

WILDLIFE SOFTWARE

TRENDS: SOFTWARE FOR A POWER ANALYSIS OF LINEAR REGRESSION

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Linear regression often is used in wildlife studies to assess trends. A typical use would be to assess growth or decline in population size over time. However, before commencing a program to monitor populations, several questions should be considered: (1) how many years should monitoring continue to detect a change; (2) how precise must an index be; (3) how large a change can be detected; and (4) what is the probability of detecting a change (obtaining a significant slope to the regression line), given that a change really is occurring?

Posing such questions is fundamental to a well-designed monitoring program. Obtaining answers through a statistical power analysis is important during both the design and analysis stages of a study. Tables (Cohen 1988) and microcomputer software (Goldstein 1989) are available to perform power analyses for many common statistical tests. We developed power analysis software for linear regression (program TRENDS) while designing surveys for dolphins (*Stenella* spp.) in the eastern tropical Pacific Ocean (Gerrodette 1987, 1991; Holt et al. 1987). TRENDS will be useful to biologists designing field studies, but it also could be used by teachers and students in courses on experimental design and statistics.

TRENDS is simple to use and parametrizes the problem in easily understood terms. It can be applied in any situation where linear regression analysis is appropriate, and where estimates of the dependent variable are made at

equal (or nearly equal) intervals. Thus, the program is not limited to detecting trends in a time series of population size, but could be applied generally to any variable of interest measured at equal intervals. The program is a single file (TRENDS.EXE) executable on any IBM-compatible microcomputer. Input and output are via ASCII files created by the program; no graphics are produced. Source code is Microsoft FORTRAN 77.

TRENDS summarizes the power analysis in 5 parameters: (1) n , the number of sampling occasions (points in the regression); (2) r , the rate of change between each sampling occasion (slope of the regression line); (3) CVI , the coefficient of variation (ratio of standard deviation to mean, a measure of precision of estimation on each sampling occasion); (4) α , the significance level (probability of a Type 1 error); and (5) power ($1 - \beta$, where β is the probability of a Type 2 error). The value of any parameter can be estimated if the other 4 are specified. The parameter of interest depends on the particular application.

The relationships among these parameters are affected by several other factors: (1) whether change is linear or exponential, (2) whether change is positive or negative, (3) whether the statistical test is 1- or 2-sided, (4) how the precision of the estimates depends on abundance, and (5) which statistical distribution is used. The latter 2 factors depend on the method used to estimate abundance (line-transect surveys,

mark-recapture methods, etc.) and the error structure of the estimates. TRENDS allows the user to choose among several possibilities.

The following example of the use of TRENDS is based on data presented in Storm et al. (1992). They found a mark-resight method superior to an area-conversion method for estimating white-tailed deer (*Odocoileus virginianus*) density, and stated that "we expect to continue monitoring the herd size during the next 5 years" (Storm et al. 1992:201). Is the mark-resight method also superior to the area-conversion method for monitoring herd size? What trends in population size can we expect to detect in 5 years? Using data presented in Storm et al.'s (1992) Table 2, we can estimate that, with 90% power over a 5-year period at a significance level of $\alpha = 0.05$, the minimum detectable annual rate of growth is 25% with the mark-resight method and 27% with the area-conversion method (see the user's guide for details). Lower rates of growth have a <90% chance of being detected in 5 years. Reformulating the problem to estimate the probability of detecting a 10%/year rate of herd size growth over a 5-year period yields detection probabilities (power) of 0.41 for the mark-resight method and 0.29 for the area-conversion method. These answers are ap-

proximate, but they indicate that mark-resight provides a slightly more sensitive method of monitoring deer herd size than area-conversion. Neither method, however, provides reasonable assurance of detecting a trend of 10%/year in 5 years. To detect such a trend with higher probability, we must expend more effort each year so that the herd size estimate has a smaller standard error, or we must continue monitoring for a longer period of time.

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