II.10 Treating Localized Hot-Spots of Rangeland Grasshoppers: A Preventative Strategy With Promise

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The Problem

In most years, and in most locations, most grasshopper species are innocuous or even beneficial to grassland ecosystems, but large-scale outbreaks can inflict serious economic damage to western rangelands. Figure II.10–1 illustrates the duration of grasshopper outbreaks in Wyoming. Some areas show grasshopper activity for up to 20 of the last 50 years. Although the grasshopper population on a broad scale collapsed across the Western United States in 1988–89 and has remained low through 1994, historical records suggest that the population is likely to resurge in this decade (fig. II.10–2).

Current economic conditions and mounting environmental concerns strongly suggest that the massive grasshopper treatment programs of the past 40 years will not be repeated. Therefore, economically viable, environmentally sound alternatives need to be found in the immediate future.

A Solution?

Scientists' understanding of North American rangeland grasshopper outbreaks is in its infancy. According to Alan Berryman's outbreak theory (1987), insect outbreaks take one of two forms, and the form of an outbreak is critical to pest management.

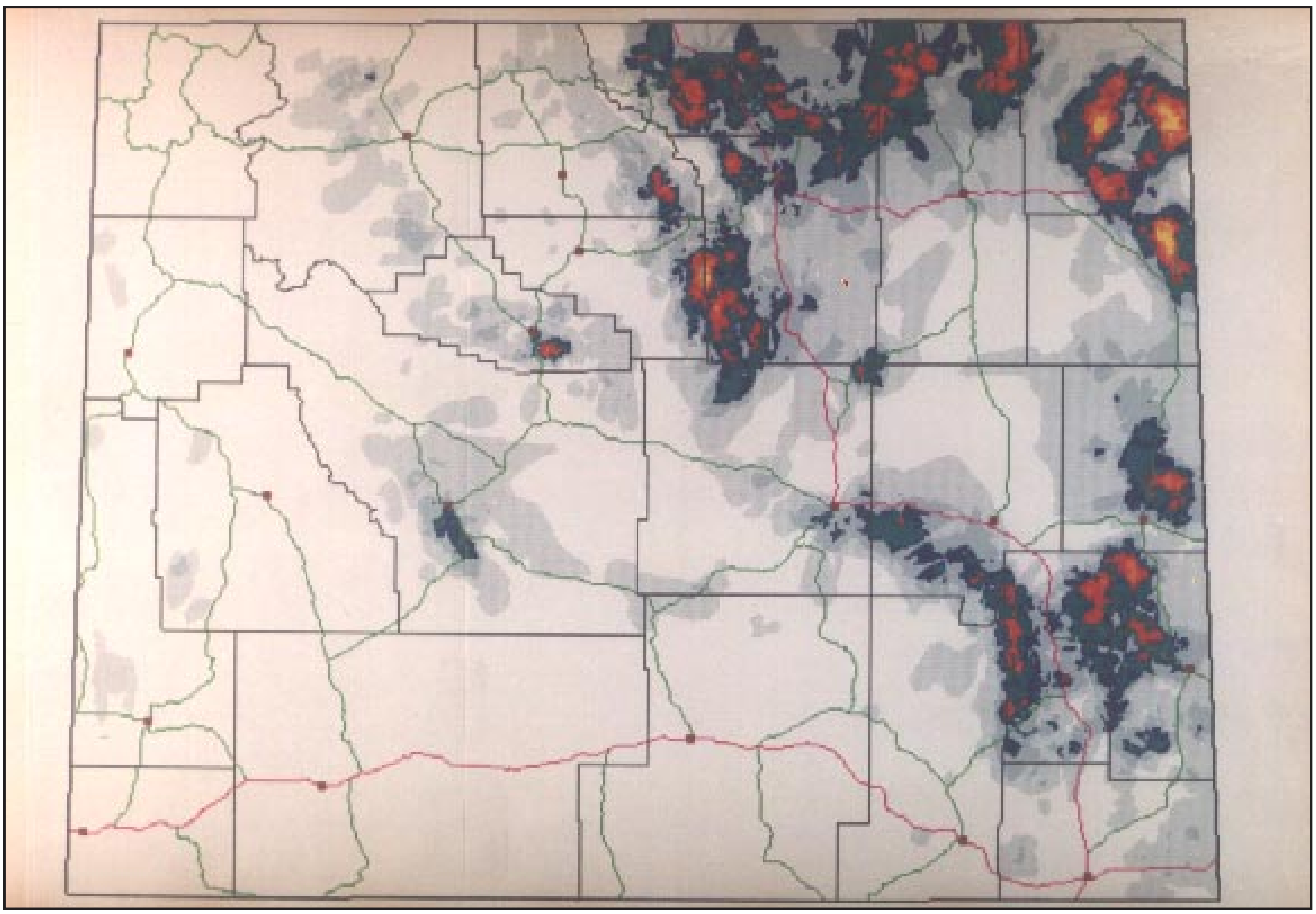

Figure II.10–1—Spatial distribution of rangeland grasshopper outbreaks in Wyoming from 1944 to 1993 (white = no infestations, light gray = 1–2 yr infested, gray = 3–4 yr infested, black = 5–6 yr infested, bluish green = 7–8 yr infested, blue = 9–10 yr infested, red = 11–12 yr infested, orange = 13–14 yr infested, and yellow = 15–20 yr infested). Interstate highways are magenta, and main State roads are yellow-green. County borders are in black, and county seats are brown squares.

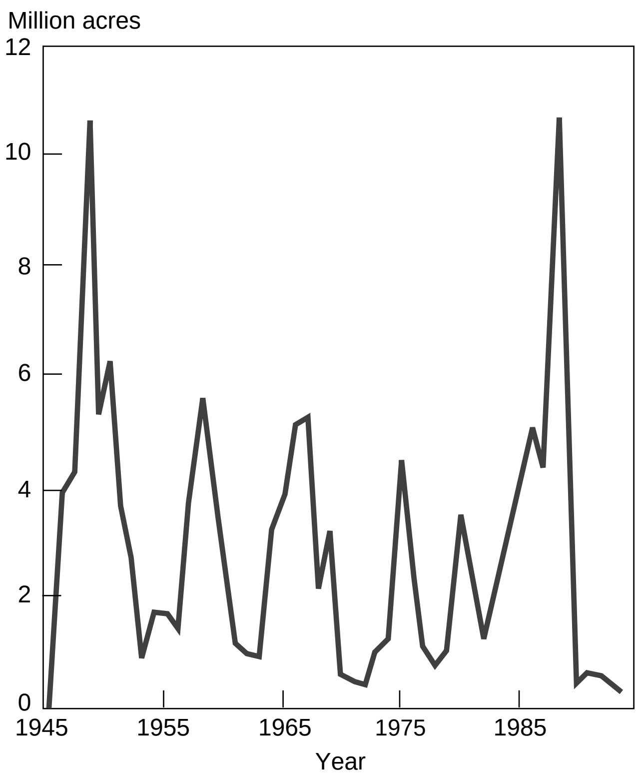

Figure II.10–2—History of rangeland grasshopper outbreaks in Wyoming. Note the erratic pattern of infestation (>8 grasshoppers/ yd^2), including the massive outbreak in 1987 and the remarkably low area of infestation since 1989.

The first is the eruptive outbreak, characterized as starting from a “hot-spot” that expands through a self-perpetuating process to encompass increasingly large areas. This type of outbreak occurs with the mountain pine beetle and the gypsy moth. With eruptive dynamics, large-scale outbreaks can be prevented if the hot-spots are controlled. This strategy is analogous to suppressing small fires caused by lightning strikes to prevent large-scale forest fires. The treatment of hot-spots from which outbreaks arise has been an effective tool in the management of several pests of natural and agricultural resources, including African locusts. Indeed, it appears that the extinction of the Rocky Mountain locust was the consequence of agricultural practices having effectively (albeit unwittingly) destroyed through cultivation of soils the highly localized eruptive foci of this species in the 1800’s.

The second form of outbreak dynamics is termed “gradient.” Gradient outbreaks occur when pest populations fluctuate over broad areas in response to external conditions, without growth from a local hot-spot. This type of outbreak is seen in forest insects, such as many cone and seed insects, some defoliators, and “nonaggressive” bark beetles. If gradient dynamics lie at the heart of grasshopper outbreaks, then little can be done with respect to prevention. By analogy, local, tactical actions will not prevent droughts.

Over the last several years, the hot-spot treatment strategy has been studied in Wyoming through the collaborative efforts of the University of Wyoming and the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Grasshopper Integrated Pest Management Project (Lockwood and Schell, in press). In the context of traditional APHIS operations, Lockwood and Schell defined a hot-spot as an area of less than 10,000 acres of rangeland infested with at least 8 grasshoppers/yd^2. Although the results of this experiment are not yet definitive, the investigators believe that continuing, long-term studies of grasshopper population dynamics will eventually clarify the process of outbreak formation. At present, there is sufficient information to provide some preliminary insights and recommendations.

Current Knowledge

Evidence for Eruptive Dynamics.—There are four lines of evidence that support the process of an eruptive outbreak dynamic. First, the existence of highly localized infestations is a necessary precursor to an eruptive outbreak. The discovery of numerous hot-spots (table II.10–1, fig. II.10–3), from which larger areas could become colonized, suggests the potential for eruptive dynamics. Although they are a necessary condition for eruptive dynamics, the existence of these hot-spots cannot be considered sufficient evidence of this outbreak form.

Next, the observation that two of the nine hot-spots for which there are data over at least 2 yr sustained or expanded with time demonstrates that these infestations can give rise to larger outbreaks (table II.10–1).

Although only one hot-spot developed into an outbreak, it should be noted that eruptive dynamics do not require that all or most of the hot-spots give rise to large-scale outbreaks. By analogy, very few lightning strikes result in major forest fires.

Third, no continued outbreak was found in the areas around hot-spots treated with insecticides (table II.10–1). If outbreaks were gradient, then treating a localized site should simply result in a "hole" in a larger region of high densities.

Finally, it appears that at least one grasshopper species (the bigheaded grasshopper, *Aulocara elliotti)* has high rates of reproduction at both very low densities and moderately high densities. This "bimodal" reproductive feature is necessary for the self-perpetuating dynamics of an eruptive outbreak.

Evidence for Gradient Dynamics.—The possibility of gradient outbreaks is supported by four lines of evidence. First, two large-scale outbreaks (greater than 15,000 acres) were found that were apparently not preceded by a hot-spot (table II.10–1). One might argue that these areas were simply very large hot-spots, but there was no evidence of continued expansion (there were no topographic or other features limiting expansion in all directions), as would be expected from eruptive dynamics.

Next, seven out of nine documented hot-spots for which at least 2 yr of data exists disappeared the season after their discovery, even without treatment (table II.10–1). This finding suggests that expansion of hot-spots into eruptive outbreaks is not common. But as with forest fires, sometimes it only takes one lightning strike to cause major destruction.

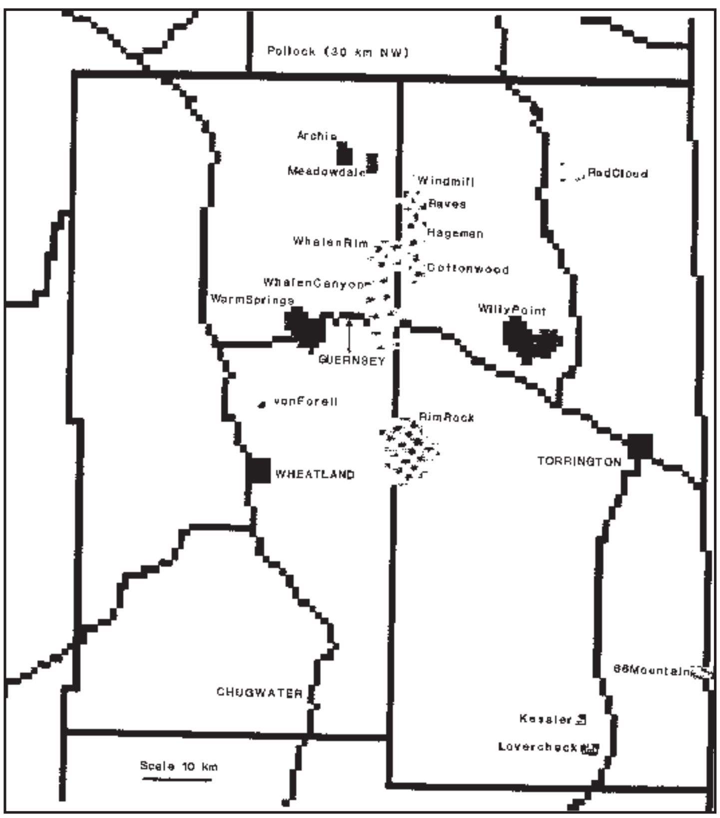

Figure II.10–3—Locations of hot-spots in Platte and Goshen counties in southeastern Wyoming (light shading = 1990, moderate shading = 1991, black shading = 1992). Hot-spots and outbreaks reduced to <10,000 acres are labelled with upper- and lower-case letters; weather stations are labelled in upper-case letters.

Table II.10–1—Dynamics of control (untreated) and treated grasshopper hot-spots and outbreaks in southeastern Wyoming

Site	Category	Status	1990	1991	1992	1993
			Area			
			Acres			
Rave	Hot-spot	Untreated	500	0	0	0
vonForell	Hot-spot	Untreated	500	0	0	0
Red Cloud	Hot-spot	Untreated	1,900	0	0	0
Whalen Canyon	Hot-spot	Untreated	7,920	10,340	1,460	0
Hageman	Hot-spot	Treated	2,140	0	0	0
Pollock	Hot-spot	Treated	2,400	0	0	0
Willy Point	Outbreak	Untreated	38,880	34,080	9,430	4,960
Kessler	Hot-spot	Untreated	0	[1]170	0	0
66 mountain	Hot-spot	Untreated	0	[1]790	0	0
Lovercheck	Hot-spot	Untreated	0	[1]240	0	0
Cottonwood	Hot-spot	Untreated	0	790	0	0
Windmill	Hot-spot	Untreated	0	1,340	1,370	0
Whalen Rim	Hot-spot	Treated	0	1,150	0	0
Rim Rock	Outbreak	Untreated	0	17,760	9,310	[2]0
Archie	Hot-spot	Untreated	0	0	460	0
Warmsprings	Hot-spot	Untreated	0	0	5,380	3,840
Meadowdale	Hot-spot	Treated	0	0	1,030	0
Table Mt.	Outbreak	Untreated	0	0	18,530	2,400
Kincaid Draw	Hot-spot	Untreated	0	0	0	640

[1] Hot-spot collapsed during heavy spring rains in 1991.
[2] Hot-spot collapsed during heavy summer rains in 1993.

Third, the species composition of a hot-spot can change dramatically between years—a discovery that suggests that dominant species may be tracking available resources. For example, a species that prefers needle grasses, *Amphitornus coloradus*, comprised only 2 percent of the hot-spot communities in a dry year (when needle grasses were sparse) but comprised 16 percent in a wet year (when needle grasses were abundant). This resource-tracking phenomenon is consistent with gradient outbreak dynamics.

Finally, most hot-spots have unique soil and topographic properties, compared to adjacent lands. Hot-spots generally occur in foothills with relatively poor soils. Thus, it appears that external factors (rather than a self-perpetuating process) give rise to these localized infestations.

A Hybrid Case?

The evidence regarding the processes that give rise to large-scale outbreaks supports both gradient and eruptive dynamics. This continuing ambiguity calls into question the viability of the current outbreak theory. Unfortunately, the matter becomes more complex as a function of spatial scale.

The scale of resolution used in our study was derived from the management needs of USDA; cooperative programs with APHIS are standardly triggered once a grasshopper outbreak exceeds 10,000 acres. Perhaps the populations examined at finer or coarser resolutions are regulated by different processes and exhibit unique dynamics. Additionally, the rate of change in the density, area, and species composition of an infestation may be related to its size; small infestations may include fewer species and change more rapidly than large outbreaks.

Indeed, such differences in the rates of change may be seen within the size range of hot-spots. For example, small hot-spots may be more susceptible to suppression by mobile predators (a 25-acre infestation of *Camnula pellucida* was eliminated by the immigration and feeding of starlings over a 2-wk period). We found that no hot-spot less than 1,200 acres persisted for more than a single year, and the only hot-spot to increase in size began at 8,000 acres.

As scientists continue to investigate the outbreak dynamics of rangeland grasshoppers, it may be important to consider the possibility that the population dynamics of these insects cannot be effectively classified using the existing theory. This theory was developed based primarily on forest pests, and there are potentially important ecological differences between forest and rangeland pest outbreaks. For example, forest pest outbreaks often involve a single insect species feeding on a single tree species, while rangeland grasshopper outbreaks often involve 10 or more species feeding on dozens of plant species. Given the complexity of rangeland grasshopper communities, it is possible that some species have eruptive potential while others exhibit gradient dynamics.

Management Practices

Although there is uncertainty about the outbreak dynamics of rangeland grasshoppers, some management strategies can be inferred from existing data. Available evidence provides some insights regarding survey strategies, treatment tactics, and programmatic obstacles with respect to a hot-spot management program. However, it should be kept in mind that these inferences are derived from work conducted in southeastern Wyoming from 1990 to 1993, and grasshopper population dynamics may be different in other times and regions.

Hot-Spot Detection

We believe that four approaches may be useful in improving the efficiency of searching for localized hot-spots. First, hot-spots are most likely to occur in areas of historically chronic infestations (figs. II.10–3 and –4). Historical maps of grasshopper outbreaks may provide vital clues as to the areas in which survey efforts should be concentrated. Unfortunately, there does not appear to be a single, consistent outbreak species on which to focus attention. The species composition of hot-spots varies dramatically between sites and years. Slantfaced grasshoppers are the most common species in hot-spots of southeastern Wyoming (especially *Ageneotettix deorum, Amphitornus coloradus, Aulocara elliotti,* and *Cordillacris* spp.). However, we also have found hot-spots dominated by spurthroated and bandwinged species *(Melanoplus sanguinipes* and *Trachyrhachys kiowa,* respectively).

Next, several features of ecosystems and habitats are associated with hot-spots. Hot-spots generally occur in foothills, the areas of transition between mountains and plains. Areas with 8 to 10 in of annual precipitation also appear to be most likely to support hot-spots. At a finer scale, hot-spots are clearly associated with poorer soils.

Within a region, soils with relatively low nitrate, phosphate, and potassium should be considered prime candidates for hot-spots. Low salt levels and high clay content may also be associated with grasshopper hot-spots. There do not appear to be substantial differences in the plant communities inside and outside of hot-spots.

Third, hot-spots apparently develop, persist, and occasionally expand during periods of normal to dry weather and collapse with the onset of wet conditions. These phenomena suggest more intense surveys in years with dry conditions.

Finally, landowners and managers need training to survey for grasshoppers. The exclusive use of federally funded scouts for the intensive surveys required to locate hot-spots over large expanses of land is cost prohibitive. With materials in this handbook, land users can take an active role in pest management, thereby allowing site-specific strategies to be effective. Along with training, systems need to be developed for the coordinated communication of potential hot-spots to APHIS and local pest-management authorities.

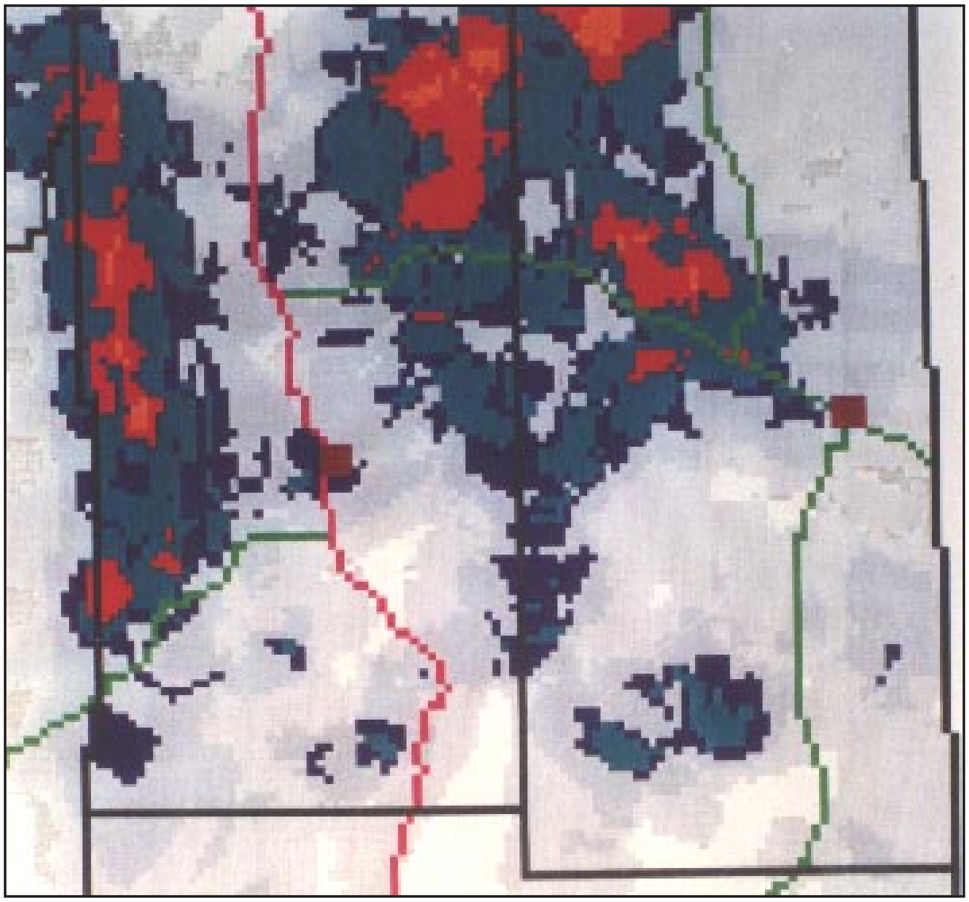

Figure II.10–4—Expanded view of southeastern Wyoming from 1960 through 1993 (Platte and Goshen counties; see figure II.10–1 for spatial reference; white = no infestations, light shading = 1–2 yr infested, dark shading = 3–4 yr infested, purple = 5 yr infested, green = 6–7 yr infested, red = 8–9 yr infested, orange = 10–11 yr infested, and yellow = 12–15 yr infested).

Treatment Strategies

With regard to the tactics of treating hot-spots for the purpose of preventing larger scale infestations, three elements bear consideration. First, it appears that most hot-spots collapse without treatment. In particular, hot-spots of less than 1,000 acres have not been found to persist or expand with time. So these areas should probably not be treated, although it may be prudent to monitor them.

Second, the annual expansion of persistent hot-spots is relatively limited, with a documented maximum of 30 percent, although the rate of expansion could be greater prior to a large-scale outbreak. Given the documented rates and likelihoods of expansion, it would appear that no hot-spot should be treated in the year of discovery. Only if the infestation persists into the subsequent year should treatment be considered.

Finally, the benefits of small-scale insecticide treatments with respect to the preservation of beneficial arthropods may potentially offset the relatively higher costs per acre of hot-spot treatments. With regard to beneficial insects, treating small areas reduces the number of beneficial insects killed by insecticides and increases the recolonization rate. These beneficial organisms may be responsible for the sustained suppression of a hot-spot after treatment. Given that the inadvertent, large-scale suppression of beneficial arthropods through the use of broad-spectrum liquid insecticides has been found to aggravate grasshopper outbreak dynamics in Wyoming (Lockwood et al. 1988), the benefits of small-scale treatments are potentially substantial.

Obstacles to Implementation

The implementation of a hot-spot program is confounded by four obvious obstacles: the Federal cost-share program, the requisite sampling intensity, the "principle of the commons," and the current state of knowledge. Fortunately, all of these problems have potential solutions.

First, the Federal cost-share program discourages preventive practices and local survey efforts and encourages large-scale treatments by triggering APHIS involvement when outbreaks exceed 10,000 acres. For the treatment of hot-spots to become an accepted grasshopper management strategy, the cost-share formula must reward participants in small-scale programs. In its most simple form, such a cost-share formula could be inversely proportional to the number of acres infested, so that the Federal cost-share would increase as the number of infested acres decreases:

$$\text{Federal cost-share proportion} = \frac{1}{\text{thousand infested acres}}$$

For example, a treatment of 10,000 acres would result in a 10-percent Federal cost-share (1/10 = 0.10 = 10 percent), while a treatment of 2,000 acres would result in a 50-percent Federal subsidy (1/2 = 0.50 = 50 percent).

Second, the intensity of survey necessary to discover the relatively small areas of infestation that constitute hot-spots effectively precludes such a program being conducted solely by USDA/APHIS. Adequately surveying Platte and Goshen counties in Wyoming required the equivalent of six full-time field scouts in May and June of each survey year. This dedication of personnel is not viable for even the high-risk rangelands, let alone for the entire West. Ranchers and land managers must become active participants in a coordinated survey effort for a hot-spot program to be a viable management strategy. Again, a cost-share formula that rewards local participation or at least does not discourage such activity would be beneficial.

Third, the principle of the commons (derived from European grazing practices) suggests that people generally act to maximize their individual gains when given access to a common or collective resource. In terms of a hot-spot program, there is a potential conflict between individual and collective interests.

Because hot-spots are not uniformly distributed and treating a hot-spot potentially protects and benefits adjacent lands from future damage, this strategy tends to individualize the costs and collectivize the benefits. One solution to this problem is to collectivize the costs, perhaps through the formation or utilization of grazing and pest-management districts in order to support the higher short-term costs of survey and treatment in a hot-spot program.

Fourth, not enough long-term data have been gathered to provide a definitive answer to the viability of the hot-spot strategy. Current field data are not adequate to determine the population ecology of most rangeland grasshopper species, and existing information can be used to support aspects of both eruptive and gradient dynamics.

Summary

The Western United States has been in an interoutbreak period since 1987, so the processes leading to the extreme infestations (such as 50,000 acres) associated with the major outbreak periods have yet to be observed. With continued tracking of rangeland grasshopper dynamics, investigators may be able to determine the feasibility of a preventive approach to grasshopper outbreaks. For now, local experiments with this strategy should be encouraged as a means of confirming the usefulness of hot-spot programs across different rangeland systems.

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