# CONTROLLING WILDLIFE DAMAGE: CAN COMPUTERS HELP?

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ABSTRACT: Expert systems, a new computer field, is presented as a method to make computers more useful and professionally relevant. Expert systems technology is discussed and is demonstrated to be available and affordable. A typical wildlife damage control problem is presented: species identification of a burrowing pest from a verbal description of a mound or burrow. Development of the expert system, BURROW, is outlined in step-by-step fashion, from statement of the problem, through translating knowledge into rules, to testing and review. Emphasis is placed on encouraging others to write simple expert systems to solve routine problems.

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## INTRODUCTION

Computers are acknowledged to be firmly entrenched in natural resource management. Universities, government agencies, and private industry all use computers. Computers have the ability to perform an amazing diversity of tasks from modeling deer population dynamics (Raedeke et al. 1987) and performing cost/benefit analysis of ground squirrel control (Salmon et al. 1985) to maintaining databases of endangered species (Zeiner 1985) and posting restricted chemical notices on electronic bulletin boards.

Early supporters of computers envisioned a futuristic workplace with a computer on every desk. Although computers have established at least a foothold in most organizations, they have yet to be universally incorporated into the everyday work routine. As long as computers are seen primarily as numeric processors their appeal will be necessarily limited.

Many wildlife damage control problems are not calculation problems, but are decision-making problems. Computers need to expand beyond data processing into knowledge processing (Goldenburg 1985). Computers would certainly become more useful if they could assume a decision-aiding role. Does this computer technology exist? Which problems would be appropriate for computer assistance? Can one technology meet everyone's needs? Professionals in the field of wildlife damage control do represent a wide variety of backgrounds, but have one common bond: each one is an expert in some specialized area. Such expertise can represent extensive training and years of field experience and, quite naturally, is in great demand (Bender 1987). Experts are frequently consulted by phone or asked to write articles or newletters.

Over the years, the advice given by the professional becomes repetitious. The problems keep recurring, but no new methods are needed to solve them. The problem is no longer intellectually compelling. The professional increasingly wishes to delegate routine problem solution to someone else. With new computer technology recently available, it is now possible to delegate responsibility to the computer (Goldenburg 1985). The computer can use expert systems technology to solve problems in much the same manner as does the expert.

An expert system is a computer program which is designed to mimic a consultation with an expert. Particularly, it is the problem-solving process that is mimicked (Fersko-Weiss 1985). Knowledge is expressed by the expert as a structured set of rules. Each rule contains a conclusion based on facts. Facts are obtained from the user in the form of answers to questions posed by the expert system. Users are the potential clientele who call on the phone or read the newsletters.

## DEVELOPMENT OF BURROW EXPERT SYSTEM

An actual example will best illustrate the use of expert system technology. Terrell P. Salmon is a Wildlife Damage Specialist at the University of California, Davis. He receives dozens of phone calls about damage control. Clients often call to complain about burrows in their lawns or fields. Naturally, the caller's primary concern is how to stop the damage and control the pest.

Identification of the involved species is essential as both control selection and timing of application is species specific. Since the caller's attention is already focused on the damage, Dr. Salmon's first task becomes identification of the pest species based on the caller's description of the mounds.

Over the years, Dr. Salmon has developed an informal protocol of which questions to ask and in what order. The first question is: is there a definite mound? If the answer is yes, the second question is: is the mound plugged with soil? If the mound does have a soil plug, the third question is: is the mound 1) round or volcano shaped, or 2) fan or crescent shaped? If the caller agrees that the mound is crescent shaped, identification of the species as a pocket gopher (Thomomys spp.) can be made with reasonable certainty.

This orderly progression of questions can be translated into a set of rules. Rules are simply ordinary statements of facts and conclusions. For example:

1. If there is a definite mound, and the mound is plugged with soil and the mound is fan or crescent shaped, then the species is pocket gopher.

This rule covers the pocket gopher. Other rules are needed for moles (Scapanum spp. and Neurotrichus gibbsii), ground squirrels (Spermophilus beecheyi and S. beldingi), and meadow voles (Microtus californicus):

2. If the mound is round or volcano shaped, then the species is mole.

3. If there is not a definite mound, then rule out mole and pocket gopher.

4. If mole and pocket gopher are ruled out and the burrow opening is 3-5 inches in diameter or the ground is usually dry, then the species is ground squirrel.

5. If the burrow opening is 1-2 inches in diameter or the ground is usually moist, then the species is meadow vole.

Basically, the task of species identification based on mound description has been reduced to 5 statements. Obviously, this is a very simplistic task that Dr. Salmon can do himself without a computer, but the expert system can stand in for him when he is out of the office. One of the office staff could answer the phone, run the expert system, correctly identify the species as pocket gopher, and mail out a leaflet on pocket gopher control (Jones et al. 1986).

Many county farm advisors also receive calls concerning burrows and mounds. A farm advisor may be trained in a field other than in wildlife damage control (Schmoldt, in press) and may not be able to correctly identify the species involved. He might not gather enough detailed information about the mounds for a consultant to subsequently identify the species. If the farm advisor had been able to use the expert system, he would have asked the proper questions. The expert system can serve as an information checklist in this case.

Expert systems also make excellent training tools (Scmoldt et al. 1987). Because expert systems work on a one-to-one basis, trainees can proceed at an individual pace. The trainee has complete information organized in a structured way at his fingertips. Both the facts and the method the expert uses to solve the problem are learned (Marcot 1986). The expert system explains which facts were important and why.

A simple expert system like BURROW, the example presented above, is easy to build. The rules can be written with any of several popular word-processing software packages on a standard PC-compatible computer. The expert is responsible for writing the rules. An expert system "shell" handles the rest. The shell compiles the rules, turning them into machine instructions. The shell also controls the way the system interacts with the user.

First, the shell examines the rules written by the expert and breaks the rules down into the basic facts that have to be known. Some facts can be concluded from the rules. Other facts are posed as questions to the user. The shell is designed to deduce the pattern of logic in the rules, deciding which facts are needed, what questions to ask, and in what order. As the user answers the questions, the facts become known and the shell progresses further down a logical path. The choice of one path rules out other paths. Eventually, the path is followed to the conclusion. The goal is reached and the species is correctly identified.

## DISCUSSION OF RESOURCES NEEDED TO IMPLEMENT AN EXPERT SYSTEM

Several commercial software companies make expert system shells. They vary widely in price and features (Citrenbaum et al. 1987). A simple system with 100 or fewer rules could be built with a $15 shell, but a complicated system with several hundred rules may require both an expensive shell and a computer with a fast, powerful processor.

Alternatively, some expert systems are programmed in a formal computer language like PROLOG or LISP. Instead of the shell existing separately from the rules, the two are written together as 1 package. This usually requires both a computer with a fast, powerful processor and the services of a computer programmer.

Developing complicated expert systems is an expensive proposition, both in terms of man-hours and equipment, but writing a simple expert system requires very little investment. An inexpensive shell, a standard PC computer, and several hours to a week of the expert's time are all that are necessary to build an expert system.

## EXPERT SYSTEM DEVELOPMENT GUIDELINES

1. Choose a simple problem dealt with frequently. Not only has the problem-solving routine been developed but the problem is certain to recur (Coulson et al. 1988).

Ex. Species identification of burrowing pest in California.

2. Define the problem as narrowly and specifically as possible (Marcot 1987).

Ex. Burrowing pest may be one of four species common to California: gopher, mole, ground squirrel and meadow vole. Identify species from verbal description of mound or burrow.

3. Write down all the possible solutions to the problem and all the facts that must be known to arrive at each solution.

| Ex. All Solutions: | Facts: |
|---|---|
| I pocket gopher | I mound presence |
| I mole | I soil plug in mound |
| I ground squirrel | I shape of mound |
| I meadow vole | I size of burrow openings |
| | I ground moisture |

4. Draw a path diagram to link the facts and solutions (fig. 1).

5. Translate the procedures into rules. There should probably be a rule for each possible path. Rules need to follow the syntax standard established by the shell. The shell may require a goal statement.

GOAL SPECIES IS WHAT?

IF there is a definite mound
AND the mound is plugged with soil

AND the mound IS fan or crescent shaped,
THEN species IS pocket gopher.

IF there is a definite mound
AND the mound is plugged with soil
AND the mound IS round or volcano shaped,
THEN species IS mole.

IF NOT there is a definite mound
OR NOT the mound is plugged with soil,
THEN rule out mole and pocket gopher.

IF rule out mole and pocket gopher
AND the burrow opening IS 3-5 inches in diameter
OR the ground IS usually dry
THEN species IS ground squirrel.

IF rule out mole and pocket gopher
AND the burrow opening IS 1 1/2 inches in diameter
OR the ground IS usually moist
THEN species IS meadow vole.

END

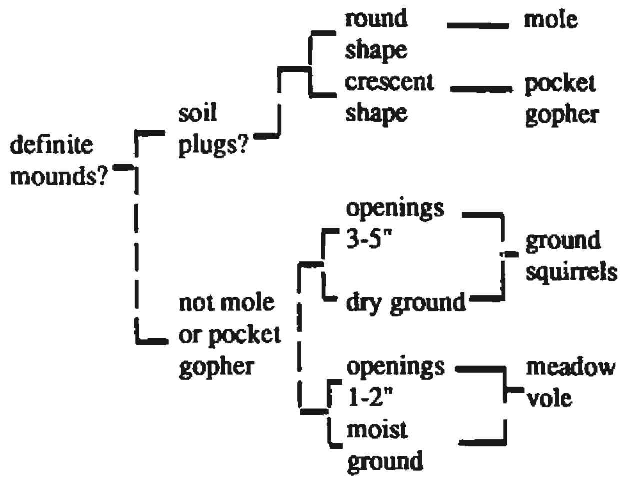

Fig. 1. Simple path diagram to link the facts and the solution.

6. Use an expert system shell to compile the rules and run the session. The expert should be the first "user" of the expert system. All logical paths need to be tested to see if the expert system arrives unfailingly at the correct solutions (Geissman et al 1988). Test the system to see if it reaches the correct conclusion despite a user's uncertain or incomplete response. This step is called verification.

7. Expand the testing by encouraging others in the office to try the expert system. Test their understanding of the questions. If users have trouble supplying the facts, the expert may need to re-examine the problem-solving protocol. Tape recording several phone consultations is often helpful. It is likely that a crucial piece of information or a helpful hint usually mentioned over the phone was inadvertently omitted from the expert system.

8. Once this initial testing phase is concluded, the expert system is ready for validation. Peer review can be conducted by comparing the expert system's performance with the independent conclusions from several experts in the field. Use the expert system to augment curriculum in a training session and evaluate the learning comprehension. Pretend to be a caller with a problem and let the office staff answer the phone and run the expert system. Consider whether the staff reached the same conclusions you would. This review process can be lengthy but it is a necessary component of expert system development. The expert system has to be tested and criticized to become truly "expert."

9. After passing all test and evaluation phases, the expert system is finished and ready to accept a large share of the routine work. The expert is freed to seek new areas of interest and innovation. Ideally, hours invested in the system will be more than offset by a decreased workload in the future.

## SUMMARY

Expert systems technology can give the computer an integral role in routine problem-solving. Expert systems are conceptually easy to understand and the technology is both available and affordable. The example presented here is similar to routine problems faced by other professionals. An expert system can be easily built by the expert following the steps as outlined. With expert systems, computers have found their place in everyday wildlife damage control.

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