CALIFORNIA GROUND SQUIRREL MANAGEMENT SYSTEMS: COMPLEXITY, UNCERTAINTY, AND SURPRISE

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Abstract: California ground squirrel (*Spermophilus beecheyi*) management programs to reduce or prevent damage to agricultural crops and structures require a good deal of information to be effective, maximize benefits, and minimize costs. Analyzing this information can be a complex process. With inputs from many decision-making processes,the potential outcome is often uncertain. In addition, surprise plays an important role when unpredictable factors suddenly become important. We provide examples of California ground squirrel management systems and show how complexity, uncertainty, and surprise interact and lead to management decisions in damage prevention and control programs.

"The key ingredient of integrated pest management is information" (Kendrick 1978:3).

"Decision makers (often politicians) seldom understand - or wish to understand - uncertainty, and scientific advisers are thus expected to proffer simplistic advice in which risks and uncertainty are not clearly delineated" (Clark 1981:398).

"But however intensively and extensively data are collected, however much we know of how the system operates, the domain of our knowledge of specific ecological and social systems is small when compared to that of our ignorance" (Holling 1978:7).

"Ecological systems are dirty, changing, growing, and declining" (Holling 1978:35).

California ground squirrel (*Spermophilus beecheyi*) management, like the management of most kinds of wildlife, requires decisions regarding when and what kind of action is to be taken, and how the action is to be accomplished. In a series of companion papers (Salmon and Schmidt 1984, Schmidt et al. 1985), we discuss many of the management techniques used in preventing ground squirrel damage and outline the important decision-making variables in ground squirrel management. In this paper, we discuss the complexity involved in California ground squirrel management decisions. In addition, we describe how uncertainty and surprise interact with complexity, resulting in the need for an adaptive approach to management.

COMPLEXITY

There is no best method for managing wildlife problems including those caused by California ground squirrels. Decisions about the need for wildlife damage control and selection of methods and materials should be based on a solid understanding of the solutions available (Salmon and Lickliter 1983).

Measures of complexity in ecological and social systems often use as a quantitative measure the number of variables required to adequately describe the dynamic conditions of the system at any moment (Holling 1978). We do not argue that California ground squirrel management systems are more or less complex than other wildlife management systems. We simply recognize the essential character of complexity within ecological and social systems.

UNCERTAINTY

Management systems concerning biological resources are often formulated and conducted under the cloud of uncertainty (Clark 1981). Weather, societal needs, efficacy of control materials, knowledge, hazard potential, damage potential, and agribusiness conflicts are just some of the variables involved in California ground squirrel management which inherently require assignment to a probability distribution (Table 1).

The exact state of nature is seldom known with a high degree of certainty (Holling 1978). This uncertainty must be factored into the ground squirrel decision-making process. For example, probabilistic weather factors which can impact a ground squirrel management program include: temperature, rainfall, soil moisture, wind speed, and both long- and short-term weather patterns (Clark 1975, Salmon and Schmidt 1984). Additional uncertainties associated with a ground squirrel management program are the economics of damage to the specific crop or structure, squirrel population growth rate (with and without control), degree or severity of damage, and variation in type of damage to the crop or structure. As a

Table 1. Some important considerations in a California ground squirrel control program.

Costs, economics materials labor benefit:cost direct, indirect costs monitoring application societal needs	Restrictions, materials availability money training required efficacy ease of application placing restrictions
Timing, scheduling conflict with other agronomic practices soil conditions	Biology seasonal activity of squirrels food habits food preferences population size population potential dispersal
Resource availability time money labor materials knowledge	Hazards human livestock pets wildlife - game species wildlife - nongame species long-term, short-term permits training risk assessment persistence damage potential
History past experiences experience, training bait-shyness efficacy	

result, the decision-maker is faced with uncertainty about what will happen if the squirrels are (or are not) controlled.

Weather is a classic example of an uncertain variable. However, historical records enable forecasters to estimate a probability distribution for many gross weather variables, including chance of precipitation, high and low temperature, and wind speed. The accuracy of these predictions can influence control program decisions and results. If we are planning to distribute anticoagulant toxicants in a broadcast manner (spread evenly over infested areas), a 7-10 day period of little or no precipitation during the season of peak activity is needed. In some areas of California, it is difficult, sometimes impossible, to pick a period of time when this is sure to happen. Fortunately, many areas have clear-cut wet and dry seasons, making control decisions impacted by precipitation more straightforward. Even in dry areas however, weather has uncertain effects. Temperature can influence bait acceptance and squirrel activity. Soil moisture will determine the feasibility of using fumigants and wind speed can determine the feasibility of broadcasting baits by mechanical means (Clark 1975).

Similarly, damage can be considered an uncertain variable. The economics of damage and control is dependent upon many factors. To predict damage, squirrel population levels need to be forecasted. The estimated invasion rate and damage potential also need to be assessed.

All of this means that the issue of uncertainty must be recognized when control programs are planned, conducted, and evaluated. More complex systems are assumed to have the potential for greater uncertainty; however, it would be untrue to state that a simple system has little or no uncertainty. Certainty of uncertainty is the key management consideration.

SURPRISE

There are many instances when unanticipated situations add an element of surprise to a wildlife control plan. A common control program, in use for many years without problems, may suddenly elicit a response from the public which stops or modifies the program. A bizarre non-target kill, the result of an unusual combination of events, may bring down the regulatory roof, resulting in major adjustments or cancellation of a control program. Sudden loss of bait acceptance may enable squirrel populations to increase rapidly before other control measures can be implemented, resulting in unacceptable damage. Finally, our lack of knowledge regarding the connectedness within ecological systems of the various components is destined to bring us surprise.

A recent field test demonstrated to us how surprise can affect a control program. In 1984 we conducted a squirrel control operation along a levee in Solano County, California. This test was designed to evaluate the cost and effectiveness of several control materials during mid-summer, a time known to be less than ideal, but yet commonly used for control. We completed our tests and began making plans for a more thorough control operation in 1985. When it was time to begin this expanded control operation, we discovered that many farmers had planted wheat fields adjacent to the levees. In fact, wheat planting was at the highest level in 10 years. Because of this, local authorities would not burn the levees (normally an annual event) because of the fire hazard to adjacent fields. The resulting dense weed cover on the levees prevented us from locating burrow openings for spot bait treatment. Economics and potential non-target hazards prevented us from blanket broadcasting bait over the levee. The unpredicted occurrence of extensive wheat plantings conflicted with our plans for this local management program. It was, in our terminology, a surprise that impacted our ability to conduct a squirrel control program.

Larger scale examples of this in wildlife and fisheries management are well known, including such famous cases as the collapse of 7 commercial fisheries in each of the Great Lakes (Holling 1978) and a not-so-famous case involving logging in California and the subsequent lack of regeneration because of uncontrolled pocket gopher (*Thomomys* spp.) populations and the economic and ecological consequences thereof. This idea of alternative stable states of ecological systems is not new (Holling 1978). Because these events happen as surprise, it is impossible to plan for specific events. However, an approach involving adaptive management (Holling 1978), or the ability to work with a management scheme that can adapt to changing conditions, can make the best of a given ecological situation.

MANAGEMENT IMPLICATIONS

The purpose of this paper is not to discourage the reader into thinking that it is useless to attempt to manage ecological systems. Indeed, most ecological systems are managed. What should be obvious is that management programs which depend on limited management options are frequently doomed to failure, at least as totally sufficient programs. This is certainly the case with many rodent control programs (Salmon and Lickliter 1983). Because of the uncertainty, wildlife managers need a number of control alternatives. This enables a decision-maker to choose the most appropriate management decision for each particular situation. It also allows another technique to be chosen should conditions warrant or the first management scheme begin to fail.

Unfortunately, in dealing with wildlife damage control, the number of management alternatives continues to dwindle with little effort to find alternatives (EPA 1985). As the number of management options decline, we should expect difficulty in maintaining optimum ground squirrel management programs. Chance events dominate some ecosystems, but the unexpected can be expected. This adaptive approach is healthy and essential. Complexity, uncertainty, and surprise are to be expected. The successful manager realizes this and makes management decisions accordingly. Ground squirrel management is not compatible with *laissez faire* approaches.

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