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The Challenge of Cost-Benefit Determinations in Bird Damage Control Programs

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Birds cause damage to a variety of crops in North America and, at least for blackbirds feeding on corn, there are fairly accurate estimates of the amount of damage that occurs (Stone et al. 1972, Stickley et al. 1979). To combat these depredation problems, a variety of management tools (cultural methods, mechanical scare devices, chemical toxicants, and repellents) have been developed and are routinely recommended to farmers. Unfortunately, little effort has gone into examining the anticipated or actual losses in relation to the effectiveness and costs of the recommended damage control programs.

With energy sources becoming more expensive and concerns over the environmental impact of control programs increasing, vertebrate-damage control personnel must do a better job of determining economic benefits in relation to costs. The user must be provided with more reliable and complete information than is done at present concerning the situations in which a particular management tool should or should not be used to achieve a net benefit.

The objectives of this report are (1) to discuss, in general terms, the economic impact of blackbird damage to corn and how we should interpret this impact and (2) to suggest the type of research and management data that need to be assembled to assess the benefits of blackbird damage control in corn in relation to costs. Although I use blackbird damage to corn as an example, I feel these principles can be extended to many other situations involving vertebrate pest control in agriculture.

The Economic Impact of Blackbird Damage to Corn

Bird damage to agricultural field crops, and especially blackbird damage to corn, is undoubtedly more objectively quantified on a state or regional basis than is the damage caused by other vertebrate pests. This
is primarily because bird damage is often easier to objectively measure than are losses due to rodents or predators.

The examination of studies during the past 10 years where blackbird damage to corn has been measured on a statewide level leads to an interesting conclusion (Table 1); in all locations, losses to birds represent less than 1% of the yield of the crop. Average losses in other crop types caused by other avian species show a similar pattern of less than 1% damage (e.g., starlings in winter wheat--Dolbeer 1979, waterfowl in small grain crops--Sugden 1976). For corn in the midwestern United States, losses caused by insects, weeds, disease and fungi probably total over 20% of the total potential harvest (Jugenheimer 1976:261, Pimentel 1976, McEwen 1978) and harvesting procedures leave 5% or more of the crop in the fields (Jugenheimer 1976:212). Even though the total dollar figure for blackbird damage to corn for a state, such as Ohio, may reach several million dollars annually (Table 1), the average loss of corn to blackbirds is quite small compared with losses from other sources and one might wonder why it is even considered a problem.

The answer lies in the sporadic nature and unequal distribution of bird damage. If all farmers received a loss to birds of 1% or less, then there would be no problem. That this is not the case is shown clearly by estimates of blackbird damage to corn in 7,237 fields in 19 counties in Ohio obtained over the period 1968-76 (Dolbeer 1980). The distribution of losses among these fields was as follows:

<table>
<thead>
<tr>
<th>Percent of crop lost to blackbirds</th>
<th>&lt;1</th>
<th>1-5</th>
<th>6-10</th>
<th>&gt;10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of fields</td>
<td>85.4</td>
<td>12.1</td>
<td>1.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The vast majority of farmers are receiving insignificant amounts of loss with only a small percentage receiving more than 5%--the threshold level above which an investment in damage prevention may be economically justified (see below). Statewide in Ohio the percentage of fields receiving over 5% loss is probably even less than the 2.5% indicated above because the 19 counties used in this survey contained most areas in the state that received heavy blackbird damage to corn.
Two important facts emerge from this pattern of damage. First, bird damage problems in corn, unlike many traditional pest problems in agriculture, are more scattered and unequally distributed among farmers and fields. Management recommendations cannot be routinely issued as is done for weed control but must be directed only toward those few farmers having severe enough problems to justify the investment in control measures.

Second, the unequal distribution of damage has an important impact on the way we interpret the actual economic loss on a statewide basis. In the period 1977-79, the total economic impact of blackbird damage to corn in Ohio averaged $5.5 million/year (range $3.8 to $6.8 million) (Table 1). Yet, based on the distribution of damage for 1966-74, about 25% of this loss ($1.4 million) was derived from fields receiving less than 1% loss—a level of loss that could not be reduced further economically—and another 40% ($2.2 million) was derived from fields receiving 1 to 5% loss—levels of loss that often are also of marginal importance because the costs of reducing them would exceed the benefits of reduced damage (see below). Thus, perhaps at most, only half of this $5.5 million annual loss is loss that is significant enough economically to justify the implementation of research and management programs. The remaining loss is too diffuse, too insignificant in the context of the total farm program, to justify an economic investment.

Thus, while the total dollar loss of blackbird damage to corn averages $5.5 million annually, the loss about which something can be done with a net benefit, may be substantially less. This economically significant loss, and not the total loss, should be what is considered in justifying management expenditures and developing damage control programs. It is not enough to just say that blackbirds cause $5.5 million damage to corn annually in Ohio. One must also state the amount of that loss about which something can be done with a net economic benefit.

Costs of Control Versus Predicted Benefits -- A Simple Model

The above discussion has referred to the economics of bird damage in the broad context of the impact on a crop over an entire state. In discussing damage to individual fields, the simple maxim that should guide us is that Benefits (dollars saved by reduced damage) exceed the costs of control. This is an obvious statement, yet in many situations the two factors, benefits and costs, are not adequately considered in the research
and development of control techniques nor in the use of these techniques once they become operational. Part of the reason is political. There will often be pressure to solve vertebrate pest problems from a public-relations viewpoint regardless of economics (e.g., Graham 1971, 1978). The wildlife manager can do little about this. However, I feel that another major factor is that we have not developed a simple framework or model by which to compare costs of control versus benefits. Such a model would provide the guidance or structure for collecting the right types of data to allow meaningful and practical comparisons of costs and benefits.

One method of developing this framework is through the use of a cost-benefit graph (Fig. 1). On the x-axis is the cost of anticipated damage per acre and on the y-axis is the cost of the control measure per acre. The equation:

\[ y < bx, \]

where \( b \) represents the fraction of damage expected to be reduced by the control measure (i.e., efficacy), represents the breakeven point for the use of a control measure. The anticipated benefits (bx) must equal or exceed the costs (y) before a management tool should be used.

As an example, Figure 1 depicts the cost-benefit equations for the use of Avitrol, a chemical frightening agent, and propane exploders to reduce blackbird damage to corn in Ohio based on data from Stickley et al. (1972). The equation for Avitrol use, \( y = 0.56x \), indicates that Avitrol reduces damage by an average of 56%. Likewise, the equation for propane exploders, \( y = 0.81x \), indicates an effectiveness of 81%. Additional studies by Stickley et al. (1976) and Linehan (1972, unpubl.) also indicate Avitrol and exploder efficacy in cornfields in Ohio at about 50 and 80%, respectively.

The cost of aerially-applied Avitrol is currently \$5.55/acre and the cost of exploders/acre (assuming 1 exploder/5 acres as in Stickley et al. 1972) is about \$5.00/acre (Wronecki et al. 1979, Dolbeer et al. 1979). Thus the breakeven points for justifying Avitrol and exploder use are anticipated damage levels of \$9.91/acre and \$6.17/acre, respectively (Table 2). Assuming a market price of \$2.15/bushel and yields of 101 bushels/acre (Carter 1979), then anticipated blackbird damage to an average field in northern Ohio would have to be over 4.6% before Avitrol use could be justified. For propane exploders, the damage level would have to be over
2.8% As can be seen in Figure 1, as long as the anticipated or projected damage level falls to the right side of the line representing the cost-benefit equation, the management measure is justified economically.

Obviously, under an efficacy value of 0.56, only a small percentage of fields (< 2.5%) could ever warrant using Avitrol. Of course, under situations where the efficacy was increased, the line representing the equation \( y = bx \) would become steeper (until \( b = 1 \)) and a greater number of fields could benefit from the use of the control measure. Even if the efficacy of Avitrol was 100%, damage must exceed 2.6% before it is economically justified.

As a final example, I show in Figure 2A, superimposed on the cost-benefit equation for Avitrol from Figure 1, the distribution of blackbird damage for 21 cornfields in northern Ohio that received commercial Avitrol treatments in 1976. Avitrol was apparently quite ineffective in these fields because of rapid bait disappearance due to cricket (\( \text{Gryllus} \)) feeding (Wronecki et al. 1979). Thus, the distribution of damage levels for these fields is probably close to what it would have been if no Avitrol had been used. As can be seen, even if Avitrol had been at its 56% level of effectiveness, only 2 of the 21 fields for which farmers requested treatments could have achieved net benefits. The other fields did not have enough potential damage to warrant Avitrol use. Even if we assume that Avitrol did reduce damage by 56% in each of these 21 fields, only 8 (38%) could have received net benefits (Fig. 2B).

Undefined Factors in Cost-Benefit Analyses

Three factors this cost-benefit equation has not attempted to incorporate are (1) possible beneficial aspects of depredating birds, (2) the external costs and benefits of control programs, and (3) the intangible, aesthetic and nuisance attributes of the pest birds.

Dolbeer (1980) noted that red-winged blackbirds (\( \text{Agelaius phoeniceus} \)) often consume important insect pests of corn such as corn borers (\( \text{Pyrausta nubilalis} \)), rootworm beetles (\( \text{Diabrotica spp.} \)), and earworms (\( \text{Heliothis zea} \)). Few studies (Mott and Stone 1973) have been undertaken to measure beneficial feeding effects of blackbirds in terms of increased yield or decreased damage to a crop. If beneficial effects were found to occur this would have to be incorporated into the equation by either adjusting costs of control upwards or reducing benefits of control. Benefits external to the
corn crop, such as from blackbirds feeding on insects in alfalfa or from a positive carry-over effect of control measures in the corn to another vulnerable crop such as sunflowers, would be difficult to incorporate as would external costs such as pesticide pollution or the kill of non-target birds resulting from control programs. Lastly, intangible, aesthetic or nuisance attributes, such as the net pleasure derived by the people of Ohio from male redwings singing and displaying on their territories in spring, or the net inconvenience caused by roosting blackbirds near a town in the fall, would be extremely difficult to quantify and incorporate into equations on cost-benefits.

Conclusions

The major question raised in this report is how often does the type of situation occur in bird-damage control whereby the costs of routinely-recommended management measures exceed the value of the crop damage that is reduced. I do not know the answer but my general experience in the field suggests that this situation frequently occurs. Because of the highly visible nature of birds and of the damage they inflict in fields, a farmer's awareness and concern for bird losses often exceed the actual magnitude of the economic threat. Vertebrate pest control workers must in the future put as much emphasis on developing guidelines for the economical use of management tools as currently goes into the research and development of new tools.

The model presented in this report is admittedly over-simplified in relation to the real-world situation. I have already discussed the lack of input on beneficial aspects of birds and external costs. In addition, the use of a single value for efficacy (b), such as 0.56 for Avitrol, is not realistic because efficacy can vary under different farming and treatment conditions. Also, in many situations it is quite difficult to predict what the damage level in a particular field will be. However, these gaps should not detract from our attempts to use cost-benefit equations with current information available. As mentioned above, the use of such equations or models forces us to better define the critical types of data needed to improve the accuracy of our cost-benefit predictions. In addition even using rather crude estimates of efficacy and predicted loss, these equations are improvements over the fuzzy "mental
models' or guesses that are often used at present in recommending bird-damage control measures. The use of such equations can help us to avoid the wasteful and inappropriate use of management tools demonstrated in Figure 2.

Literature Cited


Table 1. Statewide estimates of blackbird damage to corn in the United States derived from objective field surveys.

<table>
<thead>
<tr>
<th>Location</th>
<th>Year of study</th>
<th>Percent of crop lost</th>
<th>Total dollars lost (millions)</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio</td>
<td>1977</td>
<td>0.67</td>
<td>3.88</td>
<td>Stickley et al. 1979</td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>0.80</td>
<td>5.90</td>
<td>Unpubl. Fish &amp; Wildlife Serv. reports</td>
</tr>
<tr>
<td></td>
<td>1979</td>
<td>0.71</td>
<td>6.78</td>
<td>Unpubl. Fish &amp; Wildlife Serv. reports</td>
</tr>
<tr>
<td>Kentucky</td>
<td>1977</td>
<td>0.48</td>
<td>1.20</td>
<td>Stickley et al. 1979</td>
</tr>
<tr>
<td>Tennessee</td>
<td>1977</td>
<td>0.39</td>
<td>0.38</td>
<td>Stickley et al. 1979</td>
</tr>
<tr>
<td>New York</td>
<td>1971</td>
<td>0.60</td>
<td></td>
<td>Stone et al. 1973</td>
</tr>
</tbody>
</table>

Table 2. Determining the break-even point (where the value of the crop saved equals the blackbird damage control measures for field corn in Ohio.

<table>
<thead>
<tr>
<th>Control method</th>
<th>cost of control/acre</th>
<th>Efficacy of control</th>
<th>Loss ($)/acre required before control is justified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avitrol</td>
<td>$5.55^a</td>
<td>0.56'</td>
<td>9.91</td>
</tr>
<tr>
<td>Exploder</td>
<td>$5.00^b</td>
<td>0.81'</td>
<td>6.17</td>
</tr>
</tbody>
</table>

^aWoronecki et al. 1979
^bDolbeer et al. 1979
'Stickley et al. 1972
Fig. 1. Cost benefit equations for Avitrol and propane exploders to reduce blackbird damage to corn in Ohio. Anticipated damage must be greater than $9.91/acre for use of Avitrol and $6.17/acre for use of exploders.
Fig. 2. Cost-benefit determinations for 21 cornfields in Ohio where farmers used commercial applications of Avitrol in 1976 to reduce blackbird damage. The Avitrol applications were probably ineffective because of rapid bait disappearance caused by cricket feeding (Wronecki et al. 1979); thus the final distribution of damage (indicated by x's in graph A) for the 21 fields was a measure of the distribution of loss with no control measure used. The graph indicates that even if Avitrol had worked at the expected 56% effectiveness, only 2 of the 21 fields (10%) would have benefited from its use. Even if we assume that Avitrol did work and that the final damage distribution shown in Fig. 2A reflects a 56% damage reduction in each field, the majority of farmers could not have achieved a net benefit. In Fig. 2B we have increased the damage level in each field to reflect the projected loss before Avitrol reduced damage by 56%. Only 8 of the 21 fields (38%) would have benefited from Avitrol use.
A

PROJECTED LOSS($) /acre using no control
(Assuming Avitrol was not effective)

B

PROJECTED LOSS($) /acre using no control
(Assuming Avitrol was 56% effective)