ELSEVIER

Agriculture, Ecosystems and Environment 65 (1997) 141–149

Agriculture Ecosystems & Environment

Economics of cattail (*Typha* spp.) control to reduce blackbird damage to sunflower

J.A. Leitch [a,*], G.M. Linz [b], J.F. Baltezore [c]

[a] *Department of Agricultural Economics, North Dakota State University, Fargo, ND 58105, USA*
[b] *U.S. Department of Agriculture, Denver Wildlife Research Center, North Dakota Field Station, Bismarck, ND 58504, USA*
[c] *St. Paul Bank for Cooperatives, Fargo, ND 58102, USA*

Accepted 24 March 1997

Abstract

A benefit/cost analysis of cattail (*Typha* spp.) control to reduce sunflower depredation by blackbirds was conducted to identify trade-offs and to estimate the efficacy of chemical treatment. Although reductions in populations of certain species, such as upland game, may occur with cattail control, populations of other species such as waterfowl, may be enhanced. With all factors considered, both sunflower producers and society were found to benefit from creating a 70:30 ratio of open water and cattails. © 1997 Elsevier Science B.V.

Keywords: Cattail (*Typha* spp.) control; Sunflower damage; Economics; Glyphosate; Blackbirds

1. Introduction

Agricultural and wildlife interest groups often disagree on what is proper land management (Leitch, 1989). However, managing cattails in prairie wetlands approaches a win-win situation in that it may reduce blackbird depredations to sunflower and increase waterfowl production (Kantrud, 1986, Solberg and Higgins, 1993, Linz et al., 1996a). Bird damage is one of the most persistent production problems reducing yields for sunflower growers (Kleingartner, 1989). While most growers in the northern great plains experience sunflower yield losses to birds of less than 5%, some experience losses of 10 to 25% or more (Lamey et al., 1993). Red-winged blackbirds (*Agelaius phoeniceus*), yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) and common grackles (*Quiscalus quiscula*) are the main seed predators (Homan et al., 1994). Total sunflower losses to birds in North Dakota in 1994 was about US$2.2 million or US$3.24/ha of sunflowers planted (Baltezore et al., 1994).

This study was initiated by the USDA's Animal and Plant Health Inspection Service after many years of sunflower depredation control research by agricultural and wildlife scientists. Their work has progressed far enough to begin to assess the economic trade-offs among various control methods. The paper describes a framework for assessing economic trade-offs, provides a first approximation of their values and identifies areas where data gaps still exist.

* Corresponding author. Tel.: 701-231-7467; fax: 701-231-7400; e-mail: coa-nrm@ndsuext.nodak.edu

PII S0167-8809(97)00061-3

2. Background

Wildlife damage to agricultural crops is a complex issue, involving many scientific disciplines and perspectives. The key issues are summarized below.

2.1. Damage factors

The extent and distribution of bird damage to sunflower fields depends on several factors (Otis and Kilburn, 1988), some of which can be influenced by management practices. Some of the most important factors are enumerated below.

2.1.1. Field size

The bigger the sunflower field, the less relative damage (although absolute damage may be invariant with respect to size).

2.1.2. Proximity to wetland

The farther from a roost wetland, the less damage. Fields within 3 km may experience losses greater than 15%; at 6 km, losses drop to about 8%; at 16 km, losses drop to about 2%; and beyond 19 km losses are negligible (Besser et al., 1979, Dolbeer, 1981).

2.1.3. Size of local wetlands

Bird numbers are related to the amount of roosting habitat in wetlands. The more extensive the roost sites, the greater the potential for more blackbirds.

2.1.4. Percentage of open water in local wetlands

The higher the percentage of open water in wetlands, the fewer blackbirds will roost there, regardless of wetland size. Few blackbirds will roost in wetlands, of the sizes found in the study area, when open water exceeds 70% of the wetland area (Linz et al., 1995).

2.1.5. Number of days birds feed in each field and number of birds

Total consumption is directly related to time spent in each field and the blackbird population.

2.2. Bird pest management

Management techniques for reducing bird damage to crops should be cost-effective, environmentally acceptable and easily implemented. Lethal control methods may not meet these criteria, especially given the public concern for the environment and animal welfare (Acord, 1992). Several nonlethal control methods (e.g., mechanical scare devices, including scaring with aircraft) also do not meet all of these conditions. Mechanical scare devices are generally not cost-effective and are labor-intensive (Cummings et al., 1986). Chemical repellents are generally not cost-effective (Dolbeer, 1981) and may have spillover environmental impacts (Besser et al., 1984). Some environmental alteration methods of reducing vegetative cover, such as burning, mowing or discing, are generally not cost-effective, yet are easily implemented and cause little lasting environmental concern (Baltezore et al., 1994).

Most sunflower producers rely on some type of cultural practice to minimize bird damage (Linz et al., 1993). These include not planting sunflowers next to wetlands or shelter belts, planting an unattractive buffer crop, planting lure crops (Cummings et al., 1987), coordinating planting with neighbors to encourage uniform ripening, and delaying tillage on adjacent harvested cropland. However, if all other methods are taken to their efficient extremes and damage persists, a more aggressive strategy of environmental alteration could be considered. One new strategy is to minimize blackbird roosting habitat (i.e., cattails) with herbicides, specifically glyphosate (Rodeo® formulation, Monsanto, St. Louis, MO, USA), which is approved for aquatic use (Linz et al., 1995).

Dispersal of blackbirds, by reducing their local densities, may reduce absolute, or total, damage by allowing for compensatory growth in sunflower heads (Sedgwick et al., 1986). Compensatory growth, which can range from 6 to 44% only occurs when the seed is removed from the head during the first 2 weeks after anthesis and seed removal per head does not exceed a threshold (Sedgwick et al., 1986). Yield (based on weight) between damaged and undamaged heads does not differ significantly if 15% or less of the developed seed area on a sunflower head is removed during the soft-seed developmental stage.

The benefit of cattail management included in the analysis below is the reduction in absolute damage.

2.3. Cattail types

Common (*Typha* spp.), narrow-leaved (*Typha angustifolia*) and hybrid (*Typha glauca*) cattails are found in North Dakota (Kantrud, 1986). The first discovery of narrow-leaved cattails in North Dakota was in 1942. During the last 50 yr, hybrid cattail spread rapidly across the Prairie Pothole Region and is now the most abundant hydrophyte in North Dakota (Kantrud, 1986). Control of hybrid cattails is difficult due to a large rhizome system and ability to tolerate water up to 60 cm deep for an extended period of time (Linde et al., 1976).

Forces of climate, grazing and fire were once natural regulators of the abundance and species composition of vegetation in prairie wetlands (Kantrud, 1986). However, more intensive agriculture and the near elimination of wild prairie fires allowed cattail to spread rapidly. Roadway ditches also facilitated the spread of narrow-leaved cattails.

2.4. Benefits of wetlands

The list of wetland benefits has been widely published. Generally, wetland benefits fall into several categories, including: terrestrial wildlife habitat, aquatic habitat, groundwater recharge, flood control, sediment entrapment, nutrient assimilation, aesthetics and education/research (CAST, 1994).

Only terrestrial wildlife habitat and aquatic habitat were considered in this study. We assume that with the type of vegetation alteration and the location of managed wetlands considered, changes in the other benefits are minimal or zero, and will not affect general conclusions. The validity of such assumptions (e.g., ignoring groundwater) will need to be assessed by further research, beyond the scope of this 'meta-analysis.'

Our objective was to demonstrate that costs and returns for the anticipated changes resulting from various levels of chemical control of cattails could be estimated. Since costs and benefits accrue to both individual producers and to society in general, we evaluated cattail control from both perspectives. However, the study was done more to demonstrate the analysis, than to estimate precise numbers. We wanted to identify major factors involved and to assemble available data reflecting relationships among those factors. While scientific data are available and robust in some areas, they are all but absent or speculative in other areas. Thus, part of our contribution is identification of data needs and first-order approximations of their likely magnitudes, without which economic analyses cannot be accomplished and an improved allocation of society's resources would only occur by chance.

3. Methods

An analytical model (shown as a flow chart in Fig. 1) was developed to assess the economics of cattail management. A literature search and visits with experts helped to locate or develop data to operationalize the model. Assumptions, hopefully reasonable, were made when necessary. Those that seem unreasonable to some will hopefully encourage them to come forward with better information.

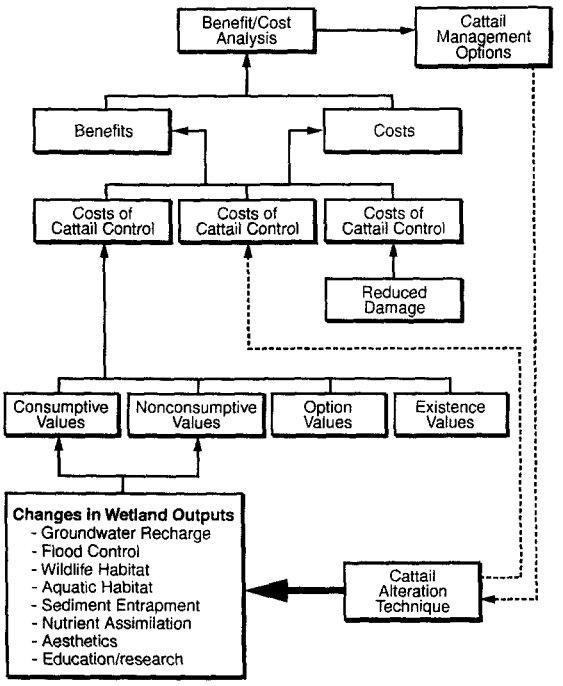

Fig. 1. Model flow chart for assessing the economics of cattail management.

The study area is the state of North Dakota, source of 60% of the country's sunflower production (North Dakota Agricultural Statistics Service, 1994). Bird damage is heaviest in counties within the Prairie Pothole Region, over half of the state's area, because they are primary sunflower production areas and have the highest concentration of individual water areas per square mile of any region in the lower 48 states, up to 54 wetlands per square kilometer (Stewart, 1975). Counties outside the PPR have only isolated cases of bird damage since they lack both preferred bird habitat (i.e., wetlands and cattails) and suitable agronomic conditions to produce sunflowers.

4. Results

Application of glyphosate to cattails impacts the natural environment; sunflower producer returns; and food, business activity, and environmental outputs valued by society. The results are generalizations and not intended to represent all situations nor to capture all conceivable efforts.

4.1. Natural environment impacts of glyphosate

Emergent vegetation, mainly cattails, is the primary vegetation in a wetland that is impacted when herbicides are applied. Glyphosate applied to cattail stands can reduce the number of live cattail stems 99.7% 1 yr after treatment (Solberg and Higgins, 1993). Cattail vegetation is sometimes replaced by other plants (Solberg and Higgins, 1993), however cattail usually regenerates in the sprayed areas (Linz et al., 1995). Algae can tolerate the low concentrations of glyphosate necessary to control cattail (Overland, 1995).

Various wildlife species will be affected by cattail habitat alteration. Cattails provide essential winter cover for many species, especially deer, furbearers and many nonmigratory birds (Kantrud et al., 1989). Nearly 100 species of birds use North Dakota wetlands (Blixt, 1993). Water bird populations generally are thought to be little affected by cattail–open-water ratios up to 50% open water, but then, with the exception of shorebirds, populations drop off as percentage of open water approaches 100. The number of sparrows and perching birds are reduced at high treatment levels (70–90%) (Fig. 2). Cattail control at moderate levels (50–70%) may increase the numbers of rails and shore birds by increasing access to shallow water and mudflat habitats (Blixt, 1993). Upland game birds may be adversely affected by cattail control, since they require dense, tall winter cover (Stromstad, 1992). Finally, waterfowl populations increase when cattail-choked wetlands are frag-

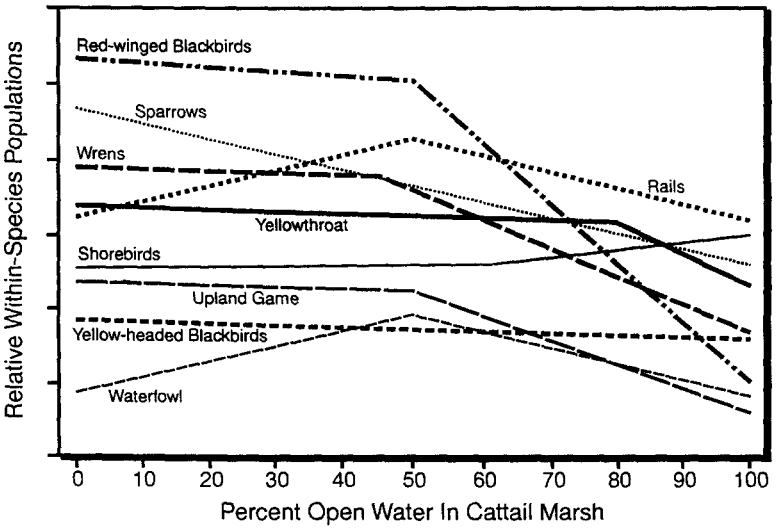

Fig. 2. Estimated relationship between avian species and percentage of open water in wetland (Source: Unpublished expert opinion).

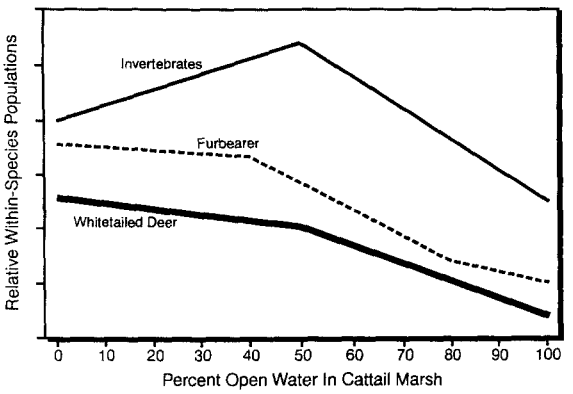

Fig. 3. Estimated relationship between invertebrate, furbearer and deer and the percentage of open water in wetland (Source: Unpublished expert opinion).

mented. Waterfowl populations do best under 'hemi-marsh' (50% open water and 50% emergent vegetation) conditions (Murkin et al., 1982, Linz et al., 1996b).

Cattail-choked wetlands provide thermal and escape cover for white-tailed deer, enhancing the chances of winter survival (Kantrud, 1986). However, little research has been done on the relationship between deer populations and cattail concentrations. Furbearer numbers are thought to decline slowly as the percentage of open water increases up to 40%, then drop more dramatically as it approaches 80% (Fig. 3).

4.2. *Sunflower producer returns*

The primary economic factors considered by individual producers are control costs and expected returns from cattail management. Producer decisions are assumed to be primarily based on profitability, although other factors influence decisions. The producer must decide if the habitat-altering technique will provide positive net returns. Agricultural producers are often motivated by outcomes other than profit, such as removal of a nuisance or the pride of being a 'good' farmer. Producers, however, are often compelled by state and federal law to maintain wetlands for the public good. They are, thus, faced with an unusual situation: they must protect wetland for society but that protection may contribute to personal financial losses.

Many producers are unlikely to place much value on changes in the natural outputs of wetland, nor to include them in their decision-making process. Most producers receive few direct benefits from these types of wetland and typically incur ownership costs. However, other incentives to maintain natural diversity may be emerging, such as some sustainable agriculture systems that incorporate nature conservation.

Many other factors complicate the cattail control issue from the producer's perspective. Some wetlands have several owners, who may have different interests. Some wetlands are owned by absentee landowners or the government. Farmers near, but not owning, wetlands can benefit without contributing. Farmers rotate sunflower on a 3- to 5-yr schedule and would not benefit from cattail control in years they do not raise sunflowers unless they experienced blackbird damage on other crops. Cattail control on selected wetlands may shift the problem to other, uncontrolled wetlands. Finally, it is not certain that blackbirds will be a problem in the next year, so control investments made this year may not have been necessary.

The cost of treating cattail with Rodeo® is US$136 (1994 dollars) per wetland hectare (Linz et al., 1995). Nearly 90% of the cost is herbicide expense, with application costs of about US$12/ha, and surfactant and drift retardant costs of about US$2.50/ha. A treatment cost of US$136 in 1 yr eliminates emergent cattail for the three following seasons or longer (Solberg and Higgins, 1993, Linz et al., 1995), so the annualized cost, at 6% discount rate, is US$52/ha.

A 10.12-ha wetland fully choked with cattails can contain more than 32,750 birds (Table 1), resulting in up to US$3437 damage to adjacent sunflower fields (Table 2). Treating the first 2.0 ha at a cost of US$125 reduces the number of birds by more than 6500 and the damage by US$687, resulting in a net return of US$562. Treatment of less than two cattail ha was not considered, nor was treatment beyond 7.28 ha which represented 70% open water and the end of treatment benefits.

The net benefit is maximized by treating 7.28 cattail ha (70% of the total) (Table 2, Fig. 4). At this point, there are few birds remaining to cause damage (Linz et al., 1995). The total treatment benefit is

Table 1
Average birds per cattail hectare, North Dakota wetlands

Wetland[a]	Wetland hectares[a]	Percentage choked[b]	Cattail hectares[c]	Blackbirds[a]	Bird adjustments factor[d]	Total birds[e]	Birds per cattail hectare[f]
Ibsen	520	90	468	142,100	1.6	225,939	483
Blegens	15	90	13	46,300	1.6	73,617	5663
Mikes	176	90	158	36,200	1.6	57,558	364
Pelican	300	90	270	26,100	1.6	41,499	154
Command	9	90	9	58,146	1.6	92,452	10,272
Swensons	4	90	4	5133	1.6	8161	2040
Johns	6	90	5	16,096	1.6	25,593	5119
Peterburg	22	90	20	12,562	1.6	19,974	999
Average	132	N.A.	118	42,830	N.A.	68,099	577

[a]Information is based on Linz et al. (1991).
[b]The exact percentage choked was unavailable. However, wetlands selected for study were those between 70 and 100% choked.
[c]Cattail hectare were wetland hectare times the percentage choked.
[d]The number of birds was adjusted to account for common grackles. The average number of blackbirds per wetland is 42,830. The distribution of birds is 63% red-winged and yellow-headed blackbirds and 37% common grackles (Nelms, 1991). This implies that the average total number of blackbirds and common grackles per wetland is 67,900 (42,830/0.63). The bird adjustment factor equals the average total number of blackbirds divided by the average total number of all birds (blackbirds and common grackles) or 1.6 (67,900/42,830).
[e]The number of blackbirds times the adjustment factor equals total birds.
[f]Total birds divided by cattail hectare equals birds per cattail hectare.

US$3437 and total treatment cost is US$378, for a net benefit exceeding US$3000. The net benefits decrease as more than 7.28 ha are treated since costs continue to increase but total benefits do not change.

4.3. Society

Society's perspective accounts for all economic impacts to the producer and to society. Society bene-

Table 2
Sunflower producer cost-returns analysis of habitat alteration using herbicide on a 10-ha wetland in North Dakota, 1994

Birds[a]	Treated cattail (ha)	Sunflower damage: period one[b] (US$)	Sunflower damage: period two[b] (US$)	Total sunflower damage (US$)	Total treatment returns (US$)	Total treatment cost (US$)	Net treatment returns (US$)
32,750	0.00	1466	1970	3437	0	0	0
26,200	2.02	1173	1576	2749	687	125	562
23,580	2.83	1056	1419	2475	962	147	815
19,650	4.05	880	1182	2062	1375	210	1165
17,030	4.86	763	1025	1787	1650	252	1398
15,720	5.26	704	946	1650	1787	273	1514
13,100	6.07	587	788	1375	2062	315	1747
10,480	6.88	469	631	1100	2337	357	1980
0	7.28	0	0	0	3437	378	3059

[a]Assumes a 10.12-ha wetland that is fully choked with cattails.
[b]See Section 4.2 for details on damage estimates.
[c]Total sunflower damage if no cattails are treated (US$3770) minus total sunflower damage for the specific number of cattail hectare treated.
[d]Annualized treatment costs are US$52 per cattail hectare. A minimum of 2 cattail ha must be treated at a cost of US$125.
[e]Total treatment benefit minus total treatment cost. Thus, from a producer's perspective, it pays to treat cattails up to 70% open water, given the assumptions and relationships of our model.

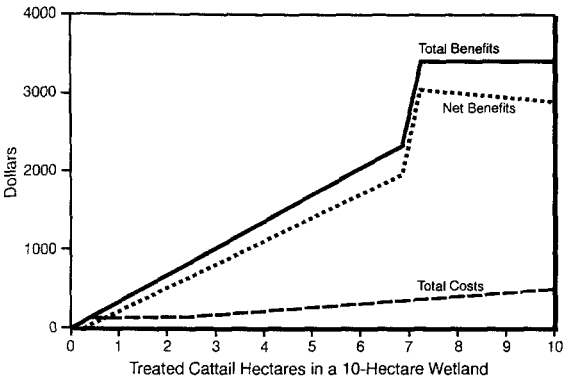

Fig. 4. Producer benefits, costs and net benefits of habitat alteration using Rodeo® herbicide, North Dakota, 1994.

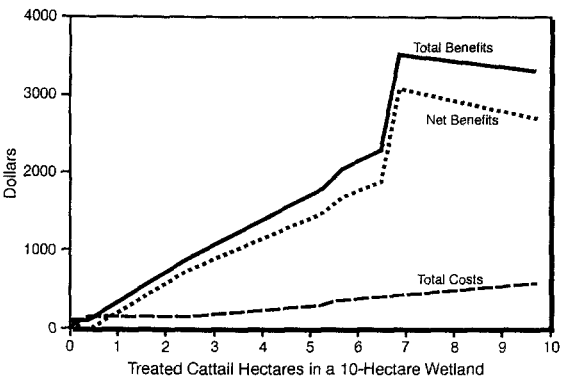

Fig. 5. Societal benefits, costs and net benefits of habitat alteration using Rodeo® herbicide, North Dakota, 1994.

fits from the net treatment returns to the producer. The additional sunflower produced are available to society, taking into account the slightly reduced price due to more sunflower available. We assume the market accurately reflects the value society places on sunflower products. Society also benefits from the positive effects on waterfowl production, which are maximized at about 50% open water. Society loses benefits in the form of reduced deer, furbearer and upland game bird numbers. Net societal wildlife

Table 3
Societal benefit and costs of habitat alteration using Rodeo® herbicide in North Dakota, 1994

Birds[a]	Treated cattail (ha)	Societal benefit: sunflower[b] (US$)	Waterflowl benefit (US$)	Deer benefit (US$)	Furbearer benefit (US$)	Upland benefit (US$)	Societal benefit: wildlife[c] (US$)	Societal benefit total[d] (US$)	Total treatment cost[e] (US$)	Net benefit[f]
32,750	0.00	0	0	16	32	25	73	73	0	73
30,130	0.81	150	5	15	30	23	72	222	125	97
28,820	1.21	287	7	14	28	22	72	359	125	234
27,510	1.62	425	10	14	27	21	71	496	125	371
26,200	2.02	562	12	13	26	20	71	633	125	508
23,580	2.83	815	17	12	23	18	70	885	147	738
19,650	4.05	1165	24	10	19	15	68	1233	210	1023
17,030	4.86	1398	29	9	17	13	67	1465	252	1213
15,720	5.26	1514	29	8	15	12	64	1578	273	1305
13,100	6.07	1747	24	7	13	10	53	1800	315	1485
10,480	6.88	1980	19	5	10	8	43	2023	357	1666
0	7.28	3059	17	5	9	7	37	3096	378	2718
0	7.69	3038	14	4	8	6	32	3070	399	2671
0	8.09	3017	12	3	6	5	27	3044	420	2624
0	8.90	2975	7	2	4	3	16	2991	462	2529
0	9.71	2933	2	1	1	1	5	2938	504	2434
0	10.12	2912	0	0	0	0	0	2912	525	2387

[a]Assumes a 10.12-ha wetland that is fully choked with cattails.
[b]Benefits are from the 'Net treatment returns' column in Table 2.
[c]Total of waterfowl, deer, furbearer and upland wildlife benefits.
[d]Total of sunflower and wildlife societal benefits.
[e]Annualized treatment costs are US$52 per cattail hectare.
[f]Total societal benefit minus total treatment cost.

benefits are at their highest when no cattail acres are treated, but when the social benefits of increased sunflower production are considered, society's benefits are also maximized at 70% treated (Table 3, Fig. 5). This social benefit maximization point is largely a function of an earlier assumption. The important implication is that, at least up to this point, agricultural producers and most wildlife experts can agree that cattail control is beneficial.

Regional economic development benefits were not estimated. However, given the agricultural-based infrastructure of rural communities in North Dakota, cattail control would likely increase local business activity and employment.

5. Conclusions

Based on the best available information with which to demonstrate the analytical approach, it appears that some chemical control of cattails in areas of sunflower production is beneficial to both producers and to society. The results are sensitive to a number of factors, but provide a relatively conservative first approximation of the economics of cattail control to reduce bird depredation on sunflowers. Numerous assumptions regarding functional relationships among and between biological, management, agronomic, market and socioeconomic variables were made to reach the results of this study. Altering any of these estimates or assumptions, or adding variables to the model, may change the optimal level of cattail treatment for a particular wetland. Changes in the estimated number of birds per cattail hectare, the price of sunflower and sunflower consumption per bird per day are most likely to affect the optimal level of cattail treatment.

6. Implications

Sunflower producers benefit from higher returns and society benefits from both the increased well-being of producers and from improved waterfowl habitat. However, some beneficial outputs are reduced with cattail control. Consequently, beneficiaries of the lost benefits could be identified to determine if compensation for the loss of these benefits would be appropriate.

Financial gains realized by producers and by society should be sufficient, in theory, to compensate others whose benefits are reduced. Beneficiaries should be willing to pay for cattail control and to compensate others for their losses. Excluding any beneficiary from these financial responsibilities allows them to become a 'free rider' on the system, to benefit from others' expenses. The issue becomes the appropriate share of the costs that each beneficiary should contribute and how to identify and compensate losers, if at all. The determination of absolute levels each should contribute is the responsibility of policy makers and a function of the ability of real-world institutions to incorporate these results.

This study has put the economics of cattail control in a framework that provides both a preliminary estimate of its feasibility and identifies the important assessment variables so that others can advance the science in those areas.

7. Research needs

Benefit/cost analysis requires an explicit identification and quantification of all the benefits and all the costs to whomever they may accrue, now and in the future. Estimating the net benefit of cattail control necessitated a number of assumptions based on professional judgment. Confidence in the quantitative results would increase if additional experimental research on the optimal size, configuration and density of vegetation patches in relation to water depth and coverages and the populations of all wildlife species that use wetlands, were conducted. Additionally, research on the relationship of wildlife species that use wetlands, and crop production should be explored.

Acknowledgements

E. Hill, S. Hirsch, L. Huffman, R. John, C. Lucken and M. McEnroe provided helpful comments on an earlier version of this manuscript. This project was supported by the US Department of Agriculture, Animal and Plant Health Inspection Service, Denver Wildlife Research Center; North Dakota Agricultural Experiment Station and Departments of Agricultural

Economics and Zoology, North Dakota State University, Fargo. Thanks to D. Reff and S. Swandal for preparing the manuscript.

References

Acord, B.R., 1992. Responses of the ADC program to a changing American society. Vertebr. Pest Conf. 15, pp. 9–11.

Baltezore, J.F., Leitch, J.A., Linz, G., 1994. The economics of cattail management: assessing the trade-offs. Agric. Econ. Rep. No. 320, Agric. Exp. Station, North Dakota State Univ., Fargo, ND, 67 pp.

Besser, J.F., Berg, W.J., Knittle, C.E., 1979. Late-summer feeding patterns of red-winged blackbirds in a sunflower-growing area of North Dakota. Proc. of the Eighth Bird Control Seminar, Bowling Green State Univ., Bowling Green, OH.

Besser, J.F., Brady, D.J., Burst, T.L., Funderberg, T.P., 1984. 4-aminopyridine baits on baiting lanes protect sunflower fields from blackbirds. Agric. Ecosys. Environ. 11, 281–290.

Blixt, D.C., 1993. Effects of glyphosate-induced habitat alteration on birds. M.S. thesis, North Dakota State Univ., Fargo, ND, 127 pp.

CAST, 1994. Wetland policy issues. Counc. for Agric. Sci. and Technol., Ames, IA, 47 pp.

Cummings, J.L., Guarino, J.L., Knittle, E.E., Royall, W.C. Jr., 1987. Decoy plantings for reducing blackbird damage to nearby commercial sunflower fields. Crop Prot. 6, 56–60.

Cummings, J.L., Knittle, C.E., Guarino, J.L., 1986. Evaluating pop-up scarecrow coupled with a propane exploder for reducing blackbird damage to ripening sunflower. Vertebr. Pest Conf. 12, 286–291.

Dolbeer, R.A., 1981. Cost-benefit determination of blackbird damage control for cornfields. Wildl. Soc. Bull. 9, 44–51.

Homan, H.J., Linz, G.M., Bleier, W.J., Carlson, R.B., 1994. Dietary comparisons of adult male common grackles, red-winged blackbirds, and yellow-headed blackbirds in North Central North Dakota. Prairie Naturalist 26, 273–281.

Kantrud, H.A., 1986. Effects of vegetation manipulation on breeding waterfowl in prairie wetlands: A literature review. Tech. Rep. 3, U.S. Fish Wildl. Serv., Washington DC, 15 pp.

Kantrud, H.A., Krapu, G.L., Swanson, G.A., 1989. Prairie basin wetlands of the Dakotas: a community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85, 116.

Kleingartner, L., 1989. Blackbird controls still on front burner. Sunflower 15, 32–33.

Lamey, H.A., McMullen, M.P., Berglund, D.R., Luecke, J.L., McBride, D.K., Zollinger, R.K., 1993. 1992 sunflower grower survey of pest problems and pesticide use in Kansas, Minnesota and North Dakota. Ext. Serv. Rep. No. 14, North Dakota State Univ., Fargo, ND, 16 pp.

Leitch, J.A., 1989. Politicoeconomic overview of prairie potholes. In: van der Valk, A. (Ed.), Northern Prairie Wetlands. 400 pp.

Linde, A.F., Janisch, T., Smith, D., 1976. Cattail: The significance of its growth, phenology and carbohydrate storage to its control and management. Dept. of Nat. Resour. Tech. Bull. No. 94, Madison, WI, 26 pp.

Linz, G.M., Bergman, D.L., Homan, H.J., Bleier, W.J., 1995. Effects of herbicide-induced habitat alterations on blackbird damage to sunflower. Crop Prot. 14, 625–629.

Linz, G.M., Blixt, D.C., Bergman, D.L., Bleier, W.J., 1996a. Responses of red-winged blackbirds, yellow-headed blackbirds and marsh wrens to glyphosate-induced alterations in cattail density. J. Field Ornith. 67 (1), 167–176.

Linz, G.M., Blixt, D.C., Bergman, D.L., Bleier, W.J., 1996b. Response of ducks to glyphosate-induced habitat alternations in wetlands. Wetlands 16, 38–44.

Linz, G.M., Dolbeer, R.A., Hanzel, J.J., Huffman, L.E., 1993. Controlling blackbird damage to sunflower and grain crops in the Northern Great Plains. Agric. Inf. Bull. No. 679, Animal and Plant Health Inspection Service, USDA, 15 pp.

Linz, G.M., Kittle, C.E., Cummings, J.L., Davis, J.E. Jr., Otis, D.L., Bergman, D.L., 1991. Using aerial marking for assessing population dynamics of late summer roosting red-winged blackbirds. Prairie Naturalist 23 (3), 117–126.

Murkin, H.R., Kaminski, R.M., Titman, R.D., 1982. Responses by dabbling ducks and aquatic in vertebrates to an experimentally manipulated cattail marsh. Can. J. Zool. 60, 2324–2332.

Nelms, C.O., 1991. Population estimates and comparison of sampling methods of breeding blackbirds in North Dakota. M.S. thesis, North Dakota State Univ., Fargo, ND.

North Dakota Agricultural Statistics Service, 1994. Agric. Stat. No. 63, North Dakota State Univ., Fargo, ND, 112 pp.

Otis, D.L., Kilburn, C.M., 1988. Influence of environmental factors on blackbird damage to sunflower. U.S. Fish Wildl. Tech. Rep. 16, 11.

Overland, J.O., 1995. Effects of glyphosate-induced changes in wetland vegetation on aquatic invertebrates and water quality. M.S. thesis, North Dakota State Univ., Fargo, ND.

Sedgwick, J.A., Oldemeyer, J.L., Swenson, E.L., 1986. Shrinkage and growth compensation in common sunflowers: Refining estimates of damage. J. Wildl. Manage. 50, 513–520.

Solberg, K.L., Higgins, K.F., 1993. Effects of glyphosate herbicide on cattails, invertebrates and waterfowl in South Dakota wetlands. Wildl. Soc. Bull. 21, 229–307.

Stewart, R.E., 1975. Breeding birds of North Dakota. Center for Studies, Tri-College Univ., Fargo, ND. 295 pp.

Stromstad, R., 1992. Cattail management: The North Dakota Game and Fish Department perspective. In: Linz, G.M. (Ed.), Proceedings of the Cattail Management Symposium. U.S. Department of Agric., Denver Wildl. Res. Cent. and U.S. Fish Wildl. Serv, Fargo, North Dakota, pp. 38–41.