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# A Rangeland Grasshopper Insurance Program

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The incidence of benefits and costs from controlling rangeland grasshoppers on public grazing lands poses problems of economic efficiency and distributional equity. Public grasshopper control programs operate like public disaster assistance. However, grasshopper infestations are an insurable risk. This article proposes a rangeland grasshopper insurance program which reduces the economic inefficiencies and distributional inequities of the existing program.

*Key words*: economic efficiency, equity, grasshoppers, insurance, public programs, rangeland

## Introduction

Since the devastating outbreak of migratory grasshoppers in the 1930s, the U.S. Department of Agriculture (USDA) has been involved with controlling grasshopper and Mormon cricket infestations on public rangelands. The Animal and Plant Health Inspection Service (APHIS) cooperative management programs were established by the Incipient and Emergency Control of Pests Act of 1937 and have continued through a succession of legislation, including the Food, Agriculture, Conservation and Trade Act of 1990. Direct involvement of APHIS is limited to public rangelands along with intermingled private lands and/or the treatment of grasshoppers on public rangelands that pose a threat to adjacent crops. The agency also offers technical assistance to state agencies and private individuals on control of grasshoppers on croplands (USDA 1987).

This article addresses problems regarding the incidence of benefits and costs which are inherent in the current rangeland grasshopper control program. The economic inefficiency and distributional inequities present in the existing program are demonstrated. A rangeland grasshopper insurance program is proposed to reduce the inefficiencies and inequities of the current program.

Rangeland reform and proposed reductions in federal agricultural and resource protection programs require rejustification of all public expenditures. Programs must not only be cost-effective, but they must also be justified as being in the public interest. The continuation of grasshopper control programs has been questioned for economic as well as environmental reasons (USDA 1987).

To date, publically assisted rangeland grasshopper control programs have operated like disaster programs. This article proposes a new method of financing publically assisted rangeland grasshopper control programs. Financing these programs by insurance, as proposed here, will better match program costs to those who benefit from the program.

Inefficiencies and inequities of the existing program are demonstrated by using a decision support system developed by the Grasshopper Integrated Pest Management (GHIPM)

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project (Davis et al.). The decision support system, called Hopper, is a simulation model based on important physical, biological, and economic parameters.

## Public Control Programs

Initial justification for public involvement in grasshopper control programs was based on (*a*) the inability of any one individual to conduct an independently effective control program, (*b*) the lack of cost-effectiveness of collective efforts to control grasshoppers and associated "free-rider" problems, and (*c*) protection of the range and soil resource base from damage and destruction by an infestation of grasshoppers. Rationale for public involvement also included (*d*) the expected prevention of the spread of grasshoppers to other lands in subsequent years (Pfadt and Hardy; Smith; Wakeland). Furthermore, (*e*) during the 1930s grasshoppers warming themselves on railroad tracks actually disrupted commerce and (*f*) likely contributed to the massive dislocation of farmers and ranchers. Some earlier perceived public benefits of grasshopper control are not widely accepted, nor are the threats a serious concern today; however, the potential damage grasshoppers can inflict on a rangeland is still very real. Grasshoppers can damage a range as severely as overgrazing. Range renovation and reclamation costs can be sizable and may require many years to complete. However, an outbreak and decline of a grasshopper population is not predictable; some researchers have applied chaos theory to their incidence (Lockwood and Lockwood).

Even though public benefits were an important part of the historical rationale for public involvement in rangeland grasshopper control programs, current decisions to initiate control programs are based solely on perceived private benefits.

In the early 1930s an economic injury level for grasshopper densities was adopted to help decide when treatments should be applied (Parker). The intervention level of eight grasshoppers per square yard (8 GH/YD$^2$) has been applied for over 50 years.

An average of over two million acres per year have been treated over the past two decades. The most recent major outbreak of grasshoppers occurred in 1985 when almost 14 million acres were treated (table 1). Approximately equal amounts of private and public lands have been treated, primarily in the 17 western states (USDA 1987). Congress appropriates funds to APHIS depending on the expected requirements for grasshopper control.[1] APHIS obligations vary with the proportions of public and private land involved. Thus, APHIS obligations in any one year do not directly correspond to the area treated.

APHIS pays the full cost of treating federal rangelands, one-half of the cost of treating state-owned lands, and one-third of the cost of treating private lands. The cost-sharing arrangement can lead to conflicts.[2] The analysis presented here assumes no state participation in the control program. Since actions to reduce the grasshopper population occur at a relatively small cost to ranchers leasing federal rangelands, they are very sensitive to the presence of grasshoppers. The grasshopper control program philosophy is that when ranchers lease public rangelands, they are, in fact, leasing a given amount of forage. Davis et al. (1992) have shown how the universally applied discrete-choice intervention level of 8 GH/YD$^2$ does not recognize factors important to the economic justification for control

[1]Surveys determine the annual presence of grasshoppers. Unused funds appropriated for treatment are carried over to a subsequent year.

[2]Some states also enter into cost-sharing programs; others do not. If states do participate, they typically pay one-third of the costs. Ranchers in states without cost-sharing arrangements have to bear two-thirds of the treatment costs on private lands.

**Table 1. Acres of Land Treated for Grasshoppers and Morman Crickets and APHIS, USDA Obligations, 1972–91**

| Year | Treated Acres (1,000) | APHIS Obligations ($1,000) |
|---|---|---|
| 1972 | 2,205 | 1,146 |
| 1973 | 3,087 | 2,176 |
| 1974 | 3,000 | 1,563 |
| 1975 | 677 | 988 |
| 1976 | 983 | 2,696 |
| 1977 | 1,408 | 2,003 |
| 1978 | 816 | 1,471 |
| 1979 | 7,200 | 5,469 |
| 1980 | 5,215 | 6,040 |
| 1981 | 1,300 | 3,393 |
| 1982 | 600 | 1,927 |
| 1983 | 0 | 1,613 |
| 1984 | 216 | 1,539 |
| 1985 | 13,800 | 21,700 |
| 1986 | 6,858 | 11,700 |
| 1987 | 1,360 | 3,800 |
| 1988 | 513 | 92 |
| 1989 | 109 | 315 |
| 1990 | 260 | 1,218 |
| 1991 | 200 | 687 |

Source: USDA administrative data, 1992.

programs. If an economic threshold as defined by economists is applied (Stern et al.; Headley), economic justification is shown to depend upon a number of factors including inherent rangeland productivity, precipitation-affected forage output from rangelands, the opportunity cost of forage, and the cost and efficacy of treatments (Davis et al.).

## Welfare Considerations

Public cost-sharing programs pose issues which involve both of the principal tenets of welfare economic analysis: allocative efficiency and distributional equity (Haveman and Weisbrod). Allocative inefficiency exists because of a disassociation between costs and benefits of the control programs between public and private land owners. The costs of grasshopper control on federal grazing land are borne entirely by APHIS, and the costs of control on state lands are shared equally between APHIS and a participating state agency. The rancher incurs no costs for grasshopper abatement on public land. The rancher does become financially involved in the costs of control on private land; then, two-thirds of the control program costs are paid by the rancher, the balance being paid by the public agencies involved.

Distributional equity problems are evident when comparing two ranches with different proportions of public and private land. Ranchers with greater proportions of their total land

base, animal unit months (AUMs), coming from public land have much smaller cost shares than do ranchers with proportionately more private land. Treatments generally occur in blocks, often blocks of 100,000 acres involving ranchers with varied cost shares. While all ranchers benefit from the public program, they share disproportionately in both treatment costs and the benefits they receive.

## Modeling Different Land Ownership Patterns

Hopper links three models to simulate the range forage-grasshopper-ranch system (Davis et al.). One model, RangeMod, simulates range forage in response to a set of physical and biological conditions (Berry and Hanson). A second model, HopMod, is a grasshopper population dynamics model based on the observed responses of alternative species of grasshoppers in rangeland and laboratory environments (Berry, Kemp, and Onsager). Interaction of RangeMod and HopMod provides estimates of forage destruction by grasshoppers. The remaining forage available from a specified grasshopper density and treatment becomes input into the third model component, RanchMod. RanchMod is a linear programming model for a typical ranch in the study area. As less forage is available, RanchMod determines the least-cost alternative source of forage to sustain the livestock herd.

Allocative efficiency and distributional equity principles are illustrated by considering two northern plains ranches with different proportions of public and private land. The ranches are identical in all ways except in their proportions of public land and private land grazing: ranch A has mostly public land and ranch B has mostly private land. The grazing season begins 1 April and continues through 31 December. Either hay feeding or private land grazing sustains the livestock from January through March.

Each ranch has a 480-head cow herd; a complement of bulls and replacement heifers use the same forage resources as the cows. A total of 16,044 acres of grazing land and 300 acres of hay land supports the livestock herd. Each ranch has 502 acres of state grazing land. Ranch A has 12,913 acres of leased federal grazing land and 2,629 acres of private grazing land. Ranch B has only 2,629 acres of leased federal land but has 12,913 acres of private land.

Treatments based on the economic threshold using Hopper compare expected private benefits to the expected total cost of applying a grasshopper treatment. Private benefits are calculated as damages abated (Headley; Davis et al.). The difference in ranch net returns between the treatment and no-treatment case, for a given grasshopper density and treatment alternative, is the measure of damages abated.[3]

### *Distributional Equity*

Given the cost-sharing arrangements of the grasshopper control program, the two ranches with their differing proportions of public-to-private land face markedly different cost shares when the treatments are applied. Shown in figure 1 are the costs to the rancher and state and federal agencies for the most cost effective of the treatments. At a treatment cost of $2.25/acre, total cost to treat the 16,044-acre ranch is $36,099.

[3]Benefit-cost (B/C) ratios of incremental costs and benefits are applied since public land management agencies are familiar with this criterion. In this case, the B/C criteria and net present value criteria are identical. Only current year benefits are evaluated. Between project comparisons are not relevant since the decision is only one of applying or not-applying treatments. Special no-year funds are appropriated for grasshopper control. Cases could arise in which funds available are not sufficient to treat all financially justified (B/C = 1.0) conditions. If allocations must occur, they should attempt to equate the B/C ratios between the various treatment areas.

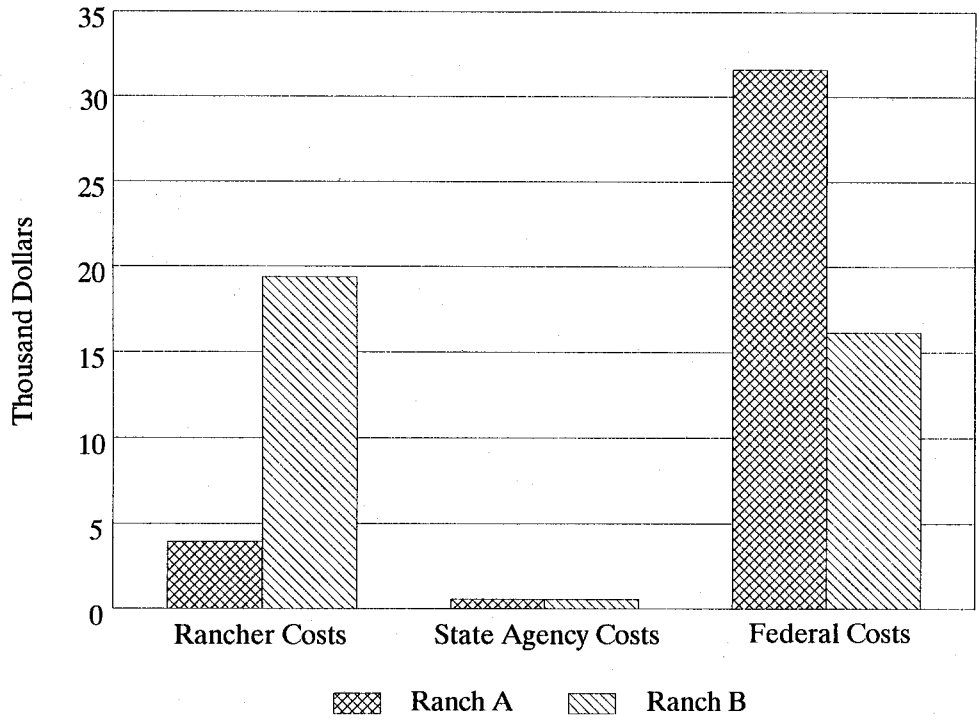


**Figure 1. Share of treatment costs paid by federal and state governments and ranchers for ranches with different proportions of public and private land**

Ranch A pays only $3,944 for treating, which is two-thirds of the cost of treating the 20% private grazing land. The state pays $565, one-half the cost of treating state land, and APHIS pays one-third the cost of treating private land, one-half the cost of treating state land, and all of the treatment cost on federal land, for a total of $31,590.[4]

Ranch B pays $19,369, which is two-thirds of the cost of treating the private land. The state's cost share is the same while the federal cost share is $16,165. Clearly, some distributional inequities are present when two otherwise identical ranches have different proportions of public and private grazing land in their ranch operations.[5]

*Allocative Efficiency*

The federal agency incurs markedly different costs for the two ranches: more public land is present on ranch A, thus, federal agency costs are also much greater. Additionally, the measured private benefits are slightly different. Ranch A has greater direct costs for leasing public land. On ranch B, which has more owned land, higher net returns above direct costs

[4]Environmental conditions often dictate the choice of treatments. One approved biological control is available, *Nosema locustae*. In general, sprays are less costly to apply to large areas, and if physical and biological conditions are right, they are quite efficacious. If environmental conditions permit use, malathion spray is the most cost-effective for the conditions simulated by Davis et al. (1992).

[5]It is possible that a ranch's benefits from publicly supported grasshopper controls could become capitalized into the ranch's value. This would add to the inequity problem. However, a treatment costing $2.85 per acre, recurring, at most, once every five to eight years, would hardly be noticeable in a capitalization evaluation.

are realized due to a much larger private asset base. Damages abated, as measured by private benefits, are slightly greater for ranch B than they are for ranch A since ranch A incurs larger cash costs for leasing more public land.

As seen in figure 1, ranch A will be willing to initiate grasshopper control programs at the density which results in $3,944 of damage. Ranch B would apply controls with a density which produces a damage of $19,369. To offset its costs the federal government would require damages of $31,590 and $16,165 on ranches A and B, respectively. The state has still a different grasshopper density economic threshold.

Existing cost-sharing arrangements make ranchers of both ranch A and B want to apply grasshopper treatments at relatively low densities. The state would also favor applying treatments at relatively low grasshopper densities. The federal agency is expected to initiate controls whenever private benefits are estimated to exceed total treatment costs. Because blocks of acres are treated, the varied ownership proportions are not factored into the treatment decision. Nevertheless, inequities and inefficiencies are inherent.

## Alleged Public Benefits

Public involvement was justified for a number of reasons mentioned above.[6] Though aside from the presence of endangered species which prohibits chemical treatments, the presence of water in the treatment area which limits the choice of chemical treatments, or the existence of commercial bee operations which are removed from treatment sites, public benefits are not recognized by the existing program.

Both knowledge about grasshopper population dynamics and the technology for control have changed since public rangeland grasshopper control programs were initiated during the 1930s. Today, approved programs include four chemical methods and one biological control method. The treatments used today are much more effective, and modern techniques (e.g., aerial spraying, effective chemicals) enable rapid treatment of large areas.

Important economic inefficiencies and inequalities arise due to disassociations between beneficiaries of publicly supported grasshopper control programs and the costs of those programs. Any effort to assign costs more directly to the beneficiaries would improve both efficiency and equity (Heady, ch. 20). Both ranchers with differing proportions of public land enjoy benefits from the control programs; however, the more public land a rancher leases, the more he/she stands to benefit.

## A Grasshopper Insurance Program

The occurrence of grasshoppers on public rangelands in the western U.S. has all the characteristics of an insurable risk. Statistical probabilities of an economically damaging outbreak at a given site can be established from APHIS surveys and records of participation in spray programs. There are a large number of cases with limited liability and a clearly identifiable loss. Events are randomly repeated over time and space and are generally considered to be independent (Heady, ch. 15; Miller and Walter). APHIS maintains records

[6]Entomologists differ about the threat of grasshopper outbreaks spreading and continuing in subsequent years (Pfadt and Hardy; Hewitt and Onsager; Blickenstaff, Skoog, and Daum). In the case of rangeland grasshoppers, financial justification is expected exclusively from the treated area. Only when rangelands are treated to protect adjacent croplands are the benefits of a control program ascribed to adjoining lands.

which detail the areas treated, including costs of application, treatments applied, cost of materials, and the ancillary costs associated with the treatments. When an outbreak occurs in a particular area, it tends to be irregular. Some lands may experience extremely heavy infestations while neighboring lands have only light infestations.

The between-year variation in acres treated is large (table 1). At any one location and year, the likelihood of finding grasshopper densities in excess of the economic threshold is small. Yet, when infestations do occur, the financial impacts are so great as to threaten the economic survival of the affected ranches. The average cost for all rangeland grasshopper control programs in 1989 and 1990 was $2.85 per acre (USDA 1991); costs are bid as cost per acre, including chemical and application costs.

*Grasshopper Insurance*

Given the risk characteristics of grasshopper infestations together with the actuarial data available from APHIS records, a grasshopper insurance program would be possible. The proposed insurance program would be mandatory. All ranchers who lease public land would be required to purchase insurance on all comanaged rangeland included in their operation; they would incur an annual premium cost for grasshopper insurance. When a grasshopper outbreak which meets the financially defined economic threshold for treatment occurs, treatment would proceed at no cost to the rancher(s) affected. The treatment costs would be borne by the insurance fund into which ranchers pay annual premiums.

Federal agencies managed grazing on 258 million acres of range and forest land in the 17 contiguous western states (USDA 1981). These public lands provided 19 million AUMs of grazing in 1989 (USDA 1990; USDI). Grazed rangelands involve intermingling of federal, state, and private land, and they are generally managed as one unit. Grasshopper control programs are most efficiently applied to contiguous blocks of land, regardless of ownership. Insurance schemes would be applied to all land whether managed by federal or state agencies or by private individuals and corporations.

Furthermore, insurance programs would have to be mandatory rather than optional. Mandatory participation is required because all land in the infested block must be treated, regardless of ownership. Unless mandatory, "free rider" tendencies would result: an uninsured rancher could become a beneficiary to treatments applied to grasshoppers on adjacent ranches.[7] Also, important economies are realized from treating blocks of land rather than parcels which might result from an optional insurance program.

This insurance program is proposed as a way to protect ranchers and the range resource from devastating infestations of grasshoppers while making the publicly supported rangeland grasshopper program more financially sound. Initiating an insurance program would reduce the economic inefficiencies and inequities associated with the existing program. Further, the proposed program will result in reduced use of chemicals to control grasshoppers as treatments will occur only when a financial (economic) threshold is met and direct beneficiaries of the treatment share proportionally in the cost of treatment.

[7]It is possible that a ranch with only private land could benefit as a free rider if that ranch is entirely surrounded by public land. Such cases are thought to be rare. Similar insurance programs could be applied to ranch situations which only utilize private land, but such is beyond the scope of this study. Applications could also be extended to control rangeland grasshoppers for crop protection.

*Actuarial Information*

The existing program has an annual average cost of about $7.1 million. Of that total, about $3.6 million is federal program costs; the remainder is borne by the private individuals and state government. Insurance would cost users of public grazing about $0.10/AUM per year on all of their grazing land, public and private. Premiums could be based on acres or AUMs. Control costs are directly proportional to acres; the cost to treat a very productive acre of range is the same as the cost of treating a much less productive acre. Basing premiums on AUMs, however, automatically adjusts premiums based on rangeland productivity. At the same time, the economic justification for treatment will require a greater density of grasshoppers per square yard on less productive rangelands than on more productive rangelands. Basing premiums on AUMs achieves greater equity between premiums and possible pay-outs than would a cost per acre insurance scheme.

The premium of $0.10/AUM/year assumes the same coverage level as has been applied in the past. However, if grasshopper treatments are applied only when the economic threshold is reached (rather than the universal guideline of 8 GH/YD$^2$), it is quite likely that less land would be treated than in the past. Treating less land would reduce aggregate expenditures and per unit insurance premium costs.

For ranches using public grazing land, federal land makes up about 28% of the total rangeland AUMs (Gee et al. 1986a, b). Another 3% of AUMs are from state lands; the remaining 69% of rangeland AUMs are supplied from private lands, both leased and deeded. Thus, for every AUM of federal grazing land, ranchers obtain 2.46 AUMs of rangeland grazing from other sources.[8] In 1989, there were about 76.5 million AUMs of grazing used by ranchers with public land grazing leases. The mandatory insurance program would apply to these 76.5 million AUMs.

From 1972 to 1991 an average of 2.5 million acres per year received treatment. With a recent-year average cost per acre treated of $2.85, the average yearly outlay has an expected value of $7.1 million. Spread over 76.5 million AUMs, the average cost per AUM for insured protection is $0.093. Publicly sponsored insurance programs, such as federal crop insurance, generally add 10% to the premiums for administrative costs (Miller and Walter). Adding 10% to the cost per AUM, grasshopper insurance could be provided for western rangelands at a cost of $0.102/AUM. Assuming an average of 13.5 acres per AUM, the annual per acre cost of the insurance program would be $0.0076.

The improvement in distributive equity can be demonstrated. Suppose ranch A and ranch B experience a grasshopper density sufficient to trigger control programs once in ten years. Over the ten-year period, each rancher would have paid an annual grasshopper insurance premium of 16,044 acres x $0.0076/ac. = $121.93, or $1,219.30 for ten years. Assume a grasshopper outbreak occurs which reaches the economic threshold density; at that density, damages abated on each ranch are approximately $36,000. Since grasshopper insurance must be purchased on all grazing land (public and private) used by those leasing public land, the benefits relative to the cost of insurance premiums would not greatly differ between the two ranches with different proportions of public and private grazing land. Costs would be shared in more direct proportion to benefits, improving the distributional equity.

[8]Treatment programs average about 50% federal land. Because the existing control programs involve minimal private cost-share for treating public lands, it is reasonable to expect than greater portions of public lands are treated than the total proportion of public lands in the grazing lands.

Since the economic threshold to initiate treatment programs is based on determining benefits from control relative to control costs, allocative efficiency also increases. Even though public benefits may be present (as they are for insured crops), it is not necessary to estimate them. However, if public benefits are perceived to be important, public subsidization of insurance premiums could easily be accommodated.

## Summary and Conclusions

The existing grasshopper control program has operated like a disaster relief program. The discrete economic threshold of 8 GH/YD$^2$ is not sensitive to rangeland productivity differences and economic measures of (private) benefits relative to control program costs. Administration of the publicly supported grasshopper control program results in economic inefficiencies and distributional inequities.

The agency which pays all of the costs of treating federal lands and cost shares with the states and private lessees on treating state and private lands faces different benefit/cost measures than do the other landowner groups. Lessees of public land, who pay nothing for treatment of grasshoppers on these lands realize positive benefits from treatment of even very low densities of grasshoppers. Further, ranchers who receive most of their rangeland forage from public lands receive more benefits from publicly financed grasshopper control programs than do ranchers who rely mostly on private land for rangeland forage.

The economic efficiency and distributional equity of the existing program could be improved if the grasshopper treatment program were designed as an insurance program. All ranchers leasing public land would be required to participate in the grasshopper insurance program. In exchange for a small insurance premium per AUM of grazing land, the insurance program would provide control of grasshoppers once they reach densities above the financially determined economic threshold. Such a scheme would improve both the economic efficiency and the distributional equity relative to the existing program. Further, insurance financing of rangeland grasshopper control programs will help protect these important land resources in the face of efforts to reduce and eliminate public resource protection and subsidy programs.

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