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MANAGEMENT MODEL FOR PINE VOLES: PRELIMINARY REPORT

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The use of computer models in scientific research has grown by leaps and bounds in the past decade. One of the primary reasons for this growth is the increased realization that computers and more specifically computer models, can be useful tools in synthesizing large amounts of information and providing insight into problem areas of research and management.

Numerous books and papers have been written on the justification for modeling, the philosophy of modeling, and model development and utilization. Recent reviews of small mammal population models are given by Conley and Nichols (1978) and Stenseth (1977). This paper will not address modeling in general, nor try to rehash old arguments about the value of models to science. Rather, it will try to outline what role a model can and hopefully will play in the major research program currently being conducted for pine vole control.

A computer model, as we refer to it here, is a mathematical representation of a biological system, for our purposes a pine vole population existing in an apple orchard. The model has been, or will be, coded and placed on a computer to facilitate multiple simulations of natural demographic processes and population responses to control procedures.

Before discussing the development of our model, we need to emphasize that there can be two distinct purposes for modeling. Modeling can provide insight, further understanding about the modeled system, and guide future research. Additionally, the modeling effort may provide a finished product, namely the model, which because of its predictive powers will be useful as a management tool. These two purposes are certainly not mutually exclusive, nor will they necessarily completely overlap. The emphasis on the first objective is in the benefits derived in the development of the model, while the main utility of the second is in the benefits obtained by using the model.

In our current modeling effort, we will attempt to achieve both goals, by synthesizing available information, obtaining a better understanding of pine vole populations dynamics, suggesting additional research, and, hopefully, developing a model with enough predictive capabilities to be useful in prescribing control procedures.

The use of computer models is not new to the field of agriculture where the primary objective has been the control of injurious insects. Numerous models have been constructed which have proved very useful for management of these pests. Mowery et al. (1975) developed a model which predicts the number of ladybird beetles (Stethorus punctum) needed to control the European red mite (Panonychus ulmi) in apple orchards. This model utilizes both chemical and biological control methods to achieve its intended goal. DeMichele and Bottrell (1976) describe the use of models for cotton insect pest management.

Pest management modeling has also been applied to birds and mammals. Dolbeer et al. (1976) have constructed a demographic model of red-winged blackbirds (Agelcius phoeniceus) to determine the numerical effect on a population under various control procedures. Wiens and Dyer (1975) modeled the bioenergetics of a red-winged blackbird population utilizing energy requirements of individuals and expanding this estimate to the entire population. By knowing the energy needs of the population and the energy available in the adjacent fields, they were able to make recommendations concerning the type of cultivation practice that would attract the birds to specific fields of non-cash crops.

There are presently two small mammal models being used or developed in Europe dealing with agricultural rodent pests (Stenseth et al. 1977, Spitz 1978). Both models were designed to aid in controlling field voles (Microtus agrestis, M. arvalis), a relative of the pine vole. The Spitz model is very simple, considering only the number of animals in the population and using a projection matrix containing numerical data for the principle population parameters of reproduction and mortality. This model was developed to forecast potential crop damage and function mainly as a management tool.

The Stenseth model was developed mainly as a research tool to synthesize information and improve understanding of the field vole's population dynamics. The model was constructed as separate submodels, each dealing with essential factors affecting the population. These submodels were then combined to form the overall population simulation model. During the process of development, critical areas for additional research were identified, including (1) food acquisition and nutrition, (2) effects of predation, (3) habitat utilization, and (4) dispersal. The researchers felt these areas need to be studied in more detail before a fully comprehensive working model could be developed.

The model we are currently developing at VPI & SU is similar to the Stenseth model in that the overall objective is to synthesize available information and guide future research. However, because Stenseth's model was developed as part of a much larger and longer research effort, generating a substantially larger data base, we will be forced to draw more heavily on information from the literature (perhaps on similar microtine species) and from personal communication with other researchers for our data base. Consequently, some parts of our model will be much simpler because adequate data does not exist at the present time. For this reason the model will be developed in submodel form to further facilitate adding additional information as it becomes available.

The central hypothesis for this model is that the major features of the pine vole population dynamics can be explained by analyzing the nutritional balance of individuals in the population. Thus, the model is based on energy requirements and acquisition of individual animals and the energy available to the animal in the environment. Because there is substantial information on the bioenergetics of pine voles (Lochmiller unpubl.), we decided to develop our model using a bioenergetic framework.

As we envision it, the pine vole management system will contain four subsystems. The biological subsystem will describe energy acquisition, and reproductive and survival characteristics of individual pine voles. The spatial distribution subsystem will incorporate such ecological parameters as home range size and shape, dispersal, and territoriality. The control and economic subsystems will incorporate the effects of various control procedures and the cost and benefits of those procedures. Development of the biological subsystem will be the major goal for the present modeling effort, with the other three subsystems being developed as time, additional data and money permit.

A major problem in evaluating or testing models is that the model is frequently compared or tested with the same data used to develop the model. This problem has hopefully been avoided in the present study, since the model is being constructed using previously collected information or information available in the literature and will be tested against population data currently being collected in two orchards as a companion study to the modeling effort.

The biological subsystem is currently being developed. The processes of energy availability, energy acquisition, and growth have been completed. Because of the problems with accurately aging pine voles, it was decided to separate the population into several energetic stages, or classes. Each stage will contain individuals whose daily energy requirements are unique to that stage. The male portion of the population will be separated into three stages: (1) sucklings, (2) juveniles, and (3) adults; the female portion will be separated into six stages: (1) sucklings, (2) juveniles, (3) non-reproductive adults, (4) pregnant adults, (5) lactating adults, and (6) pregnant and lactating adults. A separate class will be maintained for each sex for those animals that have died as a result of control practices. This category can then be used in determining the effectiveness of control procedures.

Because this model is based on the nutritional balance of individuals, it was necessary to determine some variable (or variables) that could be measured in living animals and accurately access the animal's current energy state (how well the animal relates to its present environment). Body fat was chosen as the index, since the amount of fat is a direct reflection of an individual's energetic condition. If the body fat content is low, it can be assumed that the animal is in an energetically stressful situation. This stress can then be manifested in the model as changes in biological characteristics for the individuals, namely reproduction, growth and survival. Data have already been gathered regarding deposition and utilization of fat, and demographic changes due to an energetic stress in pine voles (Lochmiller unpubl., Merson 1979).

The biological subsystem will be completed by September 1980. The capabilities of this submodel will be to predict sex- and cohort-specific population dynamics given adequate information about the population's environment. By knowing the status of the population, i.e. numbers, age distribution, mean body condition, and available energy at some point in time, it will be possible to predict the population status at some future time. After obtaining information regarding possible control measures and developing the control submodel, the model hopefully will be able to forecast the effectiveness, in terms of population status, of a control practice.

LITERATURE CITED

Conley, W., and J. D. Nichols, 1978. The use of models in small mammal studies. Pp. 14-35, In D.P. Snyder (ed.). Populations of small mammals under natural conditions. The Pymatuning Symposium of Ecology. Vol. 5. 237 pp.

DeMichele, D. W., and D. G. Bottrell. 1976. Systems appraoch to cotton insect pest management. Pp.107-132, In J. L. Apple and R. F. Smith (eds.). Integrated Pest Management. Plenum Press, N. Y. 200 pp.

Dolbeer, R. A., C. R. Ingram, and J. L. Seubert. 1976. Modeling as a management tool for assessing the impact of blackbird control measures. Proc. Vertebr. Pest Conf. 7:35-45.

Merson, M. H. 1979. Influence of restricted feed intake on the reproductive characteristics, energetics, and body composition of two species of rodents. Ph. D. Diss. V.P.I. & S.U., Blacksburg. 229 pp.

Mowery, P. D., D. Asquith, and W. M. Bode. 1975. Computer simulation for predicting the number of *Stethorus punctum* needed to control the European red mite in Pennsylvania apple trees. J. Econ. Entom. 68(2):250-254.

Stenseth, N. C. 1977. Modelling the population dynamics of voles: models as research tools. Oikos 29(3):449-456.

Stenseth, N. C., L. Hansson, A. Myllymaki, M. Anderson, and J. Katila. 1977. General models for the population dynamics of the field vole Microtus agrestis in central Scandinavia. Oikos 29(3): 616-642.

Spitz, F. L978. Population modeling as aid to rodent eontrol in the field. Proc. Vertebr. Pest Conf. 8:44-46.

Wiens, J. A., and M. I. Dyer. 1975. Simulation modeling of red-winged blackbird impact on grain crops. J. Appl. Ecol. 12(1):63-82.