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Present educational leaders recognize this handicap and are attempting to correct the problem by educating wildlife professionals in the U.S. and other countries.

Strong emphasis is being placed on updating the educational system at the Institute in Harbin. This task is being accomplished by self-improvement of faculty in residence, by importing expertise from abroad, and by sending faculty to other countries for education, experience, and training. Efforts are being made to update the literature on wildlife management principles and techniques. In 1980, the senior author was invited by the Institute to teach a 1-month short course in wildlife conservation and management to 55 wildlife personnel representing every province in China except Tibet and Xinjiang. A major weakness of the wildlife faculty at the Institute is that they were not educated in wildlife ecology. Consequently, the head of the wildlife department is currently studying wildlife management systems and administration in the U.S. Plans currently are being formulated to educate Chinese wildlife professionals at a number of institutions in the U.S.

China has fallen behind in the field of wildlife conservation and management. However, the conservation of wildlife has been recognized as important and is being promoted by the present Chinese government. The need for properly educated and trained professionals is increasing. Efforts are now being made to meet this demand through upgrading the quality of education and expanding the number of wildlife programs in China.

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Received 13 July 1981.
Accepted 16 February 1982.

COMMENTS ON *AN EXAMPLE OF SIMULATION MODELS AS DECISION TOOLS IN WILDLIFE MANAGEMENT*

White, G. C., and Lane, L. J.

In a recent article in the *Wildlife Society Bulletin*, Williams (1981) attempts to demonstrate the usefulness of simulation models in wildlife management. The author is to be commended for applying simulation techniques to an important topic in wildlife management. We believe this approach has promise for analysis and synthesis of field data. We also believe this example is quite useful in illustrating a problem common to many simulation studies. Simulation results are sensitive to the quality and quantity of input data. Input data characterized by small sample sizes and high variability can profoundly affect the subsequent simulation results.

In his Fig. 1 Williams shows the density dependent relation upon which the results of the entire article are based. This density dependent relation is based upon only 5 data points, with a correlation coefficient of 0.71 (note that this value should be negative), statistically significant at only the 0.16 level. Furthermore, the density dependence (i.e., negative slope) is greatly affected by the left most datum. When this point is eliminated from the plot, a positive regression coefficient would be estimated, indicating that the number of calves/100 cows would increase indefinitely as the breeding population increases.

A 2nd major problem with the interpretation of the data presented in Williams' Fig. 1 is that the range of the breeding population is approximately 120 (590–710), while simulated breeding populations range from 0 to >1,000. Thus the data are extrapolated far beyond the range over which the relation was established.

The subsequent simulation results are based on the tenuous relation shown in Fig. 1. How then is the reader to judge the results presented in the remainder of the paper? Perhaps a partial

Wildlife Society Bulletin 10(3):285-286, 1982

answer to this question could have been obtained by means of a sensitivity analysis. Williams may have found that his estimates of maximum sustained annual yield and post-harvest population size would have been very sensitive to the density dependent relation. If so, the sensitivity of subsequent results to the relation shown in Fig. 1 would suggest that the simulation model is not a good decision-making tool in the absence of a strong relation for data of the type shown in Fig. 1.

Although the simulation results that Williams presents may not be particularly powerful as a tool for decision making, perhaps they do perform a useful function in pointing out an area in urgent need of additional research, i.e., the relation shown in Fig. 1. In the absence of such research, it appears that our ability to suggest theories about the nature of wildlife population dynamics (i.e., to build models) exceeds our ability to collect reliable data to establish basic relationships.

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Received 21 September 1981.

RESPONSE TO WHITE AND LANE

White and Lane have correctly identified 1 of the most difficult aspects of management modeling, that of incomplete or limited data sets. However, if one wishes to assess the practical application of a model, it is imperative that he test the model under typical managerial limitations and constraints. Indeed, the Wichita study was undertaken for that very reason.

Because management data sets are often based upon small sample sizes and, therefore, often cannot withstand statistical scrutiny, it follows that other procedures must be used to establish credibility in those data. One such procedure, "data alignment" (Gross et al. 1973, Williams 1977), was applied in the Wichita study. The technique is one of logical deduction rather than mathematical computation and can perhaps best be explained by first considering a familiar example.

For purposes of the illustration, let us define "system" as any collection of components that interact with each other in a unique way. From that definition, any simple geometric figure, with its collection of sides and associated angles, could be considered to be a system. Let us now further assume that we wish to model 1 such system, a triangle. In carrying out our task we have the problem of being able to measure accurately certain components of the system but not others. For example, we know that 2 sides of the triangle are 3 units and 4 units long respectively and that the angle between them is 90°. We are uncertain about the 3rd side but believe it to be about 4.8 units long. Given this uncertainty, does it necessarily follow that we cannot model the system? No. Recognizing that the triangle is a right triangle and, therefore, that a unique relation exists among the components, we determine that the 3rd side is actually 5 units long. Thus, we can conclude that our original estimate, while not correct, was at least reasonable.

Certainly big game grazing systems are more complex than simple triangles, but nonetheless, the concepts of data alignment can be applied to those systems as well. In the Wichita example I was in essence modeling a 3-component system: population size and structure, harvest, and natality. Natural mortality was known to be minimal and immigration/emigration did not occur. Thus, during 1969–73 (the demographic conditions used to derive Figs. 3 and 4), the only system components for which reliable data were not available was natality. However, by demonstrating that simulated population size, sex and age structure, trend, and harvest size and structure generated by Fig. 1 closely aligned with actual

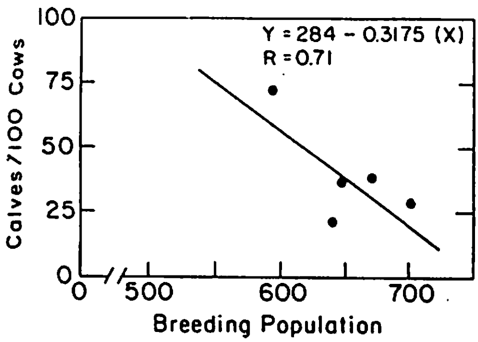

Fig. 1. Relation between breeding population size and calves/100 cows for elk on the Wichita Mountains National Wildlife Refuge, 1969–73.

population conditions, I was able to conclude that Fig. 1 is at least a *reasonable approximation* of the true natality function. Had that not been the case, 1 or more of the population alignment components would have differed greatly from known population parameters.

I hasten to point out that these arguments are not in support of the belief that "if one has a model, he doesn't need good data." This is clearly not the case! To apply the technique discussed here the data must be of sufficient quality to allow several crosschecks and comparisons. But given such data and a model that realistically mimics the interactions between system components, one can develop simulations useful for management and decision-making.

The other point raised by White and Lane, that of extrapolating Fig. 1, is based upon a misconception of how the regression was applied Fig. 1 is but 1 of 3 regressions used to simulate the population history depicted in Fig. 2. Each regression was derived independently from field data gathered for different population levels and habitat conditions. Fig. 1 is presented primarily to illustrate the general case.

The discussions presented here serve to further illustrate a point in my original paper—we have much to learn about applying models to actual management situations. Pleas for more research and better data often are heard and may represent long-term solutions. But my belief is that there is also a need to discover tools and techniques capable of using the information already available to managers—tools and techniques that can be updated and improved if and when better data do become available. In the meantime, it seems we may have much in common with the turtle (*Terrapene* spp.); we may have to stick our necks out once in a while to make any significant progress.

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