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By C. Edward Knittle  
Richard D. Porter



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# Waterfowl Damage and Control Methods in Ripening Grain: An Overview

by

C. Edward Knittle and Richard D. Porter<sup>1</sup>

*U.S. Department of Agriculture  
Animal and Plant Health Inspection Service  
Denver Wildlife Research Center<sup>2</sup>  
P.O. Box 25266, Building 16, Federal Center  
Denver, Colorado 80225*

## Abstract

Damage to swathed grains by ducks, geese, and cranes is a long-standing problem in many parts of central North America. We describe the history of the problem, its nature and extent, its causes, and control tactics used; we also make recommendations for research and management.

The problem was first recognized in the early 1900's from a growing conflict involving increased agricultural use of the land, a perceived reduction of waterfowl habitat, and increasing populations of birds. The most damage occurred to swathed grain and frequently coincided with waterfowl migration and changeable weather conditions.

Damage occurs by direct consumption, contamination by feces, and trampling of swaths. More grain is trampled than consumed by waterfowl, the ratio being as much as 5:1. One Canadian researcher has estimated Canadian prairiwide losses of \$6-\$10 million annually. Losses to waterfowl on the northern Great Plains of the United States are largely undetermined. Waterfowl tend to select high points of large rolling fields that provide unobstructed views near bodies of water. Most grain farmers never suffer waterfowl damage; those that do usually tolerate it within reason. Tolerance to damage seems to be declining in a depressed farm economy. Most farmers are willing to alleviate the problem themselves unless a local situation becomes too severe.

Many methods are available to reduce losses, but success varies. Methods include permanent and temporary diversionary feeding programs such as baiting stations (United States and Canada) and lure-crops (Canada) on government and private land; hazing with exploders, shotguns, rifles, and pyrotechnic devices; scarecrows of many descriptions; and aircraft. Chemical agents such as repellents and soporifics have been tested sparingly and with limited success. New farming practices, such as planting overwintering grains, straight-combining standing grain, delayed plowing of grain stubbles, and no-till farming, show potential for reducing losses to waterfowl if birds are allowed to feed in these fields undisturbed. Public relations should include better use of the media for disseminating information about scare methods and tactics and forecasting migratory waterfowl movements. These forecasts would alert farmers to the potential for damage so they can implement scare tactics at the earliest possible time, thereby increasing their chances of success.

We summarize the background of depredation insurance and damage compensation programs in Canada, their successes, and pitfalls. Both methods seem to be relatively expensive and controversial even though they serve a need. Several potential sources of revenue are suggested to cover the cost of waterfowl damage prevention and damage abatement or mitigation programs, including use of the U.S. Federal Crop Insurance Program.

Foremost among recommendations made for wildlife managers and researchers in the United States are problem definition and quantification, use of the media to relay information to the agricultural community, implementation of lure-crops and bait stations, possible changes in farming practices, and research to further develop an environmentally safe and cost-effective chemical deterrent to minimize depredation by waterfowl.

<sup>1</sup>Present address: 325 N. 300 West Street, Mapleton, Utah 84663.

<sup>2</sup>The Denver Wildlife Research Center was transferred from the U.S. Department of the Interior to the U.S. Department of Agriculture in March 1986.

Crop damage by waterfowl and other aquatic birds in North America has been a problem almost since native lands were first opened to agriculture. Damage worsened after 1900, and by the mid-1940's it was widespread throughout many agricultural areas of the United States and Canada (Day 1944; Horn 1949; Colls 1951) and is still a problem (Vaudry 1974; Miller 1976).

We describe crop damage by waterfowl by providing (1) a brief history of the problem, (2) its nature and extent, (3) relation between cause and effect, (4) control methods and tactics, and (5) suggestions for research and management. The species of birds referred to in this paper as waterfowl are included in the subfamilies of Anatinae (ducks), Anserinae (geese), and Gruinae (cranes).

Although we recognize that waterfowl damage to crops occurs in many areas of North America, including California and the Gulf Coast, we focus on the north-central Great Plains of the United States and the south-central Canadian Provinces because the type of damage that occurs there is unique, that is, not only direct consumption but also substantial losses due to trampling of swathed, ripening grain by waterfowl. We included the Canadian prairie Provinces because their waterfowl crop-damage problems are similar to those of the United States, and because the Canadians have implemented definitive programs designed to cope with these problems.

## History of Crop Depredation by Waterfowl

The completion of transcontinental railroads in the 1860's in the United States and 1885 in Canada allowed easy access to the West, accelerated the conversion of native lands to agriculture, and increased the potential for conflict between waterfowl and agriculture (Vaudry 1974). By 1900, 1.6 million ha (4 million acres) of Canadian prairie were under cultivation; by 1936, 1950, and 1960 this increased to 23, 27, and 34 million ha (57, 67, and 85 million acres), respectively (Davault 1971; Kiel et al. 1972). The land area devoted to cereal crops in Canada increased 15-fold between 1900 and 1953 (Mair 1953). In the United States, an estimated 40.5 million ha (100 million acres) of marsh available to waterfowl in 1900 were converted to farmland by 1944 (Day 1944). By 1980, in North Dakota alone, almost 5.7 million ha (14 million acres) of wheat and barley were being grown (U.S. Department of Agriculture 1981).

Not unexpectedly, the drainage and cultivation of wetlands resulted in depredation by waterfowl, particularly since crops such as millet, wheat, barley, and corn grown

on the reclaimed areas became easily obtainable substitutes for the natural foods of some species of waterfowl. According to Colls (1951), the conflict between agriculture and waterfowl is a clash between people concerned with the destruction of waterfowl habitat by agriculture and those concerned with the destruction of agricultural products by waterfowl. As waterfowl habitat becomes more restricted, the likelihood of waterfowl damage to crops increases. Conversely, the more that damage occurs, the more likely that agriculturalists will restrict waterfowl habitat. Agriculture had greatly encroached on wildlife habitat throughout North America; large expanses of marsh were drained to increase tillable acreages (Paynter 1955).

Marshes that were restored as waterfowl refuges caused an inadvertent depredation problem in some areas. Hammond (1957, 1961) and Day (1944) noted that in 1905 settlers in the Lower Souris River region of North Dakota reported crop losses soon after the area was settled. Drainage of marshes and the drought of the early 1930's resulted in little use of the area by waterfowl until 1935 when two refuge dams were completed on what is now the J. Clark Salyer National Wildlife Refuge. In that year a few thousand ducks were attracted to the upper portion of the refuge. In 1936 two refuge units held water, and by September there were thousands of ducks; by October an estimated 150,000 ducks were present. In 1937, a third unit was added, and by 1938 an estimated 200,000 ducks were attracted to the refuge. The first serious crop-damage complaints occurred in 1939, concurrent with the large increase in ducks using the refuge (Fig. 1).

On a continental scale, Day (1944) attributed the increasing number of waterfowl to strict and protective law-enforcement programs, the restoration of about 1.4 million ha (3.5 million acres) of marshes in the United States and similar work in Canada, and the end of the drought and return of so-called normal water conditions in waterfowl breeding areas. By 1951, waterfowl populations had increased to an estimated 125 to 150 million birds (Biehn 1951).

Even in 1934-35, at the peak of the drought and the lowest point of waterfowl populations, crop damage occurred in some places because of demands for food by local concentrations of birds (Day 1944). But it was not until the early 1940's, during World War II, that depredation by waterfowl generally became a severe problem. Problems with large increases in waterfowl populations were compounded by a reduction in hunting pressure because of inadequate supplies of ammunition during the 1941-45 war years; rationing of gas, tires, and automobiles; shortage of farm help to harvest crops during



Fig. 1. Waterfowl feeding in harvested grain field near the J. Clark Salyer National Wildlife Refuge, North Dakota. (Photo by C. E. Knittle, USDA-DWRC)

the usual seasons; increased cultivation of marginal and submarginal lands to meet war production needs; and the rising prices of commodities (Day 1944).

Since the 1940's, biologists have gained considerable knowledge about depredation problems and methods for managing and reducing them, yet the resolution of these problems remains elusive.

## The Nature and Extent of Crop Losses

Wheat, barley, oats, and rice usually are the grain crops most seriously affected by waterfowl depredation. The principal species that cause damage are mallard (*Anas platyrhynchos*) and northern pintail (*A. acuta*) ducks, with lesser influence by snow (*Chen caerulescens*), Canada (*Branta canadensis*), and greater white-fronted geese (*Anser albifrons*); and the sandhill crane (*Grus canadensis*; Boyd 1979). MacLennan (1973) reported that cranes are more destructive than the other species implicated.

The nature and extent of waterfowl damage depends on geography and topography, the weather and season, the crop type and its maturity, method of crop harvest, and the synchrony of harvest and waterfowl migration. Although depredation occurs during all seasons, the most damage occurs on swathed grain during the autumn harvest. In the northern Great Plains of the United States and Canada, grain is traditionally cut and concentrated in swaths that lie on 15–25 cm (6–10 inches) stubble to dry and ripen uniformly before harvest. If the weather is warm, the crop can be harvested in 4 to 14 days; if not, more time is required (Paynter and Stephen 1964). Protracted wet, stormy weather extends harvest time, which in turn can increase waterfowl feeding on the crop, especially if migration has started. Although waterfowl also feed on waste grain in harvested stubble and in lightly cultivated fields, swathed grain is more abundant and accessible.

Damage to standing grain can also occur, although it is less frequent than in swathed grain. With the increasing





Fig. 2. Grain swaths showing severe trampling damage by waterfowl in Canada. (Photo by J. Marley, Calgary, Alberta)

trend toward whole-section cropping, small grains are seeded in wet areas or on hilltops where growth is sometimes impeded, thereby creating thin spots. Waterfowl may occasionally alight in these areas and begin consuming grain, moving outward. Moreover, new varieties of grain most suited for straight-combining tend to have shorter stalks, thus increasing the vulnerability to damage (Serduik 1980; Fairaizl 1981a).

Vaudry (1974) suggested that weed seed consumption and soil fertilization by ducks, although beneficial, are far outweighed by the damage they cause. Damage occurs primarily from direct consumption, contamination by feces, and trampling and compaction. The last activity knocks kernels from heads or may disconnect heads entirely (Fig. 2). Grain is frequently trampled into the ground where it becomes fouled, is nearly irretrievable by combines, and is susceptible to sprouting or freezing to the ground. Grain quality, market price, and use may be reduced or changed due to these feeding activities.

Ducks frequently trample and foul more grain than they eat. Fairaizl (1981a) found that 1,500 ducks ate 354 kg (13 bushels) of durum wheat in 2 days and trampled and fouled an additional 1,064 kg (39 bushels) for a total loss to the grower of 1,418 kg (52 bushels). Hammond (1951) reported that the amount of damaged or wasted grain was

less in wet weather (40% of that consumed) than in dry weather (460% of that consumed) because when damp the kernels were more difficult to dislodge from the head. Hammond (1961) later concluded that trampling and fouling of swathed grains exceeded consumption by ratios ranging from 1.5:1 to 5.5:1. These ratios varied according to crop (durum, hard wheat, barley, oats), moisture content of the grain, weather patterns, susceptibility of grain to shattering, flock and field size, amount of time ducks fed in a field, and the length of the harvest (hence damage) season. More recent data presented by Sugden and Goerzen (1979) provided a generally accepted average damage ratio of 2:1.

Although data vary considerably, losses resulting from crop depredation by waterfowl can be substantial. Burgess (1973) noted that as much as 22% of all available grain in observed fields was consumed or destroyed. MacLennan (1973) calculated that one field-feeding duck could destroy a minimum of 870 g (1.9 pounds) of barley or 660 g (1.4 pounds) of wheat per day. More recently, Sugden (1979) estimated that a field-feeding male mallard could consume 95–115 g (0.2–0.25 pound) of 14% moisture-content grain daily from mid-August to early October. These data closely agree with consumption data provided by Jordan (1953), which showed that a wild

Table 1. *Periodic estimates of ripening small-grain losses to waterfowl in Canada and the north-central United States.*

Source	Location	Years	Estimated losses
Stephen 1961b	Canadian prairie	1959-60	\$8.2 million (1959) to \$12.6 million (1960)
Jakimchuk 1969	Alberta	1968	\$3 to \$6 million; 1.0 to 1.5% of all grain grown in Province
Kerr 1974	Alberta		Up to \$10 million/year
Goulden 1974	Manitoba		\$0.5 to \$1 million/year
Jacobson and Schmidt 1979	Saskatchewan	1972-77	\$5 million for the period
Oetting 1980	Canadian prairie		\$35 million/year (all losses)
Poston 1986, personal communication	Alberta	1978-81	\$2.93 million (all grains)
	Manitoba	1978-81	\$0.777 million (all grains)
	Saskatchewan	1978-81	\$2.82 million (all grains)
Pfeifer, Hanson 1980, personal communication	North Dakota,	1980	\$350,000, \$75,000, and \$120,000, respectively
	South Dakota, Minnesota		

mallard could consume 73-82 g (0.16-0.18 pound) of small grain per day; a Canada goose could consume about twice as much.

The magnitude of the problem and various estimates of losses in Canada, and to a lesser extent in the north-central United States, are shown in Table 1. Unfortunately, loss estimates from this region of the United States are not well documented. Oetting (1980) tried to put his estimate of \$35 million annual loss for Canada in perspective by the following example: he noted that in 1957 one hail storm in Saskatchewan caused \$17 million damage to grain crops, whereas insect damage in the same Province in 1955 was estimated at \$60 million. Perhaps more objective data were provided by Poston (personal communication), who reported that losses on the Canadian prairie for all grains were about 58.5 million kg (2.146 million bushels; \$6.527 million) from 1978 through 1981.

## Depredation Behavior of Waterfowl

Crop depredation usually occurs near water where waterfowl congregate for resting and feeding. Specific flight paths are used by waterfowl from loafing sites to feeding areas in the field. These paths may remain the same for many years because certain fields along these paths are apparently preferred over others. Selected feeding areas seem to include large fields unobstructed by trees and shrubs, elevated portions of fields, and fields

with a gradual slope from a feeding site to a nearby slough or lake (Hochbaum et al. 1954; Vaudry 1974; Fairaizl 1981a).

Feeding flights usually occur in the early morning and evening; under certain conditions, such as a full moon, ducks may feed in fields all night. Inclement weather (such as rain, strong winds, or low temperatures) or heavy hunting pressure may alter the normal feeding schedule. Jordan (1953) reported an inverse relation between seasonal air temperature and the amount of feed consumed by captive birds; maximum food intake was attained during periods of below-freezing weather. Hammond (1950) found that when grain was provided at feeding stations, ducks that fed twice daily spent an average of 35 min per day feeding. Paynter and Stephen (1964) reported that when ducks gleaned their feed from harvested fields twice daily, their total feeding time was about 8 h.

## Attitudes of Farmers Toward Depredation by Waterfowl

When duck populations were low in the 1930's, farmers often plowed around nests and raised their mower blades to avoid destroying them. They carried ducklings to water, shot crows and other predators, and generally assisted conservationists in waterfowl preservation. However, the attitudes of many farmers changed with increased waterfowl populations and increased use of wetlands for agriculture. With this change in attitude, some farmers

plowed under waterfowl nests, drove through nests in hayfields, and even punctured eggs so that female ducks would continue to incubate instead of renest. In some of the main depredation areas in Canada, farmers organized protest meetings and called for year-round shooting; many even suggested the oiling or chemical treating of sloughs (Mair 1953).

Some farmers believe they must take all possible action to protect themselves against insects and weeds, but believe they are limited in their protective action against waterfowl because waterfowl have a recognized value to man (Colls 1951) and are protected by legislation. A minority of indignant farmers have recommended everything from poisoning waterfowl to placing a bounty on them; to some, all ducks are potential predators. As one farmer commented, "Hail is an 'Act of God,' but duck damage can be prevented" (Paynter 1955).

Even though waterfowl are ubiquitous in rural areas, most farmers seldom experience losses of their crops to waterfowl. Among the small percentage that do, most are willing to help solve the problem. Some farmers have diligently erected scarecrows and done some shooting (nonlethal hazing) to protect their fields from heavy losses. Others believed that some portion of damage costs or expenses for protection should be borne by agencies responsible for or interested in the welfare of waterfowl (Stephen 1960). Generally, this attitude still prevails today.

## Methods for Alleviating Crop Damage

### *Diversionary Feeding Programs*

Diversionary feeding programs have proved successful for controlling crop depredation. Diversionary feeding takes two forms: (1) raising or purchasing lure-crops where ducks can feed unmolested and away from other commercial crops, or (2) using bait stations or field baiting for the same purpose. These programs have been used on and near waterfowl refuges and waterfowl management areas. Such areas provide protection, food, water, and cover for waterfowl and help hold birds away from commercial crops during fall (Lostetter 1956). Over the years, most of these management areas have become National Wildlife Refuges (NWR) or Waterfowl Production Areas and have provided most of the staples for waterfowl.

#### Lure-crops

A waterfowl lure-crop is a crop that is either set aside (i.e., left undisturbed) in an area where a feeding pattern

has been established or purposely planted in a strategic location to attract and hold birds to prevent them from damaging commercial crops (Fig. 3). Temporary or permanent lure-crops can be located on government-controlled land or privately owned agricultural lands. A lure-crop is generally a grain crop that has been swathed or flooded and left for waterfowl consumption.

The concept of using lure-crops to protect commercial crops from waterfowl damage is not new. Lostetter (1956) reported that crop damage could be reduced by controlling habitat, using more natural foods, and planting agricultural crops as lure-crops. In California, Horn (1949) noted that natural foods, such as pondweed (*Potamogeton* spp.), bulrush (*Scirpus* spp.), spikerush (*Eleocharis* spp.), and smartweed (*Polygonum* spp.), provided a viable food source, but were inadequate (presumably in palatability) for retaining large concentrations of waterfowl when maturing rice and barley were nearby. As early as 1944 lure-crops were used in parts of California (Horn 1949). In one instance, 323 ha (800 acres) of leased land were planted to rice and subsequently used by an estimated 1 million ducks; the result was excellent protection to surrounding commercial rice fields. This land and an additional 930 ha (2,300 acres) were purchased by the U.S. Fish and Wildlife Service (FWS) and later gave rise to the Colusa NWR. For years the area was planted to rice, barley, milo, and water grasses. These crops effectively kept ducks from the cultivated rice fields (Horn 1949). On most NWR's the practice of growing crops to hold waterfowl and other wildlife is a continuing program. However, the available tillable acreage on some refuges is not large enough to hold the multitude of waterfowl that congregate on them.

Starting in the 1950's both permanent and temporary lure-crops have been the mainstay of the Canadian Wildlife Service and its Provincial counterparts, particularly in Alberta, Saskatchewan, and Manitoba. In Canada, permanent lure-crops are grown on federally owned land, whereas temporary lure-crops are those purchased from landowners before harvest (Lungle, personal communication; Jurick 1978; Jacobson and Schmidt 1979).

Between 1975 and 1981, the FWS conducted and contracted two experimental lure-crop projects, one in western Wyoming involving cranes and geese, the other in North Dakota involving ducks. The 3-year Wyoming project took place in two isolated valleys where migrating sandhill cranes and Canada geese damaged ripening barley. For that general area, the damage was not considered serious, but on a local scale it was significant (Serduik 1980). In synopsis, a few commercial barley





Fig. 3. Waterfowl lure-crop fields are identified and posted against hunting. (Photo courtesy of USDA-ADC, North Dakota)

fields were purchased by the contractor (Wyoming Game and Fish Commission) in areas where cranes and geese had regularly congregated; birds in outlying fields were easily hazed to these lure-crop fields. Procedurally, the project was highly successful in reducing damage to swathed barley. However, its cost-effectiveness was marginal because the project was mainly a demonstration, that is, it required much more intensive monitoring (with associated manpower and operational costs) to evaluate than would be necessary on an operational scale.

The North Dakota project (Fairaizl 1982) lasted 5 years, beginning in 1975, in three counties with historically high waterfowl damage complaints. During the later years, the project was expanded to include the entire State. Results showed that lure-crop plantings of barley and wheat (mostly durum), averaging 12 ha (30 acres), were highly effective in reducing damage in several areas where complaints were highest, and produced an overall positive benefit to cost ratio of at least 2:1. The more ducks there were in an area the higher the benefit to cost ratio. The total cost of the 5-year project was \$290,000, including purchase or rental of 815 ha (2,013 acres) for lure-crops,

administrative costs, and data evaluation. The average cost of a lure-crop field of durum wheat in the North Dakota study was \$3,587. It was determined that 2,500 ducks destroyed (i.e., consumed and trampled) about this amount (\$3,813) in a 30-day damage season; thus an approximate break-even point was determined to justify a lure-crop purchase.

Certain common elements in the North Dakota project were identified as important toward the economic success of lure-crops: (1) the waterfowl species present must be susceptible to being hazed quickly and easily from field to field; (2) the concentration of birds must be large and in a potentially vulnerable area; (3) crop vulnerability, harvest season, and high bird concentrations must coincide; (4) the damage season must potentially be longer than 30 days; and (5) potential damage might be greater than consumption alone. Additional, more specific criteria were recommended by this study: (1) a minimum of 2,500 ducks are needed in an area to make a lure-crop cost-effective, (2) there are minimal alternative feeding sites, that is, the general harvest in an area is less than 50% completed, and (3) there is almost no previous damage

in a field purchased as a lure-crop; this improves its waterfowl holding potential during the damage season.

According to Vaudry (1974) some potential problems are associated with the use of lure crops: (1) lure-crop fields might not be found by ducks, (2) when all the grain is eaten, ducks must find or be given new food, (3) strays drawn to the area by the lure-crop might use nearby fields for feeding, and (4) the grain in lure-crop fields becomes less attractive and irretrievable because it is dislodged from heads and trampled. Fairaizl (1982) suggested that most or all of these problems could be overcome if the criteria he and his colleagues generated in their North Dakota experiment were met.

### Bait Stations and Field Baiting

Waterfowl feeding areas or bait stations were first extensively tested in California in the mid-1940's (Horn 1949). In the rice-growing areas of the San Joaquin Valley, 41–54 t (45–60 tons) of barley were distributed annually to keep ducks, mostly American widgeons (*Anas americana*), from commercial rice fields. The results were impressive. Difficulties in driving ducks from commercial fields diminished after the program was initiated; birds began to learn the locations of the undisturbed baited areas.

At the Lower Souris NWR (now J. Clark Salyer NWR) in North Dakota, bait stations were at or near natural feeding or loafing areas, and grain was spread either on shorelines or in fields (Hammond 1961). As much as 35% of the on- and off-refuge ducks used feeding sites within 5 days of initiation, and from 50 to 90% used them within 35 days. No indications were found that this program increased the overall waterfowl population in the general area. When necessary, birds were hazed from scattered nonrefuge water areas and moved as far as 24 km (15 miles) to the refuge where they soon found the feeding stations. Feeding stations reduce duck damage more effectively and economically through reduced trampling of grain, contrary to the situation in lure-crop fields (Vaudry 1974).

In a small-scale study of baiting stubble fields with small grains to deter or hold waterfowl from swathed grain fields in North Dakota, preliminary results showed that sizable numbers could be held for as long as 30 days in some fields (Fairaizl 1981b). As many as 6,000 ducks, 1,000 geese, and 50 sandhill cranes used such a field for several days. The timing of bait introduction was important; the most effective diversions occurred when bait was made available within 2–3 days of the first observed feeding by waterfowl.

### Scare Methods and Devices

Scare methods and devices are available in many forms. A combination of techniques and devices seems to be the most effective for moving waterfowl and minimizing depredations to crops (Horn 1949; Biehn 1951; Scouler 1952; Lostetter 1956, 1960; Hammond 1961; Stephen 1965). If a farmer detects birds in his fields, it is essential that this use-pattern be broken early and not allowed to become established. Several days of repeated harassment may be required by using shotgun or rifle patrols, scarecrows, exploders, pyrotechnic devices, and hazing by aircraft (Table 2).

Employment of scare tactics may, indeed, reduce damage to individual fields, but not necessarily to an overall area. Areawide damage may actually be increased through trampling loss by frightening birds into new fields. Sugden and Goerzen (1979) suggested that duck-trampling losses are highest during the initial feeding in new fields, but trampling rates may decrease with subsequent feedings because dislodged grain is often consumed. This suggests that the use of lure-crops or bait stations may be effective because birds frightened from individual fields may be attracted to diversionary feeding sites. Subsequent efforts at scaring waterfowl from undesired areas to these feeding sites should require less effort over time.

Visual scare devices have traditionally been used for control. Hammond (1951) and Stephen (1965) reported good results with scarecrows of many descriptions. In the early 1980's, the FWS, mostly in North Dakota and South Dakota, provided growers with a simple, effective scarecrow made of a rectangular piece of black plastic attached to a wooden lath stake. The key to its success was installation before waterfowl attempted to land in newly swathed grain fields. Responses from users indicated that these simple scarecrows were readily accepted by grain farmers; they still are commonly used today.

Scarecrows in combination with exploders seem to be effective for frightening other bird species. A humanlike scarecrow, deployed to pop up in synchrony with the explosions from a "double-banger" propane exploder, was effective for frightening blackbirds from sunflower fields during limited trials in North Dakota (Cummings et al. 1986). This device might also be effective on waterfowl in grain fields.

Gunfire alone can be an effective waterfowl deterrent, but when combined with a visual stimulus, such as a scarecrow, its effectiveness is greatly improved. A .22-caliber rifle is probably better than a shotgun because of the whistling sound of the projectile and the distance it can

Table 2. *Summary of waterfowl control procedures applied to grain fields in North America.*

Method	Crop	Species	Location	Source
<b>Diversionsary feeding</b>				
Lure-crops	barley	geese, cranes	Wyoming	Serduik 1980
Lure-crops	rice	ducks	California	Horn 1949
				Lostetter 1956
Lure-crops	wheat, barley	ducks, geese	Central Canada	Jacobson and Schmidt 1979
				Jurick 1978
Lure-crops	wheat, barley	ducks, geese, cranes	North Dakota	Fairaizl 1982
Lure-crops	wheat, barley	ducks, geese	Canada	Vaudry 1974
Bait stations	wheat, barley	ducks	North Dakota	Hammond 1961
Bait stations	wheat, barley	ducks, geese	North Dakota	Fairaizl 1981b
Bait stations	wheat, barley	ducks	Canada	Vaudry 1974
Bait stations	rice	ducks	California	Horn 1949
<b>Scare methods</b>				
Scarecrows	wheat, barley	ducks, geese	North Dakota	Hammond 1951
Scarecrows	wheat, barley	ducks, geese	Saskatchewan	Stephen 1965
Scarecrows	sunflowers	blackbirds	North Dakota	Cummings et al. 1986
Gunfire	wheat, barley	ducks, geese	Canada and North Dakota	Benson 1952
				Hammond 1951
				Hochbaum et al. 1954
				Vaudry 1974
Exploders	rice	ducks	California	Lostetter 1960
Exploders	wheat, barley	ducks, geese	Saskatchewan	Vaudry 1974
				Stephen 1961a,b, 1965
Exploders	sunflower	blackbirds	North Dakota	Cummings et al. 1986
Aircraft	rice	ducks	California	Biehn 1951, Horn 1949
Air-raid sirens	grains	ducks	California	Thiessen et al. 1957
Smoke bombs	wheat, barley, rice	ducks	California and North Dakota	Kalmbach 1935
Reflectors	grains	ducks	Canada	Vaudry 1974
Rotating beacons	wheat, barley	ducks	North Dakota	Imler 1944
				Hammond 1951
Searchlights	rice	ducks	California	Lostetter 1960
Fog-producing machinery	rice	ducks	California	Lostetter 1960
<b>Chemicals</b>				
Turpentine, Kerosene, Pestex	barley	ducks	laboratory	Neff and Meanley 1956
Morkit	wheat	ducks	laboratory	Kear 1964
Mesurol	oats	ducks	laboratory	Schafer et al. 1975
Mesurol	wheat	ducks	North Dakota	Cunningham 1976
Mesurol	sorghum	cranes	laboratory	Schafer et al. 1977
Thiram	sorghum	cranes	laboratory	Schafer et al. 1977
Diazepam	grains	ducks	laboratory	Crider et al. 1969
<i>alpha</i> -chloralose				

cover. Either weapon has inherent risks in flat, populated areas (Imler 1944; Hammond 1951; Benson 1952; Hochbaum et al. 1954).

Federal regulations require a depredation permit before migrating birds can be killed for depredation control. A permit is not required to merely scare or haze depredating

migratory birds unless the species is endangered or threatened; similar laws exist in Canada.

The exploding shotgun shell or shell-cracker and similar devices such as pistol bombs, whistle bombs, small exploding rockets, and rope-crackers all offer effective means for frightening waterfowl, but they may be expensive. These devices are not exempt from potential hazards; they may start fires in dry stubble or other vegetation if fired in a low trajectory, or a gun barrel may become clogged from spent wadding. Numbers of manufacturers and suppliers have dwindled because of changes in Federal regulations for explosives classification and transportation.

In preventing duck damage to crop fields, firearms and other pyrotechnic devices have disadvantages. Besides expense, the gun requires an operator, time is needed to conduct a proper patrol, and it is costly for a farmer to hire someone to patrol his field (Vaudry 1974). Some of these disadvantages were eliminated with the development of the automatic acetylene exploder (or cannon), which became a popular control device in the western United States during the late 1950's (Lostetter 1960). Modern exploders are simple to operate, use inexpensive bottled propane gas, and produce a sound similar to that of a shotgun. An advantage of cannons is that sound intensity and timing of explosions can be controlled by means of a valve on the gas source. The sound can be further intensified by directing the report through a hole in the end of a small steel drum from which the opposite end has been removed, and by elevating the device above surrounding vegetation (Bird and Smith 1963; Vaudry 1974). Presently, exploders cost between \$180 for a single-shot to \$300 for a rotating double exploder and can be used for years if given proper maintenance (Marley, personal communication).

The most recent development with exploders is the double-banger (Fig. 4), which employs two exploders. One configuration has one exploder stacked on top of the other; another has two exploders facing in opposite directions mounted on a crossbar atop a tripod-mounted rotating beam. Firing intervals between the two exploders can vary from less than 1 to about 8 s, and the interval from one series of explosions to the next can be adjusted up to 30 min. One device per 32–41 ha (80–100 acres) of barley is reportedly extremely effective in Canada (Marley, personal communication).

Herding or hazing waterfowl by aircraft has been successful in controlling waterfowl depredations in California. One plane adequately protected 4,050–4,860 ha (10,000–12,000 acres) of cropland (Horn 1949; Biehn 1951; Lostetter 1960). The major drawbacks to using aircraft are operating cost and risk to the pilot. Several

crashes and a few fatalities have occurred. Recently, several State and Federal laws governing the use of aircraft have been changed with respect to their legal use for herding or hazing certain species of wildlife. Before undertaking such activities local, State, Provincial, and Federal game laws should be checked.

Other scare devices have been tested with little or varying effectiveness. These have included high-intensity, low-frequency sounds from an air-raid siren (Thiessen et al. 1957), an acetylene flash gun that combined a loud sound with a flash of light, smoke bombs (Kalmbach 1935), streamers and reflectors (Vaudry 1974), rotating flashing beacons (Hammond 1951), and revolving searchlights and fog-making machines (Lostetter 1960).

In summary, if a farmer detects birds in his fields, it is essential that the use-pattern be broken early to gain effective control. Regardless of which technique is used to frighten waterfowl, it is important not to allow a feeding pattern to become established in a field (unless it is a lure-crop field). Many days of repeated harassment may be required if the feeding site becomes well established.

### *Chemicals as Deterrents to Depredation by Waterfowl*

Most waterfowl have highly developed senses of touch and taste (Gottschaldt 1974; Berhoudt 1977; Dubbeldam 1977), and to a lesser extent, smell (Wurdinger 1979). Color discrimination also appears to be well developed (Oppenheim 1968; Lipcius et al. 1980). Consequently, these senses seem susceptible to some form of chemical influence, such as repellents, soporifics, and nontoxic substances acting as color cues to deter feeding.

Some chemical agents, including insecticides, have avian repellency properties when used at sublethal levels. Rogers (1978) separated repellents into two categories: primary, in which animals react to the taste of a substance, and secondary, in which animals use the taste of a repellent as a cue to other, delayed physiological effects. Most effective repellents have been of the secondary type (Bullard 1983a,b). Kear (1964a) examined the reaction of captive mallards to grain treated with Morkit, an anthraquinone compound. By the sixth week of feeding trials, mallards reduced treated food intake by 97%, suggesting a repellent effect over time. In another study, captive mallards reduced their feeding rate of oats, treated at 100 ppm with the repellent agent methiocarb (Mesurol), by 45–68% within 48 h (Schafer et al. 1975). For captive sandhill cranes tested on grain sorghum treated with methiocarb, at 100 ppm, and thiram, at 500 ppm, the aversive responses were varied, but pronounced, suggesting that



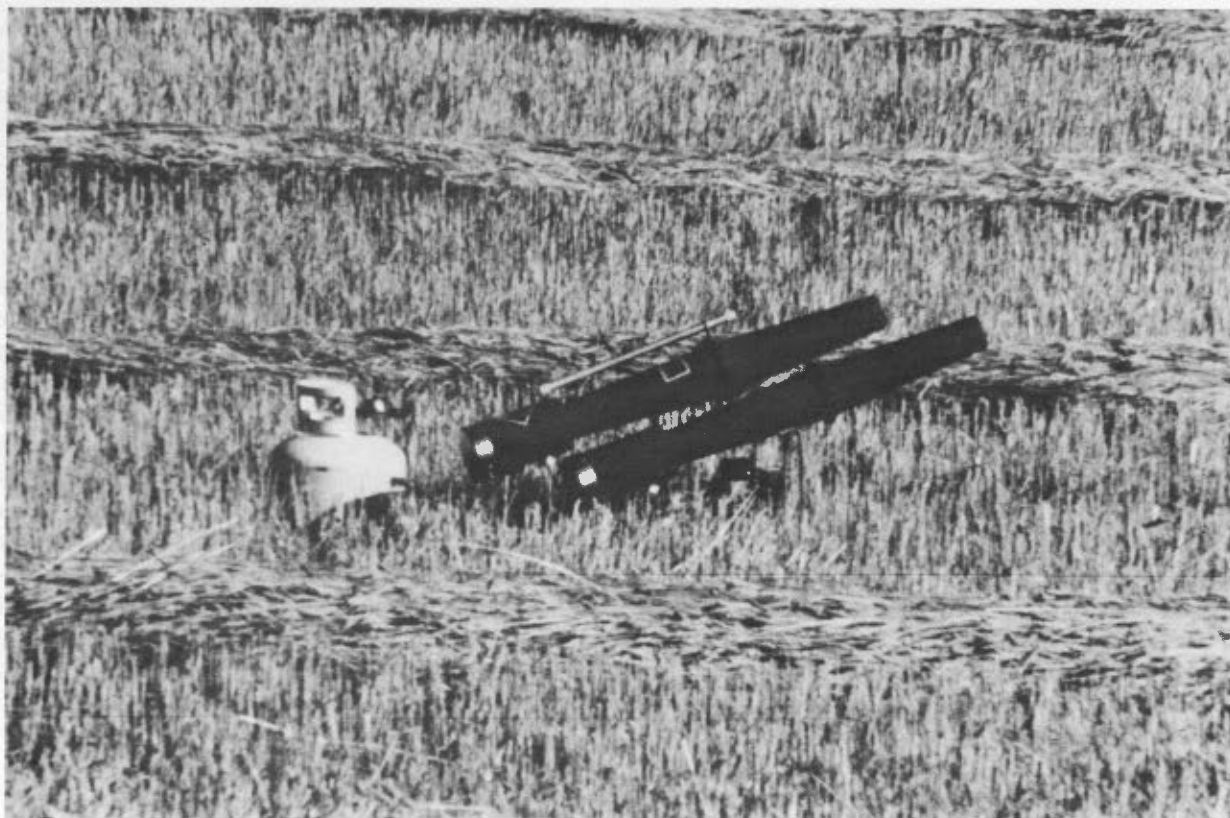


Fig. 4. One version of a new double-banger propane exploder used in Canada as a control device against waterfowl damage in swathed grain fields. (Photo by J. Marley, Calgary, Alberta)

either chemical may be an effective repellent for sandhill cranes (Schafer et al. 1977). In North Dakota, Cunningham (1976) treated wheat swaths with 250 ppm methiocarb and noted that mallards and northern pintails readily consumed wheat treated at this level. Apparently, ducks do not react rapidly enough in a field situation, even at this high treatment level, to prevent the decoying of new flocks to feeding sites, thus overwhelming the treatment when large numbers of birds are involved.

In color-response experiments, ducks and geese exhibited a general preference for green but tended to avoid orange and red (Kear 1964b). Bullard et al. (1983a) found that the addition of a cue detectable through smell, vision, or touch seemingly enhanced the effects of some chemicals, such as methiocarb, in certain passerine species. Calcium carbonate acted as a visual (white) cue to the red-billed quelea (*Quelea quelea*), enhancing the repellency effects of reduced levels of methiocarb when applied to wheat, rice, and sorghum (Elmahdi et al. 1985).

Although in the preliminary stages of testing, Dimethyl anthranilate (DMA), a nontoxic, food-flavor additive,

seems to produce a high degree of repellency in Canada geese when applied to corn (J. Cummings, personal communication). DMA applied to turf produced early signs of repellency in Canada geese and tended to reduce grazing (Mason and Clark 1987).

Chemicals such as soporifics that induce sleep or distress patterns in affected individuals have been suggested for testing as duck repellents in swathed grain fields (Vaudry 1974). Crider et al. (1969) treated grain at a feeding station with a soporific consisting of diazepam and *alpha*-chloralose that had shown an anesthetic response in ducks. They noted that erratic flight in affected individuals tended to frighten other ducks away.

Little research has been done to identify chemical agents that may be effective deterrents against waterfowl depredations on ripening cereal grains. Presently, no repellents are registered for this purpose. Because grain crops are used for human or animal consumption, special concern must be given to the types of chemicals that may be tested and potentially registered. They should be effective and relatively nontoxic, have a favorable benefit to cost ratio,



be eligible for Federal or State registration, and must not change the quality of the grain.

### *Manipulation of Farming Practices*

Changes or modifications in a few specific farming practices offer possibilities for reducing waterfowl depredation on crops. The fastest way to harvest standing grains is by straight-combining. This harvest method involves cutting and threshing at the same time, thereby removing the grain from the field without exposing it for prolonged periods to waterfowl, as occurs with swathing. However, straight-combining requires fairly even ripening of the grain at the time of harvest. In the northern United States and southern Canada this is difficult to achieve because of the shorter growing season, possible early frosts, uneven ground topography, soil types, and other factors. Straight-combining also requires a longer standing time for the grain to ripen than does swathing. This extended period of time exposes the crop to rain, hail, wind, and frost (Vaudry 1974). During the last 5–10 years, newer wheat varieties have reduced some of these problems and straight-combining has become more prevalent (W. Pfeifer, personal communication).

Grain dryers have gained acceptance in northern areas in the last decade (W. Pfeifer, personal communication). Farm or commercial dryers can be used to dry straight-combined, high-moisture grain to an acceptable level (14% or less) before it is stored or delivered to market. Not only does this reduce crop losses from natural and mechanical causes, but it also allows the crop to be harvested earlier. However, early harvest of high-moisture grain has the disadvantages of shrinkage, reduction in grade quality, and the high cost of energy to operate dryers, thereby reducing this method's cost-effectiveness in some instances.

Probably one of the most expedient ways to eliminate most or all of the cereal grain losses to waterfowl is to grow overwintering grains, such as winter wheat. Harvest could then take place in late June or July when ducks and geese are molting and flightless, and long before migratory flocks begin to congregate. Agronomic research has developed and is continuing to improve varieties of winter wheat for the northern climates; progressive farmers are beginning to use such varieties.

The practice of plowing stubble immediately after grain harvest contributes to problems of waterfowl depredation (Miller 1976). A delay in plowing of a couple of weeks to allow waterfowl to feed undisturbed on the waste grain could reduce depredation problems, particularly during inclement weather (Sugden 1976). Early plowing forces waterfowl from feeding areas where they do little harm;

delayed plowing allows them to continue feeding in harvested fields, thus reducing damage to nearby swathed fields (Hammond 1951; Hochbaum et al. 1954; Stephen 1961a; Mankelov 1974; Vaudry 1974).

Changes in cultural practices, such as no-till farming, are showing considerable economic benefits to farmers and perhaps can help mitigate problems of waterfowl depredation as an unplanned but added benefit. According to Armand Bauer (personal communication), a soil scientist in North Dakota, no-till farming (seeds are planted directly into the previous year's grain stubble) can reduce wind erosion of soil by 50% as well as reduce the evaporation of soil moisture. Unplowed stubble retains rainfall moisture and traps winter snow, which creates a soil environment similar to an increase in annual rainfall as high as 25%. Retention of snow cover also keeps the ground warmer and reduces some of the inherent risk of planting winter wheat (Hodgson 1987). Moreover, no-till farming makes grain stubble available to waterfowl during the entire fall migration, potentially reducing the extent of waterfowl damage to unharvested grain fields. In essence, these fields become a form of lure-crop.

### *Education and Public Relations*

The objectives of control programs must be publicized before assistance and popular support can be expected. Farmers that experience waterfowl depredations need to be informed of the best control techniques or combinations available. Farmers, sportsmen, and government agencies can work together to meet these needs. Information can be disseminated through television, radio, newspaper, magazines, lectures, group meetings and discussions, and special pamphlets. Three examples of information pamphlets are "Preventing crop damage: a guide to bird scaring techniques" (Canadian Wildlife Service 1982), "Waterfowl crop damage control program" (Alberta Department of Energy and Natural Resources 1985), and "Preventing bird damage to prairie crops" (Manitoba Department of Natural Resources 1982). By using the media, wildlife agencies could apprise farmers of waterfowl movements during the migration so that control methods could be initiated expediently. These waterfowl movement forecasts would alert farmers to start checking their vulnerable fields.

### **Waterfowl Depredation Insurance and Compensation Programs**

Depredation insurance and monetary compensation are complex and controversial issues. In Canada, both systems

have been in use in some form. To a lesser extent, some States in the United States practice a form of compensation by paying for big-game damage. The major difference between the two programs is that insurance requires a premium payment from farmers, whereas compensation does not. Both systems initially pay for claimed losses from funds generated by a \$1.00–\$3.00 hunting license surcharge and insurance premiums (Vaudry 1974); additional funds come from treasury revenues of the Provincial and Federal (Canadian) government.

Paynter (1955) described the formation of a depredation insurance program in Saskatchewan (apparently the only Province to have used it) that began in 1953 and continued through 1977. Farmers were charged a premium of \$1.25 per ha (\$0.50 per acre) based on their surveyed losses from 1950 to 1952. These premiums, coupled with the hunting license surcharge, which most sportsmen supported, helped generate the basis for a damage-revenue pool. No indemnity of less than \$25.00 per ha (\$10.00 per acre) was paid; if at least 85% of the crop was destroyed, 100% indemnity was paid. Crops insured in areas closed to hunting were insured to 100%.

The financial burden of such an insurance program in Canada was described by Oetting (1980). In 1971, the Saskatchewan program cost \$521,000; the license surcharge fund contained only \$140,000—the Provincial treasury made up the difference. When losses were light to moderate, the system seemed adequate, but after 1 or 2 years of heavy losses, indemnity funds were in jeopardy. According to Oetting, compensation and insurance programs are a “bottomless pit” and, once begun, are extremely difficult to rescind because of political pressure from farmer organizations. In 1978, Saskatchewan terminated the insurance plan and introduced a compensation program with a maximum payment as high as \$123.00 per ha (\$50.00 per acre). This decision by the Provincial government was not necessarily related to deficiencies in the insurance scheme, but rather the desire to join the other Provinces in emphasizing the alleged Federal responsibility for damage by waterfowl (Boyd 1979).

Alberta began a monetary compensation program for depredation by waterfowl in 1961 (Smith 1968) and Manitoba in 1972 (Sugden 1976). Initially, these Provinces and Saskatchewan funded their programs almost solely by the hunter surcharge (Kerr 1974; Sugden 1976); in 1973, however, by Federal–Provincial agreements, the programs were funded on a 50:50 cost-sharing basis. Originally, compensation payments were made to a maximum of \$37.00 per ha (\$15.00 per acre), but they have steadily risen to the current Federal–Provincial agreement of \$160.00 per ha (\$65.00 per acre). The formula used to determine payments is simple: percent damage multiplied

by market value of the crop per acre equals compensation payment or \$160.00 per ha, whichever is less.

## Discussion

Cost-effectiveness is the key to determining which control technique should be employed to reduce waterfowl damage to ripening cereal grains. Usually the simplest methods are the least expensive, assuming they are effective in reducing damage. For example, when one considers the cost of a propane exploder at \$200–\$350, with a life expectancy of 5–10 years, to protect 16 ha (40 acres) or more of grain, damage need not be great to make this protection method cost-effective. In areas of moderate to heavy damage, where direct conventional scaring methods do not adequately prevent or reduce damage, alternatives such as lure-crops and other diversionary feeding programs, manipulation of farming practices, and depredation insurance or compensation programs might be cost-effective also.

Results of tests with chemical agents show that they offer possibility as a control method. However, because no products are presently registered for waterfowl control and because of the enormous expense (several million dollars) involved in developing and registering compounds for this use, control with chemicals does not seem economically feasible. An exception may be the chemical agent methiocarb, which is currently registered as an avian repellent against passerines in certain fruit crops. With limited additional research, especially tests with compounds acting as cues to enhance repellency and reduce the cost and amount of chemical needed, positive results may allow piggyback registration or an amendment to the existing registration for use as a method for controlling waterfowl in swathed grains.

On the basis of the Canadian experience, two alternatives mentioned previously that seem to be the most controversial and expensive are damage compensation and depredation insurance programs. The politics and emotions associated with these programs crystallized in 1979 when the Canadian government attempted to withdraw financial support for these programs. The protests from Provincial governments and organizations of farmers, hunters, and naturalists were so strong that the Federal government not only reversed its decision but increased the level of funding to \$4.3 million per year from 1979 through 1983 (Boyd 1979). This funding was used to support (1) compensation and insurance programs, (2) the implementation of conventional prevention methods, and (3) a new element—the acquisition of large tracts of land to be primarily managed for waterfowl in areas of persistently heavy damage.

When considering monetary compensation or insurance programs, one should carefully weigh financial involvement by political or governmental entities. Statements made by farmers who suffer crop losses from migratory waterfowl, such as "They're the Queen's ducks" (in Canada) or "They're Uncle's birds" (in the United States), may have some validity but should not be the overriding concern in the involvement of governments in either of these programs. Given a choice between the two programs, Boyd (1979) believed that insurance was the better alternative. It tends to reduce government involvement by offering incentives to farmers for making long-term changes in land use and for utilizing improvements in agricultural technology. These incentives include (1) growing crops not attractive to waterfowl, (2) avoiding the planting of vulnerable crops in vulnerable locations, and (3) replacing swathing with straight-combining, thus reducing losses to farmers and program costs to government. Additional incentives might be (1) delaying the plowing of stubbles following harvest, (2) growing fast-maturing varieties of grains, or (3) planting overwintering grains.

Miller (1976) believed that depredation by waterfowl continues to increase despite monetary compensation programs or diversionary feeding programs in Canada. Although he conceded that crop damage by waterfowl has resulted in significant losses to the farming community, he believed that depredation problems have also created a threat to the future of waterfowl and waterfowl hunting. In trying to put this paradox into perspective, it is our opinion that the biggest factor is not necessarily an increase in depredation so much as a decrease in tolerance by farmers as to how much damage they are willing to absorb. Farming profit margins have decreased in recent years because of the high costs of land and equipment, higher interest rates on bank loans, reduced or withdrawn government subsidies on certain grains, and depressed worldwide prices on some cereal grains.

Diversionary feeding programs (bait stations and lure-crops) are apparently less expensive than compensation programs, and more efficient in areas of moderate to high duck damage (Burgess 1973). Hammond (1961) concluded that feeding stations were less expensive than lure-crops because very little grain is lost through trampling and less land is needed to operate them.

Acquiring croplands in high waterfowl damage areas, managing these lands and crops to hold waterfowl during harvest season, or purchasing maturing crops on certain commercial fields as temporary lure-crops or diversionary feeding sites are acceptable control methods and perhaps satisfactory compromises to compensation programs. The

use of lure-crops seems to be an established trend in Canada (Boyd 1979). In the United States, the FWS already owns or leases millions of acres of waterfowl habitat within its refuge and wetlands system. On many refuges, crops are grown specifically to hold waterfowl, but very few Waterfowl Production Areas have crops grown on them. Some refuges also operate feeding stations for holding waterfowl on-site to counter the common remark by farmers, "We don't mind having ducks raised on or near our land, but we do mind feeding most of them."

In the United States, some possible sources of revenue for cost-sharing depredation control programs could be derived from the following sources.

1. *State Government.* (a) *Hunting License Surcharge*—Either a fixed dollar amount (as in Alberta) or a percentage could be added to the base license fee. The latter would generate additional money from nonresident hunters who come to States that are recognized for their abundance of waterfowl and hunting success. (b) *State Income Tax Check-off*—This program would be similar to that used in a few States, in which taxpayers simply check a box on their State income tax form indicating that they will contribute a predetermined amount of money to a nongame management fund.
2. *Federal Government.* Two potential sources of Federal revenue could conceivably provide funds for cost-sharing in depredation control programs. First are funds from the sale of the Federal Migratory Bird Hunting and Conservation Stamp, commonly known as the Duck Stamp. Normally these funds are used to purchase and manage migratory bird habitat and for related activities; new legislation would be needed to divert funds from the original intent. The second source is reverted Pittman-Robertson funds that are derived from taxes on the sale of firearms and ammunition to sportsmen.
3. *Crop Insurance.* The Federal Crop Insurance Corporation offers crop-loss coverage for such circumstances as hail, drought, disease, insects, and fire. But it also offers some coverage for wildlife damage (Allen et al. 1985). This coverage needs to be better defined and used, if applicable, to waterfowl damage to swathed cereal grains.
4. *Depredation Fund.* This fund would generate tax revenue from a small mill levy enacted and administered on a townshipwide or countywide basis in areas where waterfowl damage is a chronic problem. The tax should be applied to farmers who grow crops vulnerable to waterfowl damage—in this case cereal grains. This self-help tax is analogous to the predator tax levied on livestock in parts of many western States to help cover predator control programs and livestock losses to coyotes.



5. *Organizations of Farmers and Growers and Private Waterfowl Conservation Groups.* Local and State organizations or chapters of national groups, such as the Wheat Growers Association, Farm Bureau, and others, should be supportive of their constituency by contributing financially to the initiation of depredation control programs where their members are affected by waterfowl damage. Private conservation groups such as Ducks Unlimited should also be regarded as a source.

Funds from some or all of these sources, the expertise of professional waterfowl biologists in the United States, and the experience gained from the Canadian programs could be used to establish effective, fair programs to alleviate crop depredation by waterfowl in the United States.

## Conclusions

The types and patterns of waterfowl damage to swathed cereal grain are virtually the same in the northern Great Plains and southern Canada and have been a chronic problem for several decades. Canadians seem to have documented the economic severity of their cereal grain losses to waterfowl fairly well; the United States has not. Damage alleviation or prevention methods used in Canada have similar applications in the United States. The relative success of each of the control measures described, whether for prevention or reduction of waterfowl damage to cereal grains or for monetary compensation of these losses, may vary but can produce positive results. New approaches, such as changing or modifying some farming practices and incorporating innovative agronomic techniques, can potentially mitigate losses for those farmers who can be convinced to use them. The magnitude of the problem, frequency of occurrence, and potential monetary value of losses will dictate which methods to use and when to use them. The severity of these problems in certain local areas may preclude the use of simple methods.

In summary, farmers and their respective support groups, wildlife managers, and conservation organizations must be willing to communicate and compromise on realistic goals to minimize a mutual problem. High-cost, runaway compensation programs should be avoided in favor of traditional control methods integrated with lure-crops, feeding stations, and modified agricultural techniques for alleviating waterfowl damage to cereal grains. Fiscal responsibility for implementing and operating public waterfowl depredation control programs in the United States should be shared by all parties involved. Several potential sources of funds have been suggested; each should be scrutinized and considered on its own

merit. Funds from a consortium would reduce the fiscal burden to any single source. Communication, cooperation, and education are the keys. As Sugden (1976) explained, "A reduction in crop damage as small as 5% could save a million dollars in grain in some years. No single approach is likely to solve the entire damage problem. . . . Benefits from multiple techniques tend to be additive."

## Recommendations (United States)

1. *Problem definition.* Before managers can decide future courses of action for alleviating losses from depredation by waterfowl, objective damage surveys should be conducted to determine the scope of the problem and to measure its economic severity.
2. *Crop insurance.* Define and use if applicable, the criteria of the Federal Crop Insurance Corporation program regarding depredation insurance or compensation for waterfowl damage.
3. *Lure-crops and baiting stations.* Determine the feasibility of funding these programs in areas of chronically high damage.
4. *Waterfowl forecasts.* Wildlife managers and county extension agents should use the media for notifying the farming community of potential situations for damage by waterfowl during the swathing and harvesting season.
5. *Changes in farming practices.* If feasible, promote the cultivation of overwintering varieties of cereal grains.
6. *Research needs.* (a) Changes in farming practices. Conduct pilot studies in areas where no-till farming and waterfowl damage coincide to determine if this farming practice has any significant effect on reducing damage to swathed cereal grain. If results are positive, the benefit of using this farming practice should be promoted. (b) Chemical deterrents. Retest with the chemical agent methiocarb, in combination with cues, to determine if it can be used efficaciously, safely, and economically as a means for protecting swathed grains in areas of chronic waterfowl damage. If applicable, seek registration status.

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