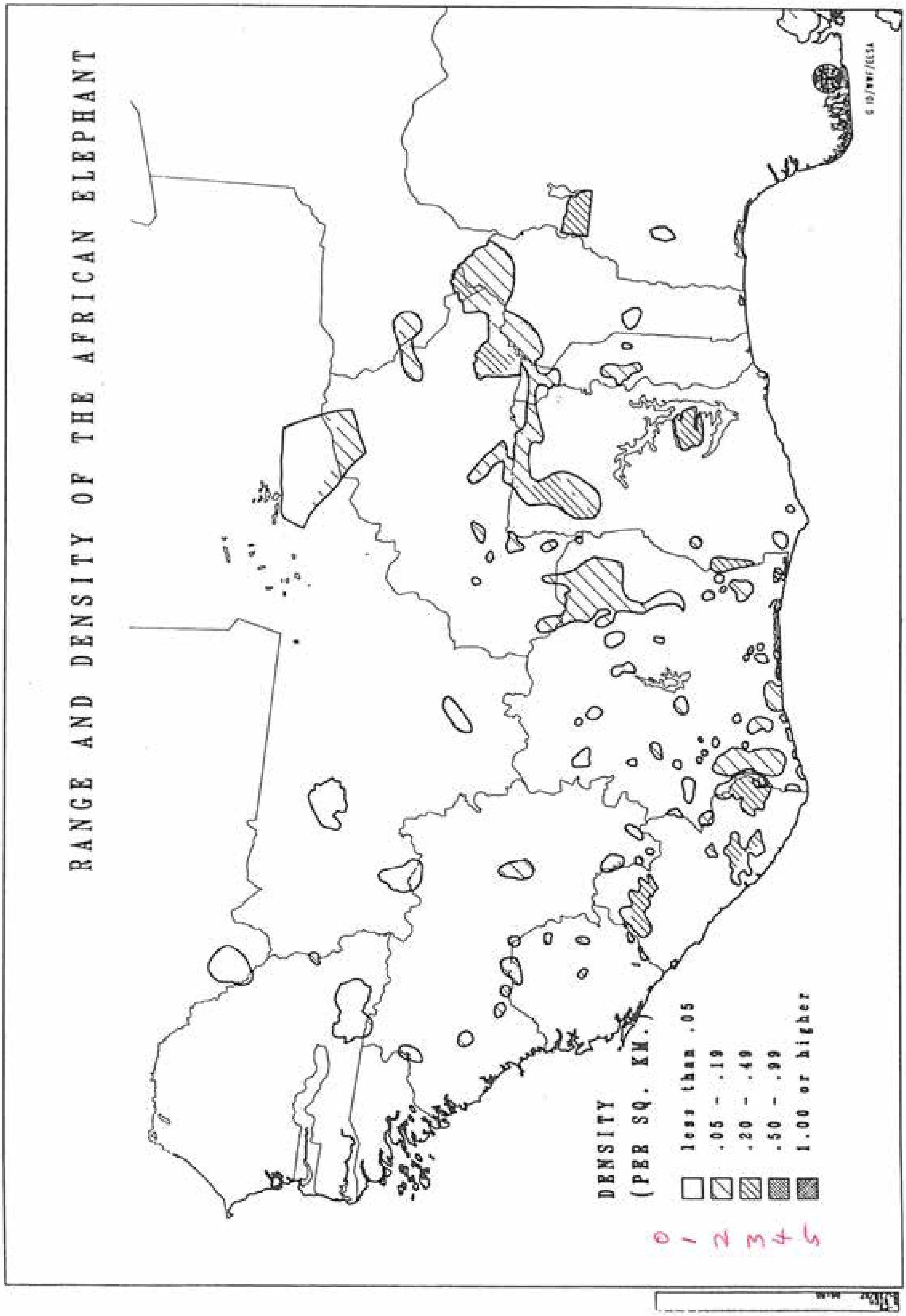
MAP 7

RANGE OF THE TSETSE FLY

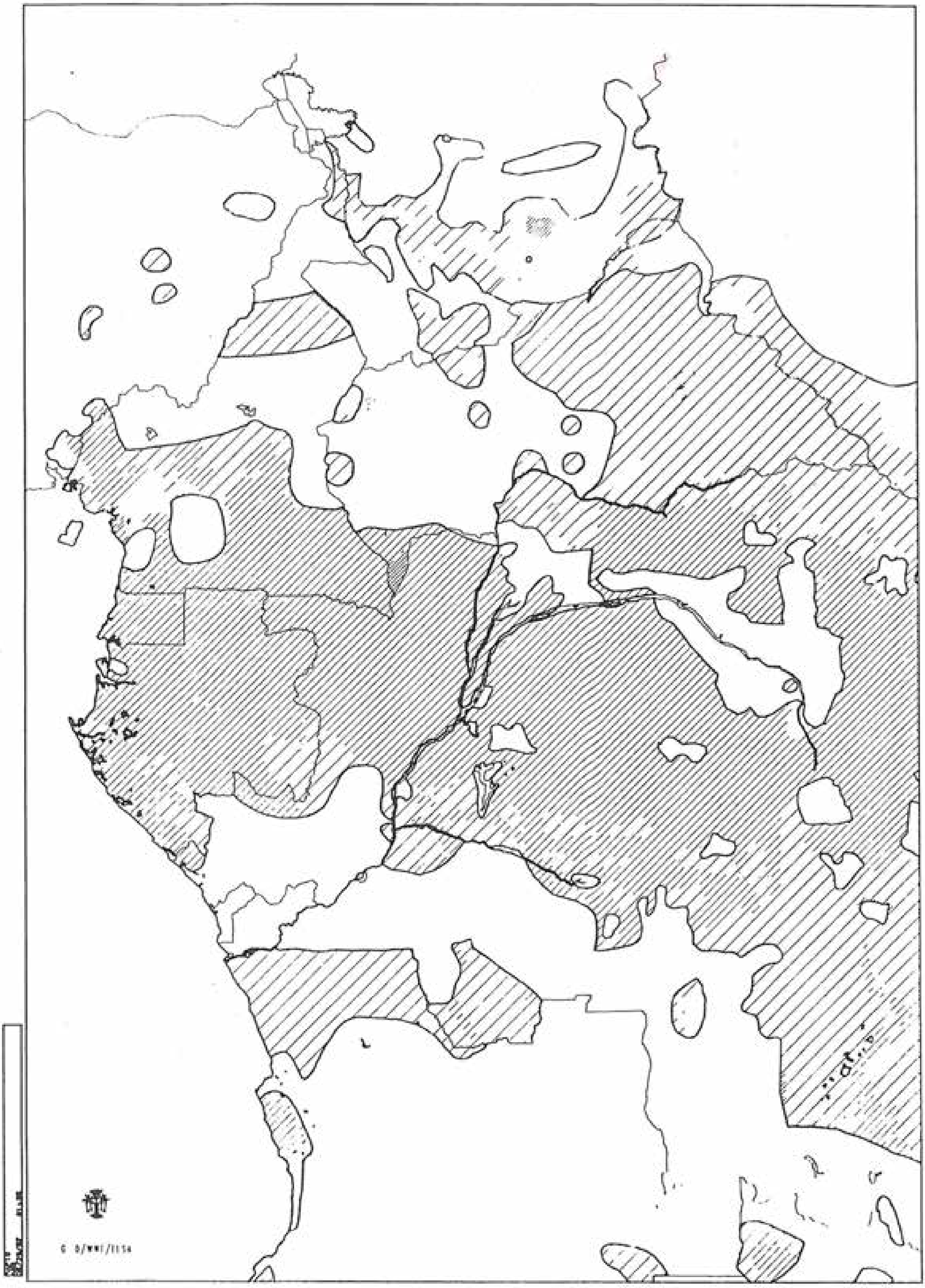
MILITARY RELIABILITY



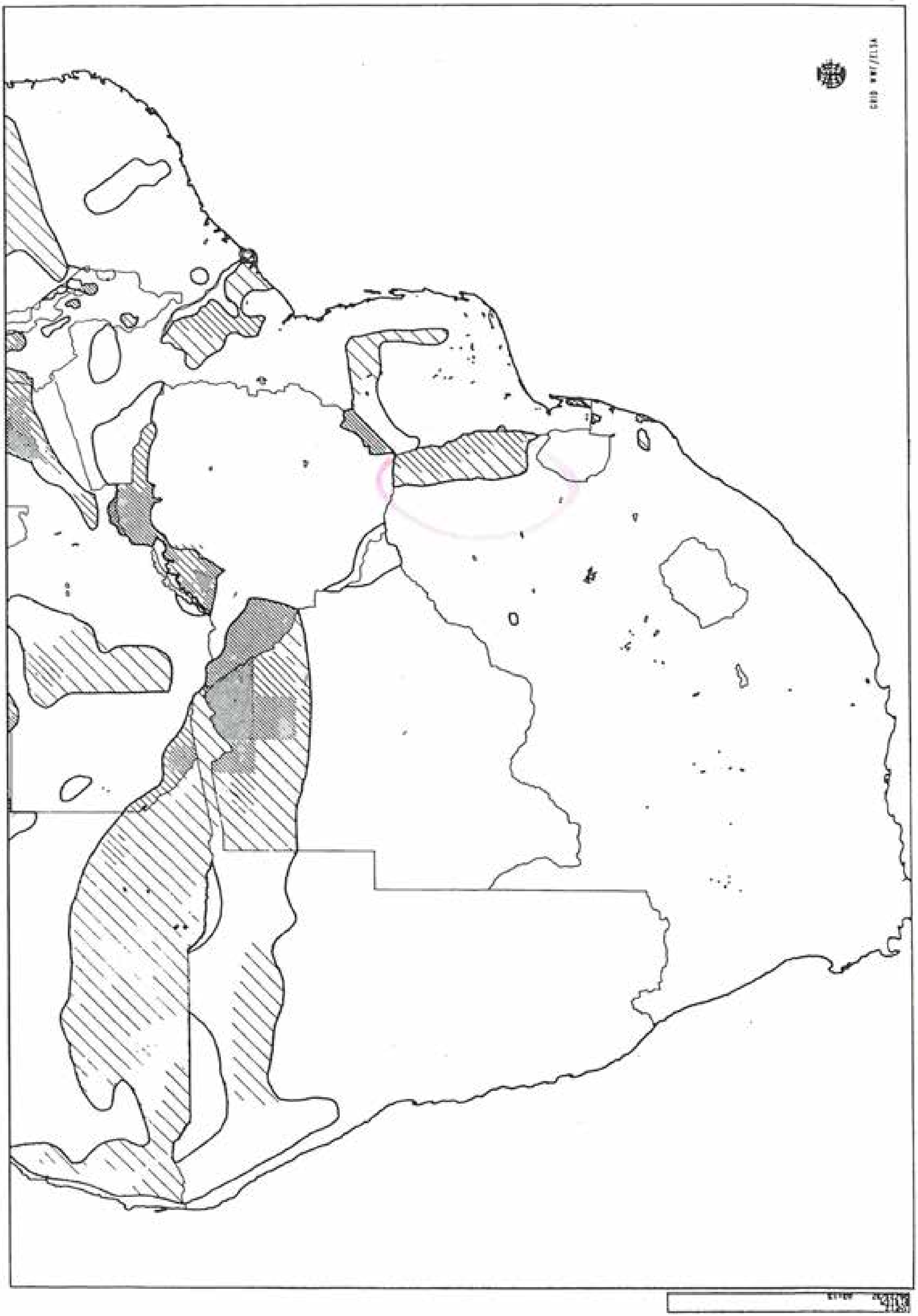
MAP 9



RANGE AND DENSITY OF THE AFRICAN ELEPHANT
DENSITY
(PER SQ. KM.)
less than .05
.05 - .19
.20 - .49
.50 - .99
1.00 or higher



MAP 11



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