March 1978

POPULATION MODELING AS AID TO RODENT CONTROL IN THE FIELD

Francois Spitz
Laboratoire de la Faune Sauvage, INRA, 78350 Jouy-en-Josas, France

POPULATION MODELING AS AID TO RODENT CONTROL IN THE FIELD

FRANCOIS SPITZ, Laboratoire de la Faune Sauvage, INRA, 78350 Jouy-en-Josas, France

ABSTRACT: Forecasting the damages by voles on plant crops depends on a good forecast of vole population density. Biological work in Vendee from 1959 till 1968 have furnished the fundamentals of a population model. Further work on the relationship between breeding and climate enabled us to set up a practical forecasting model. This is applied by the Plant Protection Service, and the damage prevention system consists of a test trapping in winter, a population forecasting in early March, and, if necessary, poisoning in March-April. Generalization of the system is in progress.

INTRODUCTION

Population modeling is a process allowing the scientist to forecast the size and structure of a population for a certain lapse of time. Damage forecasting is another process leading the plant protection specialist to an evaluation of the possible damage on plant crops, due to a given animal pest. The relation between population modeling and damage forecasting is obvious. Damages are clearly related to the density of noxious animals. However, the sensitivity of the plants to grazing varies according to various environmental factors. Among these factors some, such as the plot in question (soil), are constant while others fluctuate seasonally or yearly (climate, use of fertilizers, etc.). In a given agrosystem, with a given soil and a given agrotechnical environment, damage forecasting should take into account the forecasting of rodent population densities and a climate-related prevision of the plant sensitivity. But we know how difficult it is to do term climate forecasting. Thus we can actually only base our damage forecasting upon rodent population forecasting, for a given environment.

The principle of population modeling is very simple if we only consider the number of individuals. At time 1, the "box" contains "n" individuals; we obtain the situation at time 2 by using a matrix of numerical evolution in our example, a device which takes some individuals out of the box (death, emigration) and puts some others in (birth, immigration).

METHODOLOGICAL PROCESS

Biological Basis

The demographical informations for the field vole (*Microtus arvalis*) has been collected in 1959-1968 in Vendee (west-central France). Extensive trapping made it possible to get a representative picture of the populations on an area of ca 5,000 hectares. Thus we obtained numerical data for the principal parameters: breeding potential, body growth, mortality, and population density. The whole study was the object of a thesis (Spitz, 1974). An important point is that for such an area (several thousand hectares) the emigration-immigration balance is null. Therefore the numerical evolution matrix contains only birth rates and death rates.

Fluctuation Factors of the Natality and Mortality Parameters

At a regional scale, of the fundamental factors, the easiest to estimate are the climatic ones. Therefore, we first attempted to correlate our population parameters with the absolute values of climatic elements (rainfall, temperature, duration of sunshine). That attempt gave confusing results (Spitz, 1974). There we made a hypothesis that a normal demography is related to a normal climate. Next we drew a breeding-climate matrix with about 120 observations (12 months x 10 years) and 40 variables consisting of 4 to 6 classes of pregnancy, male-fertility rate, body weight, density, and 4 or 5 classes of climatic deviations from the normal value for temperature, rainfall and sunshine duration. This matrix was treated by correspondence analysis (Caillez *et al*., 1971; Benzecri, 1973; Hill, 1974). It gave interesting results enabling us to set up simple quantitative relations between climate and breeding (Table 1).

Building up the Model in the Practical Case of Outbreak Forecasting

The outbreak forecasting has to be made at the right time to satisfy two conditions: (1) Before any damage has occurred, and (2) soon enough to allow for mechanical-control treatment to be made on the entire agricultural area.

In the practical farming environment of western France, these conditions make it necessary to announce the forecasting by the first week of March at the latest. Besides, the best accuracy in density evaluation is to be obtained from November until January. Therefore, it is necessary to start the test trapping operations in the latter period. Evolution from this starting point is estimated by considering the probable natality calculated in terms of the climate-breeding relations (see above).

DANGER LEVELS

Only the danger of summer damages (on cereal, legume or hay crops) is considered. These damages are considered unavoidable if the regional average density of voles at the beginning of June exceeds 200/ hectare.

Table 1. Climate-breeding relationship (general trends).

Breeding events	Temperature	Rainfall	Sunshine duration
Breeding in November	above normal in October	(no conspicuous effect)	
Breeding in December	above normal in October, below normal in November and December	(no conspicuous effect)	
Breeding from February on	above normal in February	normal in January, above normal in February.	(no conspicuous effect)
Breeding from January on	below normal in December and January	below normal in December and January	above normal in December and January
No Breeding from October on	above normal in September	normal in September	above normal in September
No Breeding from September on	normal in August, above normal in September	far below normal in August	far above normal in August
No Breeding from August on	normal in July	(no conspicuous effect)	far above normal in July and August
Weak Breeding in March	far below normal in February and March	far below normal in March	(no conspicuous effect)
Weak Breeding from June on	(no conspicuous effect)	far below normal in June	far above normal in June

THE FORECASTING MODEL

The forecasting model consists of a chart presenting the probable evolution of the changes in population density according to eight spring reproduction scenarios. The scenario adapted to a given situation is deducted from direct observations on the population during the trapping, and from the climatic events as explained before. An example is given in Table 2. One must take care in using the lower limit of the range of predicted densities, i.e. of being a little too pessimistic.

Table 2. An example of density prediction for a starting point of 50 individuals/hectare in January for eight scenarios (A-H).

Scenario	Density	Density	Density	Density	Density
A	45	67	100	202	404
B	20 to 27	18 to 25	27 to 37	54 to 74	108 to 148
C	30	27	40	80	160
D	20 to 27	18 to 25	16 to 22	32 to 44	65 to 89
E	20 to 27	8 to 15	7 to 14	14 to 27	29 to 54
F	20 to 27	8 to 15	12 to 23	24 to 45	48 to 91
G	20 to 27	8 to 15	3 to 8	6 to 17	13 to 33
H	20 to 27	8 to 15	3 to 8	3 to 7	6 to 15

FINANCIAL ASPECTS OF PREVENTIVE VOLE CONTROL BY CHLOROPHACINONE-POISONED BAITS

The main interest of the forecasting model is to enable farmers to control the rodent populations before any damage has occurred. A good preventive-control operation delays the time of the population maximum up to a date when the damages are very unimportant (after crop-time) or only local, and the generalized outbreaks are avoided. But the forecasting is willfully too pessimistic, that is to say that the preventive treatment can be useless in 1/4 to 1/3 of the cases.

In 1965 we estimated the cost of a "medium-level" outbreak at 120 French francs/hectare (Spitz, 1977). At that time the expense for a generalized mechanical treatment by wheat grains poisoned with chlorophacinone (at 0.005%) was about 20 FF/hectare. For the ten years between 1959-1968, if we had made six danger forecasts but only three outbreaks occurred (1959, 1961, 1965), this would have been the largest "pessimistic" error possible, yet we could still have saved 240 FF/ha (3 outbreaks at 120 FF/ha i.e. 360 FF/hectare, minus the cost of 6 treatments, i.e. 120 FF/hectare). In fact we could have saved much more, since the 1959 outbreak was really quite destructive.

Currently costs have gone up and the chlorophacinone mechanical treatment is estimated at 37 FF/hectare, whereas the damages of an "average" outbreak is certainly above 200 FF/hectare.

PRACTICAL PROCESSING

Test Trapping

In a given climatic region in France, which covered about 5 million hectares (or 5 departments), the Plant Protection Service chooses typical agrosystems (a total of 10 to 20), which may or may not be subject to regular outbreaks. Indeed, we know that the agrosystems where the outbreaks rarely occur are damaged at different years than at the "regular" outbreak zones.

Each of these agrosystems is sampled by trapping in December-January with about 10 trap lines (100 meter-long with 50 traps each) for every important habitat of bare ground (ploughed or recently sown fields), grassy cover (hay, legumes, stubble-fields), pastures, and edges for a total of at least 40 trap lines. Thus there is a random choice of at least 40 plots for each typical agrosystem, each plot receiving one trap line. The average density of voles for each agrosystem is calculated from the trapping results.

Forecasting and Treatment

From January till March, according to the observations made on the animals caught in winter and the climatic observations, the vole population of each agrosystem is placed in one of eight possible scenarios. If the predicted density for the beginning of June is above 200/hectare (scenario A), the Plant Protection Service advises treatment.

CONCLUSION

The forecasting model and the preventive control system put in place in western France and realized by the Plant Protection Service, has enabled avoidance of great vole outbreaks and saved a large amount of money. The extension of this system to other areas is in progress.

LITERATURE CITED

BENZECRI, J.P. 1973. L'analyse des données (II) Edit. Dunod, Paris 620p.

CAILLEZ, F, MAILLES, J.P., NAKACHE, J.P., and PAGES, J.P. 1971. Analyse des données multidimensionnelles. Edit. Paris 3 Vol.

HILL, M.O. 1974. Correspondence analysis: a neglected multivariate method. Appl. Stat. 23(3);340-354.

SPITZ, F. 1974. Démographie du Campagnol des Champs (Microtus arvalis) en Vendée. Ann. Zool. Ecol. anim. 6(2):259-312.

________. 1977. Développement d'un modèle de prévision des pullulations du Campagnol des Champs. Bull. OEPP 7(2):341-347.