IV.8 Recognizing and Managing Potential Outbreak Conditions

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Introduction

An outbreak is defined ecologically as an "explosive increase in the abundance of a particular species that occurs over a relatively short period of time" (Berryman 1987). There is no doubt that certain grasshopper species in Western U.S. rangelands occasionally experience an outbreak and assume pest status, but most species do not exhibit outbreaks. Most species increase only slightly while the pest grasshopper species increase dramatically (Joern and Gaines 1990).

Identifying this rapid and dramatic increase in grasshopper numbers when it occurs is an easy task after the fact by examining regular surveys of grasshopper densities that are part of monitoring programs. However, surveys do not give pest managers the ability to predict the conditions that produce outbreaks. Understanding the ecological processes and events that produce these outbreaks is necessary for pest managers to be able to forecast outbreak events and design better management strategies.

Ecological Explanations for Outbreaks

To date, pest managers have sought simple ecological explanations in attempts to predict when outbreaks will occur in the future based upon past environmental events, such as last year's temperatures and precipitation. For example, Joern and Gaines (1990) have found research that associates warm, dry springs with grasshopper outbreaks on northern rangelands but cool, wet springs with outbreaks on southern rangelands.

Even when the above weather relationships are observed, they never explain more than 25 percent of the observed variation in grasshopper numbers between years. This explanation is not very powerful scientifically or very useful for management. Nonetheless, these correlations have been widely used to infer that density-independent factors affect mortality (the proportion dying does not vary with the population's density) because weather is independent of density, and that weather determines grasshopper population outbreaks in Western U.S. rangelands. The existence of an association between weather and grasshopper numbers is undeniable, but the interpretation of this association does not indicate that a straightforward implication of density-independent control of grasshoppers may be part of the association.

A simple analogy will help to illustrate this point. A house's temperature may be controlled by a thermostat-controlled furnace and air conditioner, but the temperature may still fluctuate with outside temperatures. Does this mean that the house's temperature is set by weather? No, the average inside temperature is set by the furnace and air conditioner, but fluctuations are created by weather. The thermostat-controlled furnace and air conditioner are equivalent to density-dependent factors operating on a population (the proportion dying or reproduction per individual varies with density) because the furnace and air conditioner adjust to changes in both the inside and outside temperatures.

Likewise, weather could be producing density-independent effects on the population and these could cause the population to increase or decrease, but the average population size could be set by density-dependent factors, such as food abundance and predation (Horn 1968). Another possibility is that the average population size is not constant but varies with weather (the equivalent of raising and lowering the thermostat as the outside temperature gets colder and warmer). For example, weather might influence food abundance, vulnerability to predators and parasitoids, or susceptibility to disease (Capinera 1987, Joern and Gaines 1990), factors that may create density-dependent effects. Therefore, the occurrence of population fluctuations because of weather does not imply that populations are controlled by weather or that density-independent factors are most important. The reliance of managers on the above weather relationships to predict outbreaks and the willingness of scientists to attribute population changes to density-independent mortality have kept our understanding of grasshopper populations in its infancy. Answers to these questions are largely unresolved (see VII.14—Grasshopper Population Regulation) but critical for designing when and how to manage grasshoppers.

Outbreak Patterns

If pest managers do not understand the ecological processes that control grasshopper populations, it becomes difficult to explain why certain populations exhibit outbreaks and how outbreaks develop. With information derived largely from studies of forest and agricultural insect pests, Berryman (1987) categorized insect outbreaks as being eruptive or gradient.

Eruptive Outbreaks.—These outbreaks occur when favorable conditions (such as less stressful weather, abundant food, and lack of predators) at a site permit the population to increase and the additional individuals move out to supplement populations at other sites. These additional individuals create the outbreak at the other sites or enable the populations at these other sites to "escape" the factors, such as predation, that have been keeping densities low. Sites producing surplus individuals are called "sources" or "hot-spots" and sites being supplemented, "sinks" (Pulliam 1988).

Gradient Outbreaks.—These outbreaks are restricted to sites with favorable conditions. Eruptive outbreaks spread over a region and require "hot-spot epicenters" to generate the outbreak, while a widespread outbreak that is gradient in nature requires widespread favorable conditions, such as common weather patterns favorable to a particular insect species.

Resolving whether grasshopper outbreaks are eruptive or gradient requires knowledge about the factors that control grasshopper populations at each site and the dispersal of individuals between populations in the landscape. If pest managers do not understand the factors controlling a single population, they will not be able to answer the issue of gradient versus eruptive, which requires knowledge about several populations. In addition, because the management of grass-hoppers in Western U.S. rangelands involves many species of grasshoppers and a variety of habitats, it is possible that some species and habitats exhibit eruptive outbreaks while others exhibit gradient outbreaks.

Without information on what controls the grasshopper populations that a pest manager is being asked to manage, how can the manager forecast outbreaks, allocate monitoring efforts to populations more prone to outbreak, and design better management strategies to prevent or suppress outbreaks? For example, a manager can prevent eruptive outbreaks by preemptive strikes against hot-spots, but a manager can respond to a gradient outbreak only after it has started. While progress is being made in understanding grasshopper population dynamics (see VII.14), scientists can seldom answer these types of issues with their current knowledge.

Broader Ecological and Economic Considerations

In developing control strategies for grasshoppers, managers must base their decisions on more than the density of grasshoppers. The observed grasshopper density must be considered in a broader ecological and economic context:

- the available forage base provided by plants and the potential reduction of this base by current and future grasshopper densities;
- the economic value of the forage base lost to grasshoppers;
- the economic cost of controlling grasshoppers; and
- the ecological mechanisms that may be controlling grasshopper numbers, and how control efforts might change these mechanisms and future grasshopper densities.

The Grasshopper Integrated Pest Management (GHIPM) Project has demonstrated that reference to a single grasshopper density, such as greater than 13/yd^2 (16/m^2), as constituting outbreak conditions is no longer adequate: density must be assessed in its ecological and economic context. This complexity is being considered in a very simple way by Hopper, the expert system decision-support tool developed by GHIPM. A set of simple examples illustrates this point.

Low Grasshopper Densities.—At densities below 6/yd^2 (8/m^2) grasshoppers can cause considerable damage to the forage base (up to 70 percent loss). High levels of damage occur if the forage base has low potential abundance (low biomass) and/or has low productivity (low regrowth) (Holmes et al. 1979). Such a forage base may be marginal for livestock production and may not be economically practical to protect. In these instances, control may not be warranted from a market perspective (Davis et al. 1992). However, individual ranchers may well call for control if any economic loss makes their ranching operations unprofitable, especially when grasshopper control costs are subsidized by State and Federal agencies.

Pest managers need to consider more than the economic value of lost forage production or the outcry of individual ranchers. Grasshopper control might provide short-term relief but worsen future problems in these environments. From GHIPM findings (see VII.14), it appears that grasshopper populations in these environments have a high potential for being limited by natural enemies. Pesticide applications that reduce grasshopper numbers could also reduce natural enemy numbers directly by outright poisoning of the invertebrate natural enemies, or indirectly by lowering the numbers of vertebrate predators as their invertebrate prey are reduced (Belovsky 1992 unpubl.). Therefore, the ultimate result of control efforts could be an increase in grasshopper numbers for the future, as they are released from the control of natural enemies.

In this kind of environment, grasshopper monitoring and control may not be warranted, except from a political/ social mandate. But while these populations may not warrant further attention for management, they may deserve scientific attention. Understanding grasshopper population dynamics under low-density conditions can help explain population dynamics under other conditions where management may be necessary and can aid in the development of management strategies that create populations that do not cause appreciable economic damage. These conditions may represent populations that only outbreak infrequently, when conditions are unusual.

High Grasshopper Densities.—At densities above 13/yd^2, grasshoppers can cause damage to the forage base, even if it is abundant (high biomass) and/or has high productivity (Holmes et al. 1979). This damage may approach 20 percent; however, because of the forage's high abundance and/or productivity, it might still be economically very valuable for livestock production and economically practical to protect despite the low percentage of damage.

Even though in these instances control may be warranted from a market perspective, individual ranchers have some alternatives that may be more cost effective than grasshopper control. These alternatives could include making up for forage losses to grasshoppers by feeding hay to cattle or leasing additional rangeland (Davis et al. 1992). Such alternatives are especially more attractive in scenarios where grasshopper control costs are not subsidized by State or Federal agencies.

From GHIPM findings (VII.14), it appears that grasshopper populations on productive rangelands have a high potential for being limited by food. Control efforts may be frequently warranted in these environments to reduce grasshopper numbers and consumption of forage. Because of the chronic nature of these outbreaks, monitoring efforts may not have to be widespread. These are the circumstances where long-term management strategies that suppress grasshopper populations without repeated application of pesticides (such as habitat manipulation) can be most useful and need to be developed. These conditions can represent populations that serve as hot-spot epicenters from which eruptive outbreaks emerge, and therefore, may deserve special attention for the study of their grasshopper populations.

Intermediate to High Grasshopper Densities.—At densities more than 6/yd^2 but less than 13/yd^2, grasshoppers can cause damage to the forage resource, depending upon its abundance (biomass) and/or productivity. Populations with such densities may demonstrate dynamics that are intermediate to those described above, reflecting natural enemy- or food-limitation in different years (VII.14), and may be the most common circumstance in Western U.S. rangelands.

Given the variability of these populations from year to year, it may not be easy to assess the economic feasibility of control because control may be economically warranted in some outbreak years but not others. When conditions approach those of low densities/low forage, control may be unwarranted; when conditions approach those of high densities/high forage, it may be warranted. Therefore, intermediate populations require very careful monitoring to detect population trends and changes in the forage resource. These situations also demand greater flexibility by managers in developing control strategies that match the varying conditions. Relying on chemical control when populations are food-limited could reduce the numbers of natural enemies and worsen the outbreaks in years when natural enemies would otherwise maintain the grasshoppers at low densities (see above).

From the simple set of scenarios developed above, it is apparent that grasshopper management is neither simple nor straightforward. This job is further complicated when you consider the tradeoff between controlling the negative effects of grasshopper outbreaks versus potential beneficial effects that grasshoppers may produce, such as weed control and nutrient cycling (see VII.16).

Like so many natural resource management issues, the more people begin to understand the dynamics of the ecological processes that they are trying to manipulate, the more difficult the problem becomes to solve. First, we find that traditional perspectives on management are not always appropriate from an ecological and/or economic perspective. Second, we see that new management alternatives that may be more complicated to develop and apply are better suited to help in dealing with the problem. While investigators are still scientifically deciphering grasshopper outbreaks (VII.14), GHIPM's expert system Hopper brings together many of these new findings to aid pest managers in recognizing outbreak conditions, when it may be feasible to control these outbreaks, and how these outbreaks may be most effectively and economically managed.

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