APPLICATION OF A BENEFIT:COST MODEL TO BLACKBIRD DAMAGE CONTROL IN WILD RICE

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ABSTRACT: From commercial fields near McArthur, California, we collected data on methods for controlling blackbird (Icteridae) damage to wild rice (*Zizania aquatica*). Using and expanding upon an economic model proposed by Dolbeer (1981), we derived economic comparisons of three control programs employing: 1. methiocarb, 2. shooting and propane exploders, and 3. all methods combined. Shooting and propane exploders used together were the most cost effective with a benefit:cost ratio of 2.16:1. Under the assumptions used in the model, methiocarb was least effective with a benefit:cost ratio of only 0.62:1. We discuss assumptions of the model and using basic initial data (cost and efficacy of control, average yield and value of the crop, anticipated damage level) illustrate a format to derive figures for the amount and value of crop to be saved at a given efficacy level, benefit:cost ratios, and net income after control.

INTRODUCTION

Wild rice (*Zizania aquatica*) is a relatively new crop in California. Initial plantings in the Central Valley were made in the early 1970s with commercial production beginning in the mid-1970s. In the Fall River Valley area of northeastern Shasta County, wild rice was first cultivated in 1982 by two growers producing 24.3 ha (60 ac) total. At that time there were 1214 ha (3000 ac) statewide. By 1985 production expanded greatly with 647.5 ha (1600 ac) in Shasta County and 6070 to 6880 ha (15,000 to 17,000 ac) statewide.

As with any new crop, growers faced new problems. In an attempt to solve them, they turned to methods and materials used in other crops, and encouraged the development of new solutions. With wild rice it quickly became apparent that red-winged blackbirds (*Agelaius phoeniceus*) would be a major pest. Rice (*Oryza sativa*) growers in the Central Valley of California have long been aware of this problem and apply control programs utilizing a variety of frightening devices (propane exploders, scarecrows, shell-crackers, bird bombs and whistles) and lethal control (shooting). These methods were quickly adopted by wild rice growers. There was also considerable interest in chemical control, specifically methiocarb, a broad-spectrum avian repellent. This material was registered nationally by the Environmental Protection Agency (in 1984) for use on blueberries, cherries and as a seed treatment on corn, rice, and soybeans against a variety of bird species. Methiocarb was tested in Minnesota on wild rice (Moulton 1979) and California growers were interested in this product.

In 1984 we began field investigations of methiocarb for blackbird damage control in wild rice. Peripheral to our project, we obtained data concerning control costs. We observed that in the search for effective control, seemingly little effort was given in comparing crop loss value in relation to costs and efficacy of damage control programs. In some cases necessary information to make such comparisons was not available. In others, control programs were experiments to find an effective method first, and then consider cost.

The objective of this paper is to illustrate the use of a simple economic model in comparing the costs and benefits of blackbird control methods in wild rice. The model can be applied to any annual crop when appropriate information is available as an aid to growers and public agency personnel in selecting or recommending a control program with consideration to costs and benefits. The model is not applicable to perennial crops or vertebrate pests, such as ground squirrels (*Spermophilus* spp.), where the beneficial effects of control may persist longer than one year.

STUDY AREA

Our studies were conducted in wild rice fields in the Fall River Valley near McArthur in northeastern Shasta County, California. The primary study site of 16.2 ha (40 ac) bordered the Fall River to the north and northwest. Upland pastures, wet meadows, and emergent wetlands in the general area, as well as riparian vegetation and other wild rice fields within 0.8 km (0.5 mi), provided favorable habitat for red-winged blackbirds and lesser numbers of yellow-headed blackbirds (*Xanthocephalus xanthocephalus*). An additional 24.3 ha (60 ac) of wild rice was planted by the same grower at a second location in the Fall River Valley. Appropriately, 486 ha (1200 ac) of commercial wild rice were planted in the Fall River Valley area during 1984.

CONTROL METHODS

The grower employed shooting propane exploders, and methiocarb for blackbird control. Although not registered for wild rice, methiocarb was allowed under an emergency exemption (Section 18) issued by the California Department of Food and Agriculture.

The shooting program relied heavily on volunteers. To motivate and enlist volunteers the grower had a barbecue early in the growing season, inviting friends and neighbors. Approximately 40 people attended. At this time the nature of the blackbird problem and the shooting program was explained. In addition, attendees were given a free, novelty tee shirt with the farm logo, wild rice, and a dead blackbird lying next to spent shotgun shells stenciled on the front.

The shooting program began the first week of August and continued until harvest 6 weeks later. The normal procedure was for volunteers, with their personal shotguns, to arrive at the fields in early evening, usually around 1800 hr. Each was given a bag of 25 to 50 shotgun shells (12 gauge) and a recommended location for shooting. Deployment in the field was ultimately at the discretion of the shooters; they tended to concentrate along flight lanes around the outside perimeter of the fields and only occasionally shot from the levees between individual impoundments. Shooting continued each night until bird activity ended with darkness. The number of gunners present on any one night varied from 0 to 10 or more on the 16.2 ha (40 ac) site. Although volunteers did shoot at the second site, we did not make observations there.

Concurrent with the volunteer program, two hired gunners, one at each site, patrolled the fields from early morning till late afternoon. Riding all-terrain vehicles or walking, they patrolled the field borders, shooting to frighten and/or kill blackbirds flying in range. These two field hands also serviced three propane cannons (two at one site, one at the second), moving them to new locations within each field every few days and refilling them with propane as needed.

Methiocarb was applied by fixed-wing aircraft to three plots totaling 11.6 ha (28.6 ac) of the 16.2 ha (40 ac) field. The material was applied at a rate of 3.4 kg/ha (3.0 lb/ac) 14 days before harvest on one plot and 21 days before harvest on a second plot. The third plot received 1.7 kg/ha (1.5 lb/ac) twice, at 21 and 14 days before harvest. The plot treatments were related to our primary study in wild rice and will not be discussed in any further detail in this paper. Over 2.5 cm (1 in) of rainfall occurred 5 days after the second treatment, or 9 days before the estimated harvest date.

CONTROL COSTS

We obtained control costs through interview with the grower. For the purpose of this paper we assumed each control method was applied to all 40.5 ha (100 ac). Although methiocarb was applied more than once and at different rates in our field study, to simulate a more realistic situation in this paper we conservatively assumed it would be applied only once at a rate of 3.4 kg/ha (3.0 lb/ac).

Total costs for the shooting and propane exploder program were $8,461, or $209.07/ha ($84.61/ac) (Table 1). Treatment with methiocarb cost $8,000, or $197.68/ha ($80.00/ac). For all control methods together, total cost would be $16,461 or $406.75/ha ($164.61/ac).

Table 1. Costs for bird control on a 40.5 ha (100 ac) wild rice farm. (For simplicity, English units of measurement are used in the table.)

Control method	Total cost ($)	Cost/ac
Methiocarb		
Material: 3 lbs/ac. $25/lb	$7,500	
Fixed-wing aircraft: $500 flat rate up to 100 ac	500	
	$8,000	$80.00
Shooting and propane exploders		
Volunteer gunners:		
Barbeque for 40 people	350	
Tee shirts $8 ea. for 50 shirts	400	
Shotgun shells:		
80 cases at $65/case (lead shot)	5,200	
Hired gunners:		
2 gunners at $1,200 each	2,400	
Propane exploders:		
3 x $135 ea. prorated over 5 years	81	
Propane:		
6 bottles, 5 ga. ea. at $1/gallon	30	
	$8,461	$84.61
All methods combined	$16,461	$164.61

ECONOMIC MODEL

The economic model illustrated here was described by Dolbeer (1981). The major principle of the model is that benefits derived (value of the crop saved) from a control program should be equal to, but preferably greater than, the control costs. The model can be described through the use of a cost-benefit graph (Fig. 1) and the equation $y \leq bx$, where y equals the cost of control per unit of area, x equals the cost of anticipated damage per unit of area, and b is the efficacy of the control measure, or the fraction of damage expected to be reduced by the control measure. The line represented by the equation $y=bx$ is the breakeven point for any specific control measure. With this model, a control measure is economically justified for any anticipated damage level falling to the right side of its breakeven line.

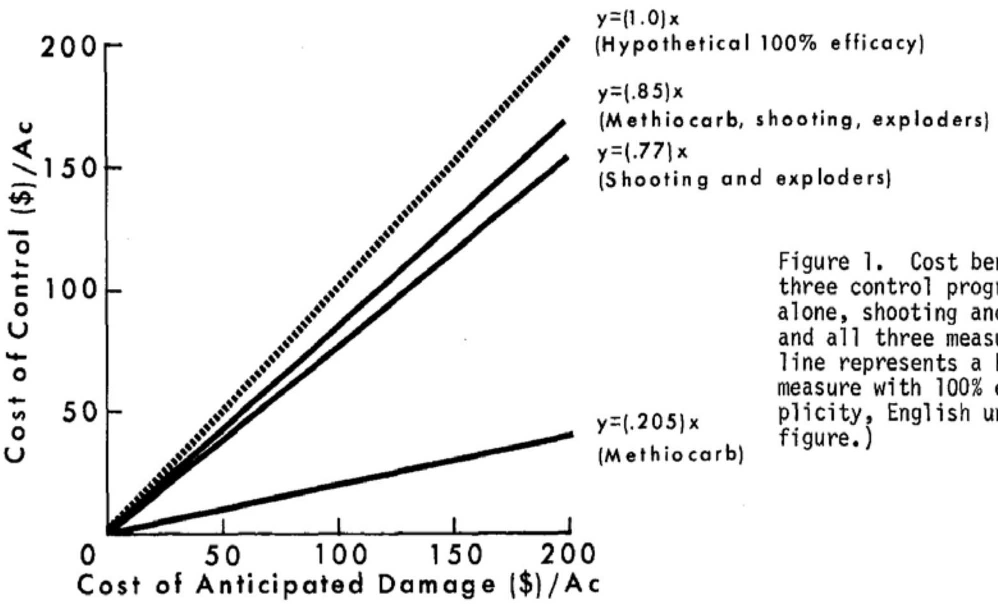

Figure 1. Cost benefit equations for three control programs using methiocarb alone, shooting and propane exploders, and all three measures together. Dashed line represents a hypothetical control measure with 100% efficacy. (For simplicity, English units are used in the figure.)

The efficacy or b values used in the Figure 1 equations were derived from the literature. We found only one study of the efficacy of methiocarb in wild rice. Moulton (1979) found an average reduction in damage of 20.5% on three plots over a 2-year period. For shooting and propane exploders, we could not find a comparable study in wild rice. However, Conover (1984) found a 77% reduction in blackbird damage to corn using one propane exploder per field. Field size ranged from 2.0 to 8.0 ha (4.9 to 19.8 ac). Stickley et al. (1972), also working in corn, found an 81% reduction of blackbird damage using two propane exploders per field. Field size ranged from 2.0 to 6.9 ha (5.0 to 17.0 ac). Although the area to be covered by each exploder was greater in our study at 8.1 to 12.1 ha/exploder (20-30 ac/exploder), we felt the presence of the hired and volunteer gunners compensated for the difference in area of coverage per exploder. As a conservative choice based on the literature we selected a value of 77% efficacy for the shooting and propane cannons together. For all control measures applied together there were no studies in the literature for reference. We felt the benefit from methiocarb would be partially additive to the shooting and propane exploders. A conservative estimate of 85% efficacy was selected.

APPLICATION OF THE MODEL

Assuming an average wild rice yield of 1681 kg/ha (1500 lb/ac) with no damage and a 20% reduction in yield from blackbirds (Gorenzel, unpubl. data) if no control is applied, then blackbirds will remove 336.2 kg/ha (300 lb/ac) which at the 1984 price of $1.76/kg ($0.80/lb) is $593.04/ha ($240/ac). After inserting the appropriate efficacy and cost of anticipated damage values into the $y \leq bx$ equation, the cost of control per unit of area to be economically justified should be no greater than $121.57/ha ($49.20/ac) for methiocarb, $456.64/ha ($184.80/ac) for shooting and exploders, and $504.08/ha ($204/ac) for all methods together. Comparing the actual costs of control (Table 1) with our theoretical costs, methiocarb is not economically worthwhile, while shooting and exploders alone or together with methiocarb appear economically justified.

However, we suggest further economic analyses beyond the simple cost-benefit graph and equation for the selection of an appropriate control program. Using basic initial data (cost of control per unit of area, efficacy of control, value of the crop, average yield per unit of area with no damage, and anticipated level of damage) and the format outlined in Table 2, it is possible to derive figures for the amount and value of crop to be saved at a given efficacy level, the control cost per pound of crop saved, benefit:cost ratios, and perhaps most importantly, total income after control costs are deducted.

Table 2. Economic analyses of blackbird control methods employed in wild rice in Shasta County, California, 1984. (English units of measurement only are used in the table.)

Item	Control method: No control	Methiocarb	Shooting and propane exploder	Methiocarb, shooting & propane exploders
Cost of control ($)/ac	0	80.00	84.61	164.61
Expected reduction in damage (%)[1]	0	20.5	77.0	85.0
Anticipated damage/ac before control justified				
Cost ($)[2]	-	390.24	109.88	193.66
lbs. lost[3]	-	487.8	137.4	242.1
% of crop lost[4]	-	32.5	9.2	16.1
Wild Rice saved/ac if control applied (lb)[5]	-	61.5	231.0	255.0
Potential yield if control applied (lb/ac)	1,200	1261.5	1431.0	1455.0
Cost ($)/lb saved[6]	-	1.30	0.37	0.64
Benefit:cost ratio for each pound of crop saved[7]	-	0.62	2.16	1.25
Total yield (lb)[8]	120,000	126,150	143,100	145,500
Gross income ($)[9]	96,000	100,920	114,480	116,400
Total Cost of Control ($)[8]	-	8,000	8,461	16,461
Income After Control ($)	96,000	92,920	106,019	99,939

[1]Value for methiocarb based on Moulton (1979), average of all plots over two years; for shooting and propane exploders, based on Conover (1984); both together based on authors' estimate.
[2]See Dolbeer 1981; y=bx, where y=cost of control/ac, b=expected reduction in damage, x=cost of anticipated damage/ac. For methiocarb, 80=.205x; shooting and propane exploders, 84.61=.77x; both methods, 164.61 = .85x.
[3]Based on wild rice value of $0.80/lb; for methiocarb, $390.24 is equivalent to 487.8 lb.
[4]Based on average yield of 1500 lb/ac if there is no bird damage, therefore for methiocarb [(487.8 lb/ac)/(1500 lb/ac)](100%)=32.5%.
[5]If 20% or 300 lb/ac removed by birds with no control, then for methiocarb, a 20.5% reduction in damage, or .205 x 300 lb = 61.5 lb/ac saved.
[6]For methiocarb, ($80/ac)/(61.5 lb/ac) = $1.30/1b.
[7]For methiocarb $0.80/$1.30 = 0.62.
[8]For 100 ac in production.
[9]At $.80/lb of wild rice.

In Table 2 we compare the control measures used on our study site in Shasta County plus an additional option, no control. In the cost-benefit equation, $y \leq bx$, the initial step is to determine y, cost of control per unit of area, based on the values of b and x. In the format outlined in Table 2, y is determined first and is then used to calculate x, which is now the lowest cost of anticipated damage per unit of area at which control is justified. This is perhaps a more realistic approach; it is possible to determine actual costs when contemplating a given control measure. The value of x is then converted into pounds of crop lost and the percentage of crop lost. The latter figure is the lowest level of yield reduction or crop damage by the pest that should occur if use of the potential control measure is to be justified.

The amount of crop saved per acre, the potential yield per acre, and the cost per pound of crop saved can be calculated in this analysis. The cost per pound saved should be less than the value per pound of the crop if the benefit:cost ratio is to be favorable. A benefit:cost ratio below 1.0, such as for methiocarb at 0.62, is not favorable. The calculated value of 0.62 means that for every dollar spent on control, only $0.62 in benefit (crop saved) is realized. In our example shooting and exploders have the best benefit:cost ratio at 2.16.

Final calculations determine total yield in pounds and income levels before and after control costs are deducted. The results in our example indicate no control at all results in greater income than achieved with methiocarb. Using methiocarb resulted in a larger overall yield, but the cost more than offset any gains in yield. Although we knew from the cost-benefit graph that shooting and exploders alone or with methiocarb were economically justified, it becomes obvious from Table 2 that the former control program has the best benefit:cost ratio and results in the greatest income.

The format in Table 2 is especially useful in comparing control measures where a range of efficacy estimates, anticipated damage levels, or costs may be possible. For example, Table 3 examines methiocarb at an efficacy level of 39.3%, the best single value for any one plot reported by Moulton (1979). Also included in Table 3 are shooting and exploders at a lower efficacy of 50%, and shooting and exploders at the original efficacy of 77% but with increased costs due to the use of steel shot ($172/case). Some wild rice fields are used as waterfowl hunting areas after the growing season. There is a possibility of waterfowl lead poisoning on these sites, especially if shooting with lead shot for blackbird control has been extensive.

Table 3. Economic analysis of blackbird control methods using highest reported efficacy for methiocarb, shooting (lead shot) and exploders at 50% efficacy, and shooting (steel shot) and exploders at 77% efficacy. (English units of measurement only are used in the table.)

	Control method		
Item	Methiocarb	Shooting (lead shot) propane exploders	Shooting (steel shot) & propane exploders
Cost of control ($)/ac	80.00	84.61	170.21
Expected reduction in damage (%)[1]	39.3	50.0	77.0
Anticipated damage/ac before control justified			
Cost ($)[2]	203.56	169.22	221.05
lbs. lost[3]	254.4	211.5	276.3
% of crop lost[4]	17.0	14.1	18.4
Wild Rice saved/ac if control applied (lb)[5]	117.9	150.0	231.0
Potential yield if control applied (lb/ac)	1317.9	1350.0	1431.0
Cost ($)/lb saved[6]	0.68	0.56	0.74
Benefit:cost ratio for each pound of crop saved[7]	1.18	1.43	1.08
Total yield (lb)[8]	131,790	135,000	143,100
Gross income ($)[9]	105,432	108,000	114,480
Total Cost of Control ($)[8]	8,000	8,461	17,021
Income After Control ($)	97,432	99,539	97,459

[1]Value for methiocarb based on Moulton (1979), best control for any one plot.
[2]See Dolbeer 1981; y=bx, where y=cost of control/ac, b=expected reduction in damage, x=cost of anticipated damage/ac. For methiocarb, 80=.393x; shooting (lead shot) and exploders, 84.61=.50x; shooting (steel shot) and exploders, 170.21=.77x.
[3]Based on wild rice value of $0.80/lb; for methiocarb $203.56 is equivalent to 254.4 lb.
[4]Based on average yield of 15-0 lb/ac if there is no bird damage, therefore for methiocarb [(254.4 lb/ac)/(1500 1b/ac)](100%)=l7.0%.
[5]If 20% or 300 lb/ac removed by birds with no control, then for methiocarb, a 39.3% reduction in damage, Or.393 x 300 lb = 117.9 lb/ac.
[6]For methiocarb,($80/ac)/(117.9lb/ac) = $0.68/lb.
[7]For methiocarb, $0.80/$0.68 = 1.18.
[8]For 100 ac in production.
[9]At $0.80/lb of wild rice.

In comparing all three programs, each has a favorable benefit:cost ratio with shooting (lead shot) and exploders still giving the highest final income. However, if lead shot could not be used, there would be little difference in final income between a steel shot shooting and exploder program versus the methiocarb alone and an increase in total income of about $1450 over no control at all.

DISCUSSION

There are two problems in application of the benefit-cost model to bird damage control programs: 1) determination of estimated damage levels, and 2) efficacy data for individual control methods and combinations of methods. Clearly both are subjects for future research.

For estimating damage levels there is little documentation in the literature, with the possible exception of blackbird damage in corn. Fluctuating population levels from year-to-year and the high mobility of birds also complicate prediction of damage levels. We need data relating specifically to the wide range of crops that birds may attack, by geographical region and by bird species if the model is to be applied on a commercial basis. Reports of specific damage are important for setting a probable range of damage levels. For blackbirds, distance from a roost may be important in predicting damage to corn (Dolbeer 1981) and may prove useful in other crops as well. However, without the hard data required, we will have to rely on past experience at a particular site and/or best estimates based on findings in other crops.

In wild rice, reliance on past history and best estimates also applies to efficacy. Except for methiocarb (Moulton 1979), there are no published studies of the efficacy of bird control methods in wild rice. Findings from other crops and regions may not be applicable to blackbirds in wild rice. For example, besides its value as a food item, wild rice is an attractive roosting habitat for blackbird flocks. The height, structure, stem density, and location over water of wild rice is comparable to a cattail (*Typha* spp.) or bulrush (*Scirous* spp.) marsh. In some locations of the Central Valley of California, blackbirds even nest *in wild* rice (Gorenzel), pers. observ.). Roosting and nesting in the crop, as well as the suitability of nearby habitat and the availability of alternate food sources introduce variables that could influence the efficacy of any given control method.

In Table 3, shooting with steel shot and exploders together were comparable to methiocarb alone in terms of final income. The decision on which program to use might then be based on ease of application, labor availability, timing with other crop management procedures, initial cash outlay, total costs, or other factors. A disadvantage of chemical methods is that once the material is applied, the grower is committed to paying the total costs. With a shooting-scaring program, the degree or intensity of application, and therefore the costs, can be altered over time to meet the need. The options of lowering or raising the level of effort, stopping, or restarting such a control program are available. In addition, the efficacy of chemical repellents and toxicants may be influenced by weather factors. A rainstorm shortly after an application may reduce efficacy to low levels, and label directions may prohibit retreatment. The impact on the benefit:cost ratio is obviously detrimental. In regions where rainfall is possible, selection of a control method vulnerable to weather factors is a gamble.

This model puts control costs in perspective with potential losses. Growers often must decide between a number of available control methods and the degree of implementation. In the end, this all relates to income either lost or saved for the grower. The grower should not only select a control method with a favorable benefit:cost ratio, but a method that maximizes that value. The model emphasizes that point by calculating income after control costs are deducted. Despite the gaps in our knowledge concerning efficacy and damage levels mentioned above, the model is flexible and permits evaluation of benefit:cost ratios using a range of estimated damage and efficacy values. As additional research findings become available, they can be incorporated into the model to broaden its application and refine its accuracy.

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