

The north-western elephant population of Zimbabwe

The population estimates for Zimbabwe since 1980 are shown in the table on the following page. Two models for the population are presented. The first is a simple growth model which takes into account the numbers of animals killed annually including the major culls of the mid-1980s. The second is a technique developed by Martin (1992b) which uses a maximum likelihood estimator to obtain the most likely growth rate for the population in combination with the starting population in 1979.

The use of maximum likelihood analysis is only possible where confidence intervals obtained from sample survey techniques can be attached to all the estimates in the data set. Such a situation pertains for the Matabeleland North population from 1980 to the present date. For any population estimate with confidence intervals, the true value of the estimate is most likely to lie midway between the upper and lower values of the confidence interval. The probability that the true value is somewhere else decreases as one moves away from the central value according to the standard shape of the normal distribution.

A model population can be constructed by specifying a starting population in a given year (1979 in the model overleaf) and a rate of growth. In each year of the model, the number of animals which were killed due to culling or problem animal control is deducted from the population for that year and the population is then increased by the specified growth rate. This results in a set of hypothetical values for the population over the time span involved. In any given year, the hypothetical value can be compared with the actual population estimate and a probability assigned, based on the confidence interval, that the model value is the specified difference away from the estimate. The formula for this probability is –

$$P_x = \frac{e^{-\frac{(x - \bar{x})^2}{2\sigma^2}}}{\sigma\sqrt{2\pi}}$$

– where x is the model prediction for the population

\bar{x} is the actual population estimate

σ is the standard deviation (obtained from the confidence interval)

The values for the probabilities obtained in this manner are very small numbers and in the analysis shown on the next page they have been multiplied by 10,000 to bring them close to unity.

The probability that all the values in the data set lie in the positions predicted by the model is the product of the probabilities for all the estimates (box labelled 'INDEX' on the next page). This is an extremely powerful estimator. It does not rely

on a 'sum of squares' to ascertain the best fit to any curve but rather on a set of statistical likelihoods that the true values for all the estimates are where the model has placed them.

The best fit is obtained with a population of 20,575 animals in 1979 growing at a rate of 6.892%, taking into account the numbers of animals killed in the time period. The model curve does not pass through the 95% confidence intervals for two estimates (1991 and 1992) and it must be suspected that these are faulty. Excluding them from the analysis results in a slightly lower value for the starting population (19,911 animals) and a slightly higher growth rate (7.075%).

Simple growth model					Maximum likelihood analysis			
Population 1979		22,384			Population 1979		20,575	
Rate of growth %		6.361			Rate of growth %		6.892	
0.001 x Sum of squares		557,389			INDEX		277.43	
Year	Estimate	Mortality	Predicted	Difference ²	95% CI	Std Dev	Predicted	Probability x 10,000
1979		314	22,384				20,575	
1980	20,444	574	23,474	9,180,129	34	3,545	21,657	1.06134
1981	20,297	794	24,357	16,479,813	19	1,967	22,536	1.060773
1982	24,981	60	25,061	6,456	21	2,675	23,241	1.206869
1983	25,888	2,083	26,592	495,168	25	3,301	24,779	1.142272
1984	20,122	4,140	26,068	35,351,102	30	3,079	24,260	0.525172
1985	17,980	2,474	23,322	28,542,295	31	2,843	21,506	0.650147
1986	16,906	1,259	22,175	27,758,904	29	2,500	20,344	0.619925
1987	21,292	173	22,246	910,341	25	2,715	20,400	1.3924
1988	26,660	324	23,477	10,130,287	32	4,351	21,622	0.468956
1989	27,411	75	24,626	7,756,430	28	3,914	22,765	0.503949
1990	32,318	71	26,113	38,506,369	26	4,285	24,254	0.158505
1991	39,788	43	27,698	146,164,247	22	4,464	25,850	0.00683
1992	41,149	51	29,414	137,703,089	22	4,617	27,586	0.011547
1993	27,841	81	31,231	11,492,804	20	2,840	29,432	1.200742
1994	37,422	141	33,132	18,407,859	34	6,489	31,374	0.398201
1995	30,985	75	35,089	16,843,568	18	2,844	33,386	0.982288
1996			37,241				35,606	
1997	36,280		39,610	11,090,628	20	3,701	38,060	0.960235
1998	35,992		42,130	37,673,424	16	2,937	40,684	0.379233
1999	45,803		44,810	986,548	15	3,504	43,487	0.915217
2000			47,660				46,485	
2001	49,310		50,692	1,909,249	12	3,018	49,688	1.311628
2002			53,916				53,113	
2003			57,346				56,773	
2004			60,994				60,686	
2005			64,873				64,869	

Table 1 Matabeleland North Elephant population in Zimbabwe