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Economic Analyses of Alternative Grasshopper Control Treatments on Rangelands

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Historically, the economic threshold for publicly supported grasshopper control programs has been eight grasshoppers per square yard. A simulation model of the range forage-grasshopper-ranch system shows that the economic threshold should vary with rangeland productivity, precipitation, and treatment option.

Introduction: The control of grasshoppers on rangelands has been a long-standing management concern for livestock producers and public land managers. Competition between livestock and grasshoppers has lead to grasshopper management control strategies being an integral part of rangeland management in the western U.S. (Hewitt, 1977).

The USDA has provided monetary assistance and control programs for grasshopper infestations since 1937 (USDA, 1987). Current procedures use a grasshopper density of eight per square yard (8 GH/YD^2) as a guide to the initiation of grasshopper control programs (USDA 1987). Approved control programs generally involve the use of chemicals. Because of environmental concerns and concerns about the cost-effectiveness of existing practices, a Grasshopper Integrated Pest Management (GHIPM) project has been initiated. A portion of the GHIPM project is to conduct economic evaluations of alternative treatment strategies. This paper reports on the economic evaluation for one of the pilot areas of the GHIPM project. The analyses apply to the northern plains; more specifically, to the range-livestock situation found on the Little Missouri National Grasslands (LMNG) in western North Dakota. Based on the results, however, inferences can be drawn to other range-livestock situations.

Methods: The economic threshold for initiating grasshopper control programs, as defined by Headley (1972) is the level of pest population at which the private benefits of pesticide use outweigh the costs of control. Even though this analysis includes only the financial benefit-cost perspective, it demonstrates how the economic threshold is sensitive to a number of physical, biological and economic factors.

The results reported here are derived from simulations linking a range forage simulation model, RangeMod (Berry and Hanson, 1990), a grasshopper population dynamics model, HopMod (Kemp and Berry, 1990) and a ranch decision model, RANCHDC (Davis, Skold, Berry and Kemp, 1990). The analytical system which links these models is capable of evaluating a large number of parameters important to grasshopper control decisions. Only a few parameters are varied here; they serve to demonstrate the need for a flexible economic threshold which depends on the prevailing conditions.

Simulation of the range forage-grasshopper-ranch system begins with the range forage model, RangeMod. Rangelands with two different inherent productivity levels are considered. Two levels of precipitation, Below Normal and Normal on these rangelands result in varied forage supplies. The Below Normal precipitation level represents a level for which 21 percent less precipitation is received than the Normal amount (long-term average). Associated with each of the two precipitation levels, four densities of grasshopper infestations are imposed through HopMod to reflect 8 GH/YD^2, 16 GH/YD^2, 32 GH/YD^2, and 40 GH/YD^2 grasshopper infestations. Six grasshopper treatment options are evaluated under each precipitation and density condition. Control options are assumed to be applied on June 15; at that time grasshoppers are in their fourth instar. Treatments vary as to their costs and as to the immediacy and extent of mortality caused to the grasshopper population. Consequently, variation exists between control options as to how much forage is saved from destruction by grasshoppers.

When a grasshopper infestation occurs, several options are available. One option is to do nothing; the control simulation assumes that no treatment is applied. If chemical treatments are used, four alternatives are approved: acephate, carbaryl bait, carbaryl spray, and malathion. The choice of treatments is decided by the time of year, age and species of the grasshopper population encountered, and the cost of the chemical and its application. A final treatment choice is to use an approved biological control agent Nosema locustae. Nosema locustae is a pathogen which results in morbidity and death to grasshoppers and Mormon crickets.

The RangeMod-HopMod interaction results in varied levels of forage available for livestock grazing on a typical ranch after satisfying the grazing requirements of the grasshoppers. Solution of RANCHDC provides ranch net returns and alternative sources and values for range forage, given the productivity and cost characteristics specified for the range-livestock economy. As grasshoppers reduce the amount of forage available to the cow herd, the ranch must either purchase hay or lease alternative forage at increasing distances (and costs) from the ranch. The cow herd is maintained at a constant size regardless of the short run adjustments necessary. Benefits from treatments are evaluated as damages abated (Headley, 1972b). Ranch net returns are compared with and without grasshopper damage allowing the benefits from control to be evaluated relative to the cost of each approved treatment alternative.

Damages Abated: As increasing densities of grasshoppers compete with livestock for available forage, ranch net returns are adversely affected. Damages abated are taken as the difference between the net returns on a typical ranch for a given treatment case and net returns when no treatment occurs. Thus, damages abated are:

$$DA_{t,d,c} = NR_{t,d,c} - NR_{o,d,c} \tag{1}$$

Where: $DA_{t,d,c}$ = damage abated for treatment t, (t = 1,2,..,5) grasshopper density d, (d = 8,16,32,40) and precipitation level c, (c = Normal, Below Normal)

$NR_{t,d,c}$ = ranch net returns for a specified treatment

$NR_{o,d,c}$ = ranch net returns for the no treatment case

The calculated damages abated, DA_t, for each treatment reflect the unique characteristics of each treatment for the immediacy and extent of grasshopper mortality. Treatments which are fast acting and result in higher mortality rates provide larger damage abatement estimates than those which are slower acting and have lower mortality rates.

Treatment Costs: Treatment costs also vary. Recent per acre costs experienced are; acephate spray, $2.47; carbaryl spray, $3.50; carbaryl bait, $4.50; malathion spray, $2.25; and Nosema locustae, $4.75 (APHIS, 1990). Total costs of treatment change in direct proportion to the area which must be covered to protect a specified amount of forage. For example, on the LMNG, some of the more highly productive rangeland requires only 2.2 acres per AUM. Other, less productive rangeland requires 3.3 acres per AUM. Consequently, treatment costs depend on the treatment selected and the area to be treated to protect one AUM of forage from destruction by grasshoppers. So,

$$TC_{t,p} = \$/Ac_t * Ac/AUM_p * AUM \tag{2}$$

Where: $TC_{t,p}$ = treatment cost on the typical ranch for treatment, t, and rangeland productivity level, p (p = highly productive, less productive),
$/Ac = per acre treatment cost for treatment, t,
Ac/AUM = rangeland productivity level, p and
AUM = total AUMs of treated rangeland forage on the typical ranch

Benefit/Cost Ratios: From the damages abated in (1) and the treatment costs in (2), benefit/cost ratios (B/C) can be estimated. The ratios, in Table 1 are derived by:

(3) $$B/C_{t,d,c,p} = DA_{t,d,c} / TC_{t,c}$$

The analysis does not distinguish as to who receives the benefits (private) and who bears the cost (public). Rather, resulting financial benefits from treatments are compared to the costs incurred. Consequently, the analysis can apply to any land ownership circumstance whether Federal, state or private land. The financial benefit-cost analysis evaluates the economic threshold; the level of pest population at which the benefits accruing to the ranchers from control are equal to the cost borne by the USDA; ie., B/C = 1.0.

From Table 1 the B/C ratios are plotted in Figures 1 to 4 against grasshopper densities. Figures 1 and 2 reflect the Below Normal precipitation condition. Comparing Figure 1 with Figure 3, it is seen that treatments are financially justified on the highly productive rangeland at grasshopper densities of 14-15 GH/YD^2 when precipitation is Below Normal but densities must reach 24-25 GH/YD^2 under Normal precipitation to reach a B/C = 1.0. Carbaryl bait reaches a B/C = 1.0 at about 34 GH/YD^2 on the less productive rangeland (Figure 2) and Below Normal precipitation but when precipitation is Normal, financial feasibility is not reached at any of the grasshopper densities graphed.

When precipitation is Normal, Figures 3 and 4, none of the treatments are financially justified at 16 GH/YD^2. Acephate and malathion can be used on the better rangeland as grasshopper densities of 24-25 GH/YD^2 are reached. Figure 4 shows that grasshopper densities must reach 29-30 GH/YD^2 on the less productive range before treatment can be justified. At the densities of 40 GH/YD^2 each of the treatments have B/C > 1.0 on the higher productivity rangeland. Carbaryl bait and Nosema locustae are not financially justified even at 40 GH/YD^2 on the less productive rangeland, however.

Conclusions: Financial justification for grasshopper population control programs has been shown to depend upon (i) the inherent productivity of the rangeland to be treated, (ii) the prevailing precipitation conditions, and (iii) the effectiveness of the treatments imposed. The discrete-choice economic threshold of treating grasshoppers which reach densities of eight GH/YD^2 does not appear to be financially justifiable.

Rangeland productivity is shown to be an important determinant of the financial justification for treatment of grasshoppers. Under Normal precipitation, malathion can be applied to the more productive rangeland when grasshoppers reach densities of about 25 GH/YD^2. Grasshopper densities must reach about 30 GH/YD^2 on the less productive rangeland before malathion can be applied. The LMNG is quite productive relative to most other western range areas. As rangeland productivity falls to where it requires 10, 20 or more acres to provide an AUM of grazing, achieving financial justification of grasshopper control programs will be very difficult to attain.

Precipitation conditions cause a similar shift in the economic threshold. Often grasshopper outbreaks occur when forage supplies are already limited by drought. Treatments can be justified at lower grasshopper densities when Below Normal precipitation conditions occur than when Normal precipitation prevails. Important to the economics threshold is the opportunity cost of forage; as the opportunity cost increases, the economic threshold will occur at lower grasshopper densities.

From Figures 1 and 2, one can also see the relative cost-effectiveness of the treatment alternatives, given the assumed species composition and age of the grasshoppers. For the cases simulated, the sprays (acephate, carbaryl, malathion) are always superior to carbaryl bait and Nosema locustae. Largely because of its smaller per acre costs, malathion is always superior to the other sprays.

Entomologists and range managers are divided in their conclusions about the multiple-year effects of grasshopper controls. With this analysis, however, one can make static comparisons of the stream of discounted benefits with treatment costs and estimate the number of years of control necessary to justify intervention at a given range forage-grasshopper-livestock condition.

The financial justification for grasshopper treatments depends on rangeland productivity, precipitation conditions and the treatment applied. Financial justification will vary between sites and between years. When the area to be treated to protect an AUM of forage from destruction increases, it is increasingly difficult to financially justify treatment.

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Table 1. **Benefit cost ratios for grasshopper controls by range productivity, Precipitation condition, treatment and grasshopper density**

Treatment/ grasshopper population	Benefit/Cost ratio when:			
	Below Normal Ppt.		Normal Ppt.	
	2.2 ac/AUM	3.3 ac/AUM	2.2 ac/AUM	3.3 ac/AUM
Acephate				
8 GH/YD^2	.46	.31	0	0
16 GH/YD^2	1.26	.84	.16	.11
32 GH/YD^2	3.27	2.18	1.53	1.02
64 GH/YD^2	3.72	2.48	2.45	1.63
Carbaryl bait				
8 GH/YD^2	.23	.15	0	0
16 GH/YD^2	.57	.38	.09	.06
32 GH/YD^2	1.52	1.01	.84	.56
64 GH/YD^2	1.66	1.11	1.34	.90
Carbaryl spray				
8 GH/YD^2	.33	.22	0	0
16 GH/YD^2	.88	.58	.11	.07
32 GH/YD^2	2.28	1.52	1.08	.72
64 GH/YD^2	2.58	1.72	1.73	1.15
Malathion				
8 GH/YD^2	.51	.34	0	0
16 GH/YD^2	1.38	.92	.17	.12
32 GH/YD^2	3.61	2.40	1.68	1.12
64 GH/YD^2	4.11	2.74	2.69	1.79
Nosema locustae				
8 GH/YD^2	.17	.11	0	0
16 GH/YD^2	.43	.29	.08	.05
32 GH/YD^2	1.16	.77	.80	.53
64 GH/YD^2	1.17	.78	1.17	.78

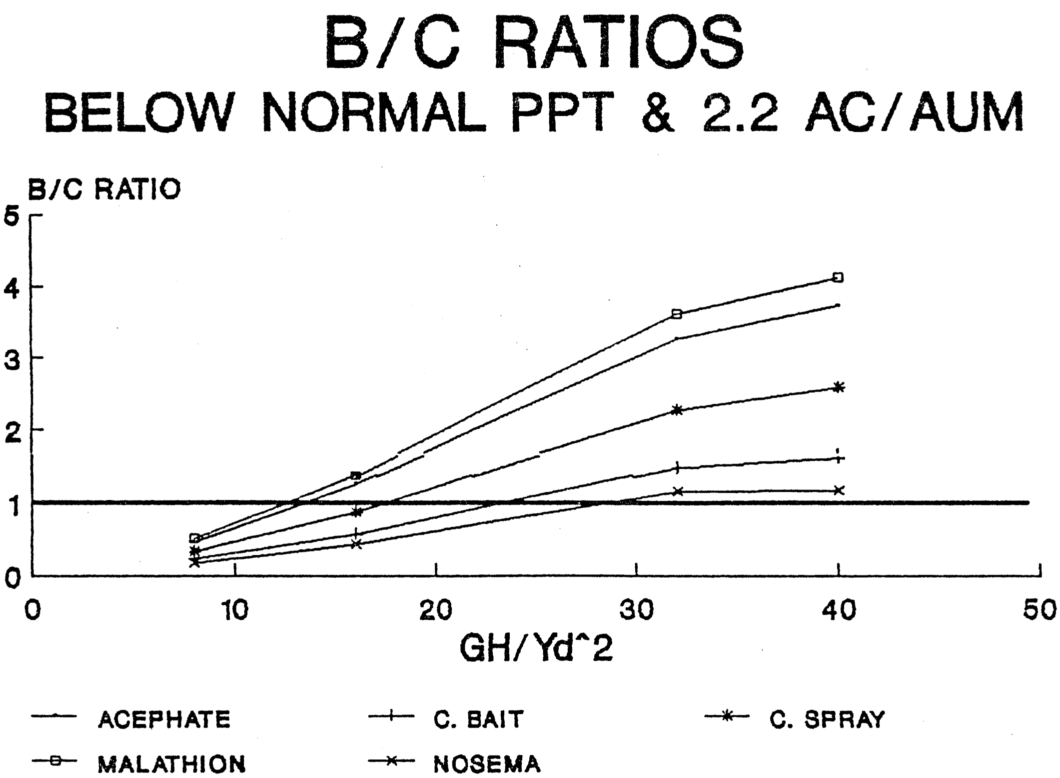

Figure 1. Benefit/cost ratios for Below Normal precipitation and highly productive rangeland

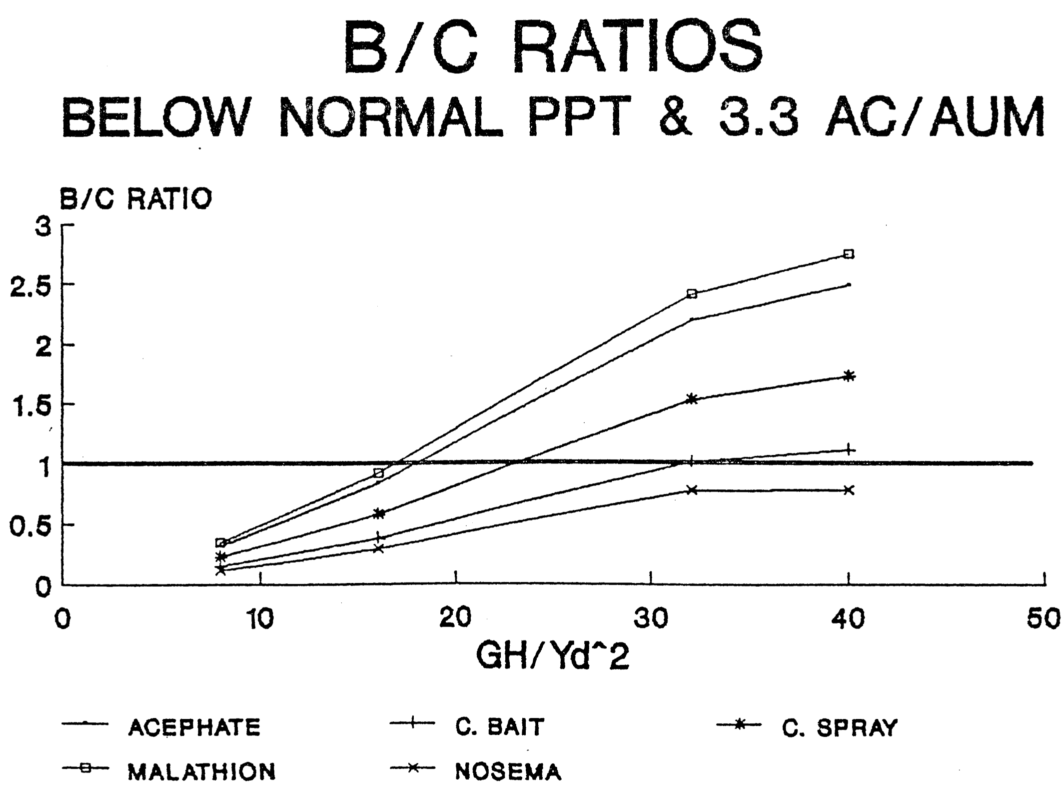

Figure 2. Benefit/cost ratios for Below Normal precipitation and less productive rangeland

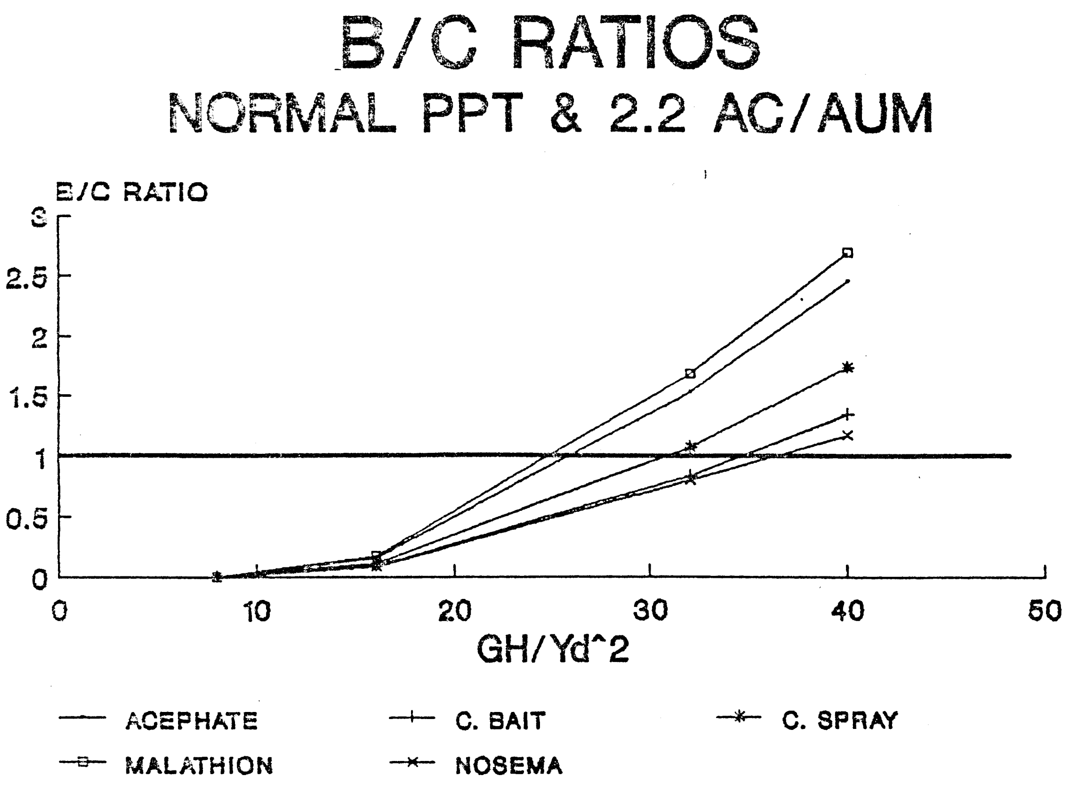

Figure 3. Benefit/cost ratios for Normal precipitation and highly productive rangeland

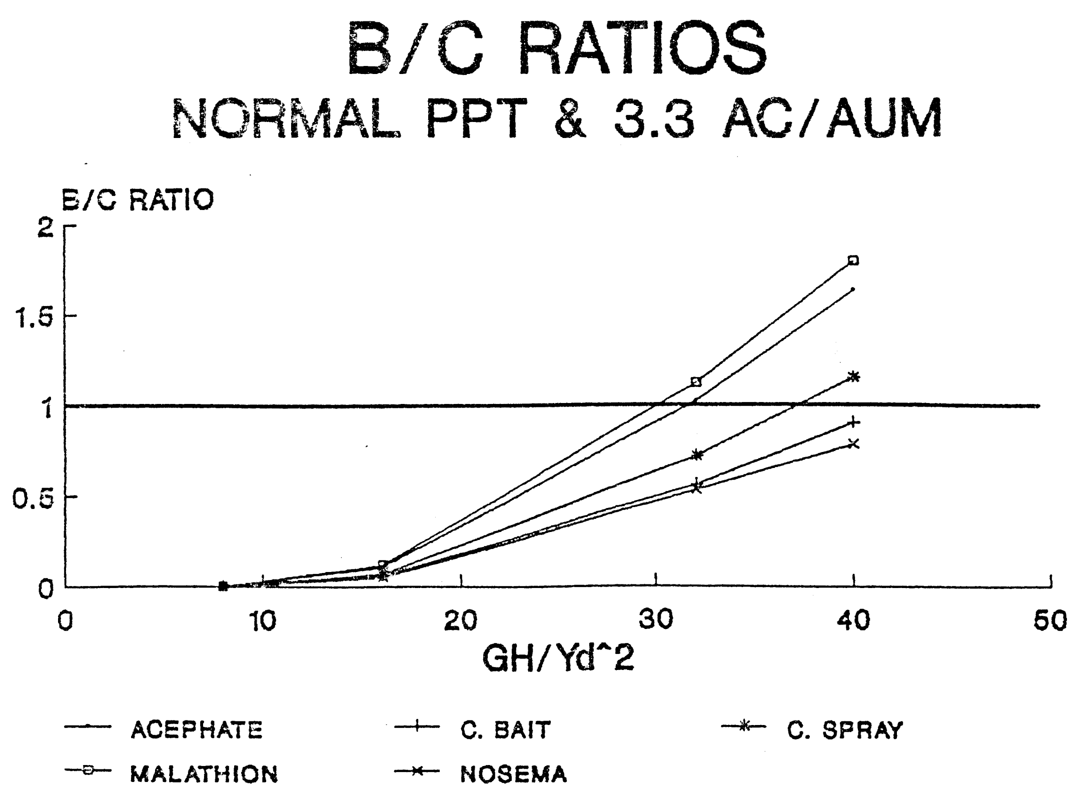

Figure 4. Benefit/cost ratios for Normal precipitation and less productive rangeland