Waterfowl damage to Canadian grain

by Lawson G. Sugden

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Abstract

Waterfowl damage to crops in Alberta, Saskatchewan and Manitoba first became severe in the 1940's when the practice of swathing grain became prevalent. Mallards (*Anas platyrhynchos*) cause the most damage, which is sustained primarily by barley and wheat. Loss of grain is most severe in wet autumns that delay the harvest and tends to be chronic near large wetlands that harbour ducks in autumn. Losses have averaged about 1% of the crop value, and currently exceed $10 million annually. The threat of damage can also inhibit the programs for habitat preservation and development on private farmlands that are vital to North American duck production. Efforts to reduce losses to farmers have included both damage prevention and compensation programs, on which government agencies are currently spending over $1 million annually. Damage prevention has consisted of cultural methods, scaring devices, and provision of feeding stations and lure crops. Continuing losses by grain farmers plus the high costs of compensation and crop protection programs demand further research into economical ways of protecting crops. Combinations of control methods have the most potential for solving the overall damage problem. Therefore, a broad spectrum of related questions might profitably be investigated, including the field-feeding behaviour and the grain consumption of ducks, better ways of measuring the severity and distribution of damage, encouragement of farmers to make more use of available control methods, evaluation of new methods, the role that shelterbelts might have in damage prevention, and the relationship between the field-feeding habits of ducks and the features of the marshes they use. Small advances in crop protection will probably be the rule.

Résumé

L'ampleur des dommages causés par les oiseaux aquatiques aux cultures céréalières d'Alberta, de Saskatchewan et du Manitoba s'accrut pour la première fois entre 1940 et 1950, lorsque se répandit l'usage de mettre le grain en andains avant de le battre. Ce sont les Canards malards (*Anas platyrhynchos*) qui causent les dommages les plus graves, s'en prenant surtout à l'orge et au blé. C'est lors des automnes humides qui retardent la moisson que les dommages aux récoltes céréalières sont les graves. Ces dommages tendent à la chronicité dans les parages des grandes terres humides qui abritent les canards à l'automne. Ces dommages ont été en moyenne de l'ordre de 1% de la valeur des récoltes et leur importance dépasse actuellement les $10 millions par an. La perspective de tels dommages peut aussi mettre un frein aux programmes de préservation et d'amélioration de l'habitat faunique à même des terres de culture qui sont d'une importance vitale à la production des canards en Amérique du Nord. Les mesures prises en vue de réduire les dommages encourus par les cultivateurs comprennent des programmes tant de prévention que de compensation qui émargent au budget d'organismes gouvernementaux pour un montant d'un million de dollars par an. Les mesures préventives comportent des techniques de culture idoines, divers épouvantails et la création tant de cultures de diversion que de mangeoires bien approvisionnées. Il existe, du fait de la continuation des dommages subis par les cultivateurs de céréales ainsi que du coût élevé des programmes de protection des récoltes et de compensation, un besoin impérieux de recherches plus poussées pour trouver moyen de protéger à moindres frais les récoltes. Ce sont des combinaisons de diverses techniques inhibitrices qui offrent les meilleures perspectives de solution du problème des dommages dans son ensemble. Par conséquent, il y aurait avantage à étudier un vaste éventail de questions connexes, y compris le comportement des canards qui se nourrissent dans les champs ainsi que leur consommation de céréales, l'amélioration des méthodes de mesure de la gravité et de la répartition des dommages, l'incitation des cultivateurs à l'emploi plus poussé des techniques inhibitrices déjà en usage, l'évaluation de techniques nouvelles, la fonction éventuelle de ceintures-refuges en matière de prévention des dommages et les rapports entre la diète des canards aux champs et les caractéristiques des marais où ils se posent. Il est probable qu'en règle générale, les progrès en matière de protection des récoltes se feront petit à petit.

Introduction

Cereal crop damage by waterfowl on the Canadian prairies was recognized as a problem in the 1940's (Hochbaum, 1944; Soper, 1944, 1948). Increasing damage and perhaps greater awareness soon brought warnings that the problem was acute and needed attention (Munro, 1950*a*; Colls, 1951; Leitch, 1951; Mair, 1953; Munro and Gollop, 1955). During the past two decades, governments and others have undertaken research and developed programs to give farmers some relief from crop losses (Hochbaum, Dillon, and Howard, 1954; Paynter, 1955; Beck, 1959; Stephen, 1961*a*, 1965*a*, 1967; Smith, 1968; Renewable Resources Consulting Services [RRCS], 1969; MacLennan, 1973). This paper reviews the current problem of waterfowl crop damage and identifies the need for further research.

The problem

Waterfowl have fed on upland grain fields since settlers first cropped the land (Sowls, 1955; Denny, 1956; Bossenmaier and Marshall, 1958), but severe damage did not become prevalent until the mid-1940's. The change was believed caused by the new practice of allowing grain to ripen in swaths before threshing (Colls, 1951; Bossenmaier and Marshall, 1958), and possibly by the increased acreage of durum wheat and barley, which ducks prefer to common wheat (Bossenmaier and Marshall, 1958; MacLennan, 1973).

Crop damage on the Canadian prairies is caused mainly by mallards (*Anas platyrhynchos*) and pintails (*A. acuta*). Mallards do the most damage because they remain later in autumn (Hochbaum, 1944), have a greater tendency to field-feed (Bossenmaier and Marshall, 1958), and are more abundant. Geese that migrate through the Prairie Provinces (Alberta, Saskatchewan, and Manitoba) damage some grain crops in autumn, but such damage is localized (Bossenmaier and Marshall, 1958; MacLennan, 1973). Sandhill cranes (*Grus canadensis*) also damage crops in a few areas (principally in Saskatchewan) where they concentrate in the fall (Munro, 1950*b*; Stephen, 1967; MacLennan, 1973).

1. Nature of damage

Wheat, barley, and oats comprise over 75% of the cropped acreage in prairie Canada (Statistics Canada, 1972) and receive virtually all of the waterfowl damage. Bossenmaier and Marshall (1958) believed ducks preferred barley to common wheat because the unthreshed barley kernels were easier to extract. However, according to Hammond (1950), when the grain was threshed, common wheat was preferred to barley. RRCS (1969) suggested that barley received relatively more damage because it was swathed earlier than wheat. Oats are preferred less by ducks and much smaller acreages are planted, so that the monetary loss from oat damage is small compared with that for barley or wheat.

Most damage is done when grain is lying in the swath, where it is eaten, trampled, and fouled by ducks. As a rule, ducks waste more grain than they eat and mainly during their first few visits, when they dislodge grain while trampling the swaths. Extrapolations by Hammond (1950) and Benson (1952) indicated that waste grain exceeded eaten grain by four to six times, though the ratio was as low as 1.5 with damp grain (Hammond, 1961). But if ducks feed on swathed grain long enough, they recover most of the fallen kernels (MacLennan, 1973). Standing grain is seldom damaged except when flooded (Bossenmaier and Marshall, 1958) or if it is short-stemmed (McWhorter, 1961).

Crop damage by ducks varies both in time and space. Autumn precipitation appears to be the most important variable affecting the severity of damage (RRCS, 1969; MacLennan, 1973). Damage increases when wet weather delays harvesting, and especially when crops remain drying in the swath for long periods. Damage tends to be greater and more frequent in northern areas (e.g., Meadow Lake, Saskatchewan; The Pas, Manitoba; Peace River, Alberta) when late springs dictate a relatively late harvest (Stephen, 1965*a*; RRCS, 1969). Late harvests result, too, from delayed seeding caused by wet spring conditions. Northern areas may also receive relatively more damage simply because ducks delay their migration when food is abundant (RRCS, 1969), though the evidence appears to be circumstantial.

Damage is also greater near large wetlands used by ducks in the fall (Bossenmaier and Marshall, 1958; Stephen, 1961*b*; RRCS, 1969; MacLennan, 1973), and its severity tends to be inversely proportional to the distance between the wetlands and susceptible fields. Although damage has occurred over most of the grain-growing region of prairie Canada, some areas consistently receive more damage than others (Stephen, 1965*b*; RRCS, 1969, 1970). These chronic damage areas are invariably associated with large wetlands.

Over the years, the severity of crop damage has not been related to the size of the duck population (Kalmbach, 1935; RRCS, 1969; MacLennan, 1973). Indeed, duck populations were comparatively low when some of the worst damage occurred because weather conditions made crops vulnerable for long periods. Notwithstanding the lack of correlation between provincial mallard and pintail numbers, and damage intensity, on a local basis *many* ducks undoubtedly cause greater damage than *few* ducks.

2. Cost of damage

From mail surveys, damage for the three Prairie Provinces was estimated at $12.6 million in 1959 and from $5.7 million to $8.2 million in 1960 (Stephen, 1961*b*). A 1955 survey in Saskatchewan showed a damage loss of $10.6 million (Paynter and Stephen, 1964). Losses in Alberta for 1966, 1967, and 1968 were given as $5.8 million, $3.6 million, and $6.0 million respectively (RRCS, 1969). The comparable bushel loss nowadays would be more costly because of the currently high market value of grains. The value of lost grain averages about 1% of the crop value. The authors caution that estimates based on their mail surveys may be biased upwards, though part of this bias may be offset by damage that goes unnoticed. Regardless of bias, the estimates are what the farmer believes he has lost and this dictates the seriousness of the problem (Stephen, 1961*b*).

The impact of duck damage is aggravated when losses are not uniformly distributed among farms. In a 1964 prairie-wide survey, 16% of 5327 respondents reported duck damage valued at $227,749 (Stephen, 1965*b*), but only 5.6% reported losses in excess of $200 each. Similarly, 12% of Alberta farmers reporting damage in 1968 gave a figure over $500 each (RRCS, 1969). That report suggested that $500 represented the approximate upper threshold of tolerable dollar loss from waterfowl damage. High loss by relatively few farmers is the cause of the greatest animosity (Munro, 1958).

Crop losses due to waterfowl are low compared with losses from other causes. The average annual loss from hail in Saskatchewan was estimated at 4% of the provincial crop (University of Saskatchewan, 1975) and one storm in 1957 caused about $17 million damage. Annual losses from hail in Alberta also average about 4% of the crop value (Summers and Wojtiw, 1971), and from 1961 through 1968 averaged $23 million. The highest loss in that period was $58 million in 1966. The 1955 survey that estimated duck damage in Saskatchewan at $10.6 million also placed insect damage at $60 million.

In monetary terms, waterfowl damage may be overshadowed by damage from other causes, but the nature of the agent puts it in a different light. Hail is considered a natural farming hazard, and crops can be insured against it as well as other hazards. In Alberta hail damage is concentrated and substantial research on weather modification is being undertaken. Considerable research has also been done on methods of forecasting insect damage and techniques for control. Pest control is often subsidized by government programs.

The farmer views grain-eating waterfowl differently. Migratory game birds are protected by the Migratory Birds Convention Act and are managed primarily for their use by hunters and birdwatchers. The grain farmer identifies waterfowl with the users and believes that they should accept the responsibility. While it is doubtful that the damage situation would change were the mallard officially declared a pest and not protected (Murton, 1968), the question is academic. Wildlife management agencies accept a major role in efforts to reduce losses from waterfowl depredations. Such involvement is imperative because their interests extend beyond the legal or moral aspects. Any program to alleviate duck damage is likely to affect recreational opportunities and, of more importance, the damage impedes efforts to preserve and develop waterfowl habitat on the Canadian prairies (Leitch, 1951). Close to half the ducks in North America are produced on the privately-owned lands of prairie farmers, but no program to preserve or develop wetland or upland habitat can win the co-operation of farmers who continue to suffer severe crop losses from waterfowl. The cost of waterfowl damage in terms of debilitated habitat management programs is unknown and is probably unmeasurable, but periodic opposition to wetland development and requests to drain large wetlands in severe damage areas show that the problem exists.

Although the value of lost grain can only be estimated, the costs of reducing farmers' losses are measurable. Payments to farmers in Alberta and Saskatchewan through compensation and insurance claims have each exceeded $500,000 in recent years of severe damage. Details of these costs as well as damage control programs are discussed later. The programs cover but a fraction of the total crop loss because of ceilings on damage claims and incomplete participation by farmers.

Solving the problem

Efforts to reduce the loss to farmers have been many and varied. One main approach is to reduce the damage to crops; another allows the farmer to recover part of his loss through compensation.

Methods and devices for reducing crop damage by ducks are discussed in many papers (Kalmbach, 1935; Wagar, 1946; Horn, 1949; Biehn, 1951; Hochbaum *et al.*, 1954; Lostetter, 1956, 1960; Bossenmaier and Marshall, 1958; Hammond, 1961, 1964; Stephen, 1961*a*, 1965*a*, 1967; Paynter and Stephen, 1964; Buckley and Cottam, 1966; Dykstra, 1966; Williams and Neff, 1966; Anderson, 1969; Cowan, 1970; Kozicky and McCabe, 1970; MacLennan, 1973; Canadian Wildlife Service, 1973).

Sources of scaring devices and repellents are listed in U.S. Fish and Wildlife Service (1964) and Anderson (1969). Additional bird control information appears in the literature on conflicts between birds and aircraft and other human activities (e.g., Aldrich, Robbins, and Dykstra, 1961; Kilgore and Doutt, 1967; Murton and Wright, 1968).

1. Cultural practices

These practices include growing non-susceptible crops such as flaxseed or rapeseed, growing grain varieties that can be harvested earlier or straight-combined (no swaths), using shatter-resistant varieties, leaving a high stubble to discourage ducks, and delaying cultivation of harvested fields until nearby susceptible crops have been harvested. The last practice provides a place for ducks to feed where they can do no harm, as they would be eating waste grain. On areas of marginal farmland that suffer chronic waterfowl damage it may be practical to put the land to other uses, including damage abatement and recreation.

The extent of farmers' attempts to reduce crop damage through cultural practices is not precisely known but appears slight. In Manitoba, Bossenmaier and Marshall (1958) found such practices almost non-existent. In the Alberta survey (RRCS, 1969) cultural methods were not listed in the questionnaire, though some were included by a few respondents under *other methods* used to prevent damage, so the insignificant number of responses may not be representative. These mentioned speeding up the harvest, straight-combining, and growing non-susceptible crops. None reported leaving harvested fields uncultivated until harvesting was finished, though this is a widely recommended technique.

The reasons for infrequent use of cultural practices that reduce crop damage are not clear. Certain techniques (planting early-ripening varieties and an early and swift harvest) are useful regardless of the damage threat, so would not be considered a special measure for damage prevention. Likewise, spring cultivation (as opposed to fall cultivation) is beneficial where soil erosion by wind is a problem (University of Saskatchewan, 1975) so cultivation would be delayed in any case. Conversely, postponing cultivation is often impractical in northern areas with short growing seasons (Stephen, 1961*a*) or for fields with heavy straw cover. Finally, the efficient farmer who has completed his harvest may entertain no obligation to maintain alternative feeding sites for ducks that might damage his less efficient neighbour's crops.

Because ducks waste so much grain through trampling, biologists have suggested growing shatter-resistant varieties where such damage occurs. After reviewing studies by Truscott (1950) and Beck (1951), Gollop (1950) concluded that the grains most resistant to shattering were already in common use and were also among those most preferred by ducks. Kalmbach (1943) stated that waterfowl showed some aversion to unnaturally coloured grain, though in Stephen's (1959) experiment, ducks continued to eat swathed grain that was treated with green lawn paint.

One significant tract of marginal farmland in prairie Canada has been converted to an area primarily for wildlife use because of severe crop damage by sandhill cranes and ducks. This is the Last Mountain Lake Wildlife Area in Saskatchewan comprising over 8000 ha (20,000 acres) (Hatfield 1971). The conversion eliminated over 3000 ha (8000 acres) of marginally commercial cropland that were susceptible to chronic damage and provided land for an extensive feeding crop program that helps to protect adjacent farmlands. Additional benefits accrue from livestock grazing and recreational uses of the area. Stephen (1965*a*) stated that cultivated land in the vicinity of Quill Lakes, Saskatchewan and Big Grass Marsh, Manitoba were similar by reason of poor soils and high waterfowl damage and could be considered possible candidates for a similar conversion. The long-term economics of land-use conversion on such areas need more study.

2. Scaring waterfowl

Techniques and devices used or tested for scaring ducks from fields include shooting (to scare or kill), *cracker shells* fired from shotguns, tracer cartridges, Very signals, acetylene exploders, firecrackers, ground bomb mortars, *sky rockets*, hand grenades, rifle grenades, sirens, wind-powered noisemakers, scarecrows and other strange objects such as barrels or farm implements, flashing lights, road flares, rotating beacons, spotlights, *spirillum whirlers*, fires, smoke bombs, fog-making machines, gas-filled balloons, and herding by foot, horseback, or aircraft. Frequently, two or more methods are used in combination.

No universal technique or device for keeping waterfowl out of susceptible crops has been discovered that is quick, cheap, easy to use, effective, and acceptable to the grain grower. Because crop damage on the Canadian prairies is widespread and often unpredictable, scaring is frequently attempted only after the foraging ducks have been discovered. By then considerable damage may have occurred, as much of the waste grain is lost during initial feedings. For this reason, biologists point out that scaring ducks from field to field actually increases total damage if alternative non-commercial feeding sites are not available in the vicinity. Nevertheless, the success of a feeding scheme often depends on a simultaneous scaring program.

Shooting permits have been issued to farmers at times to scare and kill troublesome ducks. In theory these permits enable busy farmers to enlist the help of hunters, who, as primary waterfowl users, would contribute to the management program. The practice has had mixed public relations values, but there is no evidence that it has substantially reduced crop damage (RRCS, 1969). Permit-holders were concentrated near urban centres rather than in frequently damaged areas, tending to confirm the belief of many that their motive was unlimited pre-season shooting. Among farmers claiming compensation, the damage intensity was similar for those who had shooting permits and those who did not. Finally, much damage occurs after the waterfowl season opens and when special permits are no longer needed.

Automatic acetylene exploders have had considerable use in damage control programs, though mainly by wildlife agencies (Gollop, 1960; Krentz, 1960; Stephen, 1961*a*, 1967; Burgess, 1973). Experiments with acetylene exploders to control damage by ducks (Stephen, 1961*a*) and sandhill cranes (Stephen, 1967) showed that exploders effectively kept the birds from swathed grain. Generally, one exploder was needed for each one-quarter section (65 ha or 160 acres). In the crane study the cost to operate an exploder for an average season was about $44 (in 1965) including depreciation. As with other scaring methods, the effectiveness of exploders in reducing damage tended to be proportional to the availability of non-commercial feeding sites.

The modern acetylene exploder with automatic electric timing appears to come closest to the ideal scaring device. It is comparatively inexpensive, requires infrequent maintenance, and is reasonably effective for keeping waterfowl from crops. Nevertheless it has had little acceptance by farmers experiencing crop damage. In the RRCS (1969) survey, only about 2% of those with damage stated that they used exploders. Why so few use them is not clear, but cost is probably the answer. Often, insurance or compensation may be a *better buy* than an acetylene exploder, because the programs are financed largely by hunters and government revenue (Stephen, 1965*a*). Perhaps not enough effort has been devoted to selling the technique to farmers, or further study may prove that it would pay wildlife agencies to subsidize part of the cost of exploders purchased by grain farmers (Stephen, 1961*b*). The difficulty in obtaining acetylene gas in rural areas may also discourage farmers from buying exploders (S. Woynarski, pers. comm.).

None of the many other devices for keeping waterfowl out of crops has had much success for a variety of reasons. Some are not effective over a wide enough range of conditions; others are too costly or time-consuming. The homemade scarecrow in its many variations seems as useful as any and has been the most used. Most farmers agree that it is more effective if parts of it move and flash in the wind. Like all devices, it does a better job if erected before waterfowl start feeding on the crop, as they are more easily frightened when they first arrive.

Hochbaum *et al.* (1954) experimented with combined patrols and scaring to reduce crop damage on a Manitoba area. Shooting and scarecrows were used to frighten the ducks after they had been discovered. The authors estimated that one man could patrol about 80 sq. km (30 sq. miles) during an average season with a resulting reduction in crop damage. RRCS (1969) concluded that the method would be too costly to control the widespread damage in Alberta.

Herding field-feeding waterfowl, principally by aircraft, has been used extensively in the United States but only experimentally in Canada. It has served mostly to drive large numbers of ducks from fields and wetlands to nearby refuges that supply supplementary food (Horn, 1949; Biehn, 1951; Lostetter, 1960; Hammond, 1961). Lostetter (1960) reported that two aircraft could protect about 12,000 ha (30,000 acres) of rice crop in California.

Gollop (1951) described 22 flights near The Pas, Manitoba to drive ducks from crops. Flares were used during some flights. Because the cropland was interspersed with many wetlands, the method did not effectively move ducks from the vicinity of susceptible crops. Previously, Gollop (1950) had noted that ducks feeding at dark in the early morning or evening would be difficult to detect or herd by aircraft. Experiments to drive sandhill cranes from crops using up to three aircraft were also unsuccessful (Gollop, 1960). During three years that feeding stations were used near Delta, Manitoba, Krentz (1960) successfully herded ducks onto the feeding station marshes with an aircraft. Regardless of effectiveness, herding waterfowl by aircraft or other means on the Canadian prairies would be extremely expensive because the damage areas are many and dispersed.

3. Feeding programs

Feeding methods for preventing damage provide grain and undisturbed feeding sites to keep ducks out of susceptible crops. One method provides threshed grain for ducks at *feeding stations*, usually on the shore of major resting places. Another supplies grain which is cut and left lying in the field. These fields are often called *lure crops* but the term implies more active attraction than in fact occurs. A crop may be planted in anticipation of ducks feeding on it or a commercial crop may be purchased after they have started damaging it. In the latter instance, the wildlife agency might not pay for any grain that the farmer can harvest after the field is no longer needed for damage control.

Many forms of recompense for farming services are used, such as standard crop sharing, cash payment for services, harvest of residual grain, cash payment for grain, and combinations of these. In no known instance are the farming operations carried out by government employees, in contrast to the practice on many National Wildlife Refuges in the United States. Hunting or other harassment is prohibited on feeding areas. Protecting ducks from disturbance while they feed in harvested fields could be considered as a third method in this category, though it would not be necessary to provide extra feed.

Feeding stations for keeping waterfowl out of commercial crops have had more use in the United States than in Canada. Hammond (1961) described the extensive feeding station program at Lower Souris Refuge, North Dakota and concluded that it was economically justified with 50,000 or more ducks. Ancillary benefits included the greater use of natural foods by ducks, less field-feeding, and favourable public reaction. Hammond (1961) gave useful information on feeding station operations, including site selection and preparation.

Feeding stations on a smaller scale were used from 1957 through 1959 in a Manitoba area (Krentz 1959). The project involved four to six stations and some scaring, and cost $27,000 to $36,000 per year. Crop damage in the area was apparently reduced but it was not evaluated.

RRCS (1969) identified several chronic damage areas in Alberta and recommended the use of feeding stations in pilot programs. Evaluations of feeding stations on two Alberta areas – 3 years at one and 2 years at the other – (Burgess, 1973) showed that crop damage was significantly reduced and that the projects were economically justified. Benefit/cost ratios (farmer's loss prevented in relation to project cost plus compensation paid despite the program) averaged between two and four. Costs included scaring from nearby commercial crops. The average feeding station accommodated 439,500 duck-days of use (range, 162,380 to 845,000) and stations attracted ducks daily for an average of 57 days (range, 35 to 80). Average feeding station cost was 1.8¢ per duck per day (range, 0.6¢ to 4.4¢). Burgess (1973) estimated that one feeding station used for 35 days would cost $5677. This estimate included feed for close to 6000 ducks daily as well as costs of a complementary scaring program. Altogether there were 18 areas in Alberta believed suitable for the described treatment. These would require about 37 feeding sites.

Lure crops to control damage have been used to varying degrees in the Prairie Provinces. For example, in 1970 there were 4 in 2 Alberta damage areas, 29 in 5 Saskatchewan damage areas (18 of these were on the Last Mountain Lake Wildlife Area), and 10 in 5 Manitoba damage areas. A reduction in damage was evident in most cases and costs of operating lure-crop programs are fairly well documented, but few benefit/cost evaluations are available. Eleven lure crops used in Stephen's (1967) sandhill crane study near the north end of Last Mountain Lake, Saskatchewan included some grown on public lands, some purchased in entirety from farmers, and some partially purchased from farmers. Costs averaged \$8.25 per acre (0.4 ha). Stephen concluded that, when combined with scaring (acetylene exploders), lure crops improved an already favourable benefit/cost ratio.

J. P. Hatfield (pers. comm.) estimated that 1 acre (0.4 ha) of lure-crop barley grown on publicly-owned land cost \$7.00 in 1969 and that it would feed 20 sandhill cranes or 40 ducks for 2 weeks. If land had to be purchased, MacLennan (1973) calculated that 1 acre (0.4 ha) of lure crop would cost \$10.30 annually. Capital costs were amortized over a 20-year period and it was assumed that two-thirds of the land would be cropped annually. From insured crop losses – thought to be one-third to one-half of the actual loss – MacLennan (1973) conservatively estimated that there were about 20 areas in Saskatchewan feasible for lure-crop programs, including 5 already treated. The 10 areas studied by MacLennan varied from about 31 to 130 sq. km (12 to 50 sq. miles) and were among the worst damage areas in the province.

Burgess (1973) used higher land and farming costs and assumed that all the land would be cropped annually when he calculated that an acre of lure crop would cost \$23.50. If the crop were purchased it would cost \$35.00 an acre (0.4 ha). Using the last figure for crop costs and combining it with costs for posting, patrolling, scaring, etc., Burgess estimated that a *crop damage control unit* involving a 65-ha (160-acre) lure crop would cost about \$8000 for 35 days of control. Cost per duck per day for the 10 lure crops evaluated averaged 3.2¢. High variability (0.5¢ to 41.0¢) resulted from the erratic numbers of ducks using the different sites.

The most efficient size and number of lure crops depend on the number and distribution of ducks in the area, the length of time for which protection is needed (harvest progress), and the number of ducks each lure site may attract. Since this information cannot be predicted accurately, only experience will show what is needed to give a margin of safety. If one always manages for a *bad* damage year, lure crops will more often than not be inefficient in terms of grain uneaten, though at times some of the uneaten (and untrampled) grain can be harvested. An alternative is to prepare for an average year and, in the event of greater threats, convert commercial crops into lure crops (MacLennan, 1973).

Burgess (1973) studied 10 lure crops ranging from 28 to 65 ha (70 to 160 acres). Three were completely used by ducks. Unharvestable grain on the remainder amounted to 13 to 39% of the original crop. Eighteen lure crops on the Last Mountain Lake Wildlife Area ranged from 12 to 24 ha (30 to 60 acres) of barley (J. P. Hatfield, pers. comm.). MacLennan (1973) assumed a lure crop size of about 40 ha (100 acres) – two-thirds of 65 ha (160 acres) in crop, one-third fallow – to estimate the needs for damage control on Saskatchewan areas. A Manitoba proposal recommended lure crops of 16 to 24 ha (40 to 60 acres) each. The reasons for differences in sizes recommended or used presumably relate to different crop rotation practices on the standard land unit, the *quarter-section* or 65 ha (160 acres). Growing a non-susceptible crop on part of the field can help offset the cost of owning a large acreage, as at the Last Mountain Lake Wildlife Area, where forage revenue more than offsets lure-crop costs.

Attempts to attract ducks to lure crops have included using decoys, flooding the field, and burning the crop. There is little information on the effectiveness of these methods, or indeed the need for them. The fact that there have been few trials, indicates little need. Bossenmaier and Marshall (1958) believed that burning straw on harvested fields made them more attractive to ducks, and a similar effect might be expected when swaths were burned. The flooded lure crop monitored by Burgess (1973) for three years was no better than crops on dry land judging by the number of ducks attracted and the quantity of grain eaten. Presumably, decoys on lure crops would be as effective as those used extensively by hunters and those used by Krentz (1960) and McWhorter (1961) to attract ducks to harvested grain fields. A well-placed lure crop may rarely need additional measures to attract ducks. Features of good sites have been described as: a large field (not necessarily all lure crop) devoid of trees, an open field with a high spot in it, at least 0.4 km (0.25 mile) from buildings and busy roads, a history of duck use, located on traditional flight lanes used by ducks flying from their resting places, and near principal resting places. Early ripening grains are best because the lure crop should be available before commercial crops are swathed. Short stubble may be more attractive to ducks once they land (Bossenmaier and Marshall, 1958). Mowing, rather than swathing, lure grain may result in less wastage, but ducks may not recognize mowed grain as readily (Gollop, 1950). Mowing would also make it impractical to salvage uneaten grain. More grain can be exposed by turning the swath with a side delivery rake (Krentz, 1960) or disking the field after about a month's use (J. P. Hatfield, pers. comm.).

Both feeding stations and lure crops will probably be used more in future programs to reduce waterfowl damage on the Canadian prairies, and a careful analysis of their relative merits should precede any choice between the two. The Alberta experiment (Burgess, 1973) showed that capital and operating costs for feeding stations were less than those for lure crops with equal protection. The difference increases with extended control because, during late harvests, an additional lure crop may have to be purchased. Feeding stations attracted ducks daily for longer periods than did lure crops, though there was not much difference in the number of ducks fed each day. Feeding stations can be started when needed and kept operating as long as necessary. They require little land and grain is seldom wasted. Provision of feed can be flexible and adapted to existing conditions. MacLennan (1973) believed that lure crops would provide cheaper protection than feeding stations in Saskatchewan. Since the damage areas are many and dispersed, the equipment and staff necessary to service them all with feeding stations would cost too much. Also, road conditions in wet seasons would make it difficult and costly to service feeding stations when they are most needed. Experience and careful record-keeping as done by Burgess (1973) will show where each feeding method is best used.

Burgess (1973) warned that the effect of feeding programs on duck populations and hunting opportunities must be measured and corrected if found detrimental. Feeding projects may alter migration patterns that, in turn, could affect crop damage or hunting opportunities elsewhere; though in one Alberta area feeding projects apparently made no measurable change in duck migration patterns in three years (Burgess 1973). But in the area located near a large urban centre, the feeding projects did make large numbers of ducks unavailable to hunters. Finally, ducks concentrated at feeding stations are more vulnerable to disease outbreaks.

Production of natural foods that would keep potential field-feeding ducks on marshes has had little investigation, probably because the method is thought to hold little promise. Hochbaum (1944), Horn (1949), and Bossenmaier and Marshall (1958) concluded that ducks fed on grain fields despite an abundance of natural foods in the marshes. Conversely, Leitch (1951) believed development of a smartweed bed (*Polygonum* sp.) in certain Alberta wetlands helped to keep pintails out of crops. Gollop (1950) made experimental plantings of sago pondweed (*Potamogeton pectinatus*), millet (*Echinochloa crusgalli*) and wild rice (*Zizania aquatica*) in southern Alberta. As the resulting plant production was insignificant, it could not be evaluated.

4. Payments to farmers

Payments for losses from waterfowl damage have been made to farmers in Saskatchewan since 1953 in a form of insurance (Paynter, 1955) and in Alberta since 1961 as compensation (Smith, 1968; RRCS, 1969). In both provinces revenues have been derived mainly from imposts on hunting licences – $1 in Saskatchewan and $3 in Alberta ($2 before 1969). Farmers in Saskatchewan pay a 2% premium on the insured value of the crop, with a maximum of $25 an acre (0.4 ha). Policies have to be purchased prior to 10 August. Alberta farmers can claim damage compensation up to a maximum of three-quarters of the crop value or $25 an acre (0.4 ha), whichever is less ($15 an acre or one-half of the value before 1973) upon payment of a $25 adjustor's fee.

From 1956 through 1967, insurance claims for crop damage in Saskatchewan averaged $87,000 annually; the average for 1968 through 1971 was $428,000 (MacLennan, 1973). The program could not be supported in recent years ($521,800 in 1971) by annual revenue of $140,000 to $180,000 from hunting licence imposts, and had to be subsidized by other government funds. MacLennan (1973) could not definitely determine if the rise in claims reflected more severe damage in recent years or simply greater participation by farmers. The first reason was indicated by the increase in the percentage of policy-holders making claims between the two periods (41 vs 54%) and the rise in average claim ($433 vs $741). However these measurements could have been affected by changes in average acreage insured, an unknown figure. Although the reasons for the rise in insurance claims in recent years may be unclear, there has been a definite trend toward greater participation by farmers over the years.

Using 1971 insurance claim figures and assuming that the actual damage was two or three times the insured damage (RRCS, 1969), MacLennan (1973) predicted that a compensation scheme for Saskatchewan would cost between $1.1 and $1.7 million annually. Apparently he assumed no change in farmers' participation. The crop damage insurance program in Saskatchewan has not been entirely acceptable to farmers, as is shown by perennial recommendations to abolish premiums, raise the insurable ceiling, and abolish the time limit for purchasing policies (Stephen, 1965*a*).

Annual compensation for crop damage in Alberta was not over $6000 during the first 3 years, 1961 to 1963 (RRCS, 1969). It exceeded $300,000 in 1964, and from 1964 through 1968 averaged about $224,000. Figures in annual reports of the Alberta Department of Lands and Forests indicate that payments averaged about $500,000 from 1969 through 1973. As in Saskatchewan, annual revenue from hunting licence imposts, which has amounted to about $360,000 since 1969, could not alone support such high levels of compensation. The RRCS (1969) report concluded that the compensation program fell short of its objectives of reducing farmers' losses from crop damage and improving the attitude of farmers toward waterfowl and their users. First, a small proportion (12% in 1968) of farmers with damage were submitting claims. Some were not aware of the program and others were apparently willing to accept a certain level of crop loss. Second, the fixed ceiling of $15 an acre (0.4 ha) did not provide for fluctuating market values of grain nor for regional differences in crop yields. Farmers in low yield areas might recover close to one-half of their crop value, but those in high yield areas recovered much less. For those making claims, compensation payments averaged about one-third of the loss sustained.

The report recommended greater publicity for the compensation program and the use of a sliding scale for payments based on current grain values rather than the dollar ceiling. Maximum compensation could be based on one-half of the crop value, but the scheme could include an option allowing a farmer to insure the balance of his crop. These recommendations were made on the assumption that an extensive damage control program could accompany the more realistic levels of compensation.

Manitoba has had a compensation scheme since 1972. Before then the government was prepared to purchase damaged crops in special cases and use them for lure crops. Compensation payments in 1972 were $5000 and in 1973, $33,000 (S. Woynarski, pers. comm.). The program is supported by a *wildlife control fund* to which hunters contribute by purchasing a $2.25 annual wildlife certificate. Revenue from this source amounted to $149,000 during the first year, 1970.

Research needs

Despite efforts to solve it, much of the waterfowl damage problem remains. Part of the burden has been shifted from the farmer to the government agency and the waterfowl user, who supports abatement programs through imposts. This has helped to reduce the antipathy of grain farmers, but the shift of responsibility does not make the problem disappear. It seems probable that a majority of farmers will always tolerate a certain level of damage though, in doing so, they are not likely to regard waterfowl as anything but pests. Also, despite programs to protect crops, severe damage will occur periodically, particularly during delayed harvests, and nothing short of compensation or insurance will ease the problem then (Farmes, 1969); but, as Cummings (1971) stated: "It cannot be regarded as an ultimate solution as it ignores the reason for the wildlife conflict." A solution can exist only when economical ways are found to reduce crop damage.

Not all factors that affect waterfowl damage or the success of control measures will be fully understood without more study of the behaviour of the birds. How long do individuals remain in one area? How much flock turnover is there? How far do birds fly to fields and how often do they feed? Are there differences in field-feeding habits between ages or sexes? More knowledge of the birds' behaviour and ecology would provide a stronger base on which to plan research and management projects aimed at damage control (Murton, 1968, 1974).

Better ways must be found to measure the distribution and severity of damage so that its relationship to the variables that affect it can be accurately determined. Questionnaires, records of compensation or insurance claims, and scaring permits all have biases that render them useful only for broad surveys. Reliable data on damage are needed to plan crop protection programs.

1. Farming practices

Forty years ago Leopold (1933) stated: "Only the landowner can practice game management cheaply." Leopold's *theorem* is no less valid today and, logistically, the grain farmer is in the best position to protect his crops. Some useful methods are available but little used. Reasons for this should be determined and ways devised to achieve more participation. In some cases it may simply mean better communication between wildlife agencies and the agricultural community. Some known crop protection techniques may need retesting; some never have been adequately tested. New devices and methods should be sought. The more techniques available, the better the chance that one will be used.

Growing non-susceptible crops on high-risk fields is one obvious way for the individual farmer to prevent losses from waterfowl. In some regions, however, it may not be culturally possible or economically advantageous to grow anything but wheat or barley. There are other limitations to changes in farming practices, such as the farmer's existing capital investment in equipment or the lack of capital to invest in alternatives. One may postulate, however, that tradition or inadequate information are the only reasons why wheat and barley are persistently grown in areas that experience chronic duck damage.

The use of chemicals to hasten ripening of standing grain and thereby eliminate the need for swathing was investigated briefly in North Dakota in the 1950's (Hammond, 1955). Reports on the final results are not available, but preliminary results suggested that further research would be justified. Even without treatment, it may pay farmers to straight-combine grain in areas where waterfowl damage is an annual hazard. Usually the advantages of swathing grain outweigh the disadvantages (Dodds, 1967), but the difference is small enough that its elimination could be seriously considered for chronic damage areas. Crop scientists have been successful in breeding grain varieties resistant to insects and diseases. Could they also produce a variety resistant to duck damage (Kozicky and McCabe, 1970)?

2. Repelling waterfowl

One gains the impression that the search for new and better ways to repel waterfowl died with the development of the improved acetylene exploder. Development of feeding schemes now seems to be the popular approach. The fact that scaring often increases total damage has dampened enthusiasm in the search for better methods, but scaring is often a necessary adjunct to feeding projects and so will always have a role in damage control. Moreover, feeding programs are economically feasible only in restricted areas with persistent severe damage. Elsewhere damage must be controlled by other means. Many farmers willingly devote reasonable effort to protecting their crops, and providing them with better techniques would help solve the crop damage problem.

The array of scaring devices that has been tried is impressive and seems to cover all possible stimuli that might deter waterfowl. But I believe that all possibilities have not been exhausted and that further research on scaring methods is justified. Some devices have been suggested but have not been adequately tested, e.g., the ways that hawk models might be used to scare ducks (Melzack, Penick, and Beckett, 1959). Seemingly innocuous objects might prove effective. In one study (Pfeifer and Keil, 1963) a variety of birds were tested with reflecting glass balls, but only raptors were repelled. There appeared to be no explanation for this response peculiar to raptors. The use of chemical repellents to protect crops from ducks is suggested in the literature, but little research has been done. Generally, results from a traditional approach to repel ducks chemically have been disappointing (Kear, 1965). But the success with chemicals that cause flock-disturbing behaviour in other species (Goodhue and Baumgartner, 1965; De Grazio *et al.*, 1972) indicates a need for parallel studies with ducks.

Scaring devices that produce loud sounds other than explosions have had little testing. Thiessen *et al.* (1957) obtained conflicting results when they used a siren to scare mallards and pintails from wetlands, and concluded that the method would not be economically practical for crop protection. Perhaps the ducks' response threshold would have been lower had they been field-feeding during the tests (Boudreau, 1968). Development of amplified recorded sounds (Frings, 1964) might make some acoustical methods more attractive as a means of scaring waterfowl. Any sound, including shotgun blasts, could be projected over large areas with suitable equipment. A tape recorder could be programmed to broadcast a variety of high-intensity sounds at varying intervals; the mixed noises should delay habituation, wherein lies the weakness of most scaring devices (Frings and Frings, 1967).

Bio-acoustics, using recorded alarm and distress calls to scare birds, have shown promise in some situations, but most research has been confined to larids, sturnids, icterids, and corvids (Frings, 1964; Boudreau, 1968; Busnel and Giban, 1968). Particularly fascinating is the possible use of synthetic *super-signals* that may suppress habituation to the stimulus. The use of broadcast predator calls (Frings and Frings, 1967) may also deserve investigation. Bio-acoustics that frighten waterfowl seem to have been dismissed as a crop protection method, probably because damage is dispersed and traditional equipment is costly. But perhaps we have been too preoccupied with the costs of the tools at hand when contemplating options for crop protection research. Discovery of a technique that requires an inexpensive device to be practical need not await development of the device itself. Demonstrated utility will stimulate technology to look for it, as witnessed in the development of biotelemetry aids.

Field-feeding ducks prefer large open fields free of tree or shrub growth (MacLennan, 1973) and lure crops may never attract waterfowl if placed close to trees, shelterbelts, etc. There is little doubt that, above a certain density, shelterbelts would give protection from waterfowl damage, though this has not been evaluated. The effective density should be determined, and also whether the altered habitat increases damage by other vertebrates such as blackbirds (Howard, 1967). Although their value for reducing waterfowl damage remains uncertain, shelterbelts on cultivated farmland are useful for soil and moisture conservation (Staple and Lehane, 1955), and increase the presence of passerine birds (Stewart and Kantrud, 1972) and upland game birds (Hunt, 1974). Provision of multiple benefits makes any technique more attractive. More study is needed on the relationship between the field-feeding habits of waterfowl and landscape features, including shelterbelts and natural tree growth.

Another practice in biological control alters habitat to attract natural enemies of troublesome species (Howard, 1967). Would the addition of perching sites attract raptors to grain fields and, if so, would it help to reduce duck damage? This, too, may warrant some investigation.

3. Alternative feeding sites

Techniques for operating feeding-station and lure-crop projects are well known, though future experiences are likely to reveal new problems and innovations. To illustrate, Hammond (1955) recommended that low-cost bulky feeds, including oats, be tested as substitutes or additives to the usual grains distributed at feeding stations. Although the ratio of grain eaten to grain wasted is of little concern to the farmer who loses both ways, it is important to the lure-crop manager who tries to make the most efficient use of the grain. Verified measurements of consumption by field-feeding ducks are lacking, and estimates commonly used seem to be based on the grain found in a small number of mallard crops and the assumption that all ducks feed on the grain twice a day. Some mallards may feed on grain but once daily (Gollop, 1950; Sterling, 1952). Also, estimates based on feeding-station records may not be applicable to swathed grain because of differences in availability. The popular figures used for a mallard's daily consumption – 198 to 227 g (7 to 8 oz.) – seem high in view of the measured intake of 73 g (2.6 oz) daily by male mallards penned outdoors in Illinois in October (Jordan, 1953), as well as predicted values based on indirect measurements (Kendeigh, 1970; Owen, 1970; Sugden, 1971). Studies are needed to determine if realistic estimates of grain consumption are being used, as these measurements are critical when evaluating feeding programs.

It would be useful to know if feeding projects do delay movements of ducks southward. A project in the north that reduces damage along the flyways to the south should reap greater benefits than one in the south.

Although culture of natural foods as a technique to keep ducks out of commercial grain appears to have limited utility, there is little quantitative evidence upon which to base the conclusion. Reliable information on the autumn diets of mallards and pintails that feed in prairie marshes is almost non-existent, most studies being based on gizzard material that may give biased results (Swanson and Bartonek, 1970). Few attemps have been made to measure the abundance and availability of foods in marshes used by field-feeding ducks. We do not know how the features of a marsh are related to the tendencies of the ducks to forage in grain fields (Gollop, 1951). At Delta, Manitoba, Hochbaum (1944) observed that some mallards obtained most of their food from fields, while others were strictly marsh-feeders. Elsewhere, some mallards apparently fed in fields twice daily, while others visited fields once each day (Sterling, 1952).

Severely damaged areas are invariably associated with large wetlands harbouring flocks of ducks. But not all large wetlands have associated damage, despite the fact that some have comparable fall populations of mallards and pintails (D. J. Nieman, pers. comm.). Hammond (1955) believed years of good pondweed (*Potamogeton* spp.) seed production at Lower Souris Refuge, North Dakota were associated with low crop damage because mallards and pintails depended more on natural foods. These observations suggest that marshes differ in their ability to hold potential field-feeding ducks. Observations made in the past were largely of ducks that habitually fed in fields. Even less is known about ducks that do not field-feed or the wetlands they utilize. Further study might reveal important clues concerning the relationship between natural food stocks and field-feeding intensity. Demonstration of such a relationship would justify research on natural food management (Toth, Tourine, and Toth, 1972).

4. Conclusions

The urgency of the problem tends to generate short-term research projects seeking quick solutions, yet some questions will be answered only after years of careful data collection or experimentation. Examples of these would be the relationship between damage severity and the distribution, numbers, and movements of waterfowl; the relationship between field-feeding activity and the wetlands used by the ducks; the influence of landscape features on the behaviour of field-feeding ducks; and the application of bio-acoustics to scare ducks. The testing of some techniques may require several years to produce meaningful results.

Small gains in crop protection will probably be the rule and should not be dismissed. 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 and programs will always be multiform, if for no other reason than that more than one group of people is involved. Benefits from multiple techniques tend to be additive.

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