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WILDLIFE DAMAGE IN CONSERVATION TILLAGE AGRICULTURE: A NEW CHALLENGE

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ABSTRACT: Conservation-tillage farming systems have changed agriculture and brought new challenges to the wildlife damage field. Associated minor problems may result from the presence of rattlesnakes (Crotalus viridis) or badgers (Taxidea taxus), but sprout-pulling damage by birds has not been reported. Rodents dig and consume newly planted corn. At least 14 small mammal species have been captured in no-tillage cornfields, some species throughout fields and others primarily at edges. Deer mice (Peromyscus maniculatus) generally have been the most abundant, comprising 71 to 93% of total captures. Small mammal populations in no-tillage fields are generally no higher than in conventionally tilled fields, but they may be more diverse, and possibly more stable. Rodent damage to newly-planted corn is variable among fields and years but is at times substantial, possibly resulting in annual losses of up to $16 million in Nebraska. Six rodent species have been implicated in the damage problem but the overall amount of damage caused by each species is unknown. Currently, there are no satisfactory control methods. A new zinc phosphide grain bait is being developed; other potential controls include cultural methods, alternate feeding, and repellents. Benefits of small mammals such as their consumption of crop-damaging cutworms should be considered in control decisions. Wildlife damage problems in conservation-tillage systems, particularly rodent problems, challenge further research to better quantify associated impacts and to develop appropriate control measures.

INTRODUCTION

As farming systems change, associated wildlife communities and interactions with agriculture may also change. In relation to agricultural production, some of these wildlife changes may be neutral, others harmful, and still others perhaps beneficial. Changes offer new opportunities and challenges to researchers and others to understand the impacts, both positive and negative, and how best to deal with them. Changes in vertebrate communities that are harmful to agricultural production translate into vertebrate pest problems; these pose challenges of particular interest to those who work to prevent and control wildlife damage.

Conservation tillage farming systems have expanded markedly in recent years, changing agriculture and presenting new challenges to the wildlife damage field. Nationwide, these systems in 1984 had grown to 39 million ha (97 million acres) of cropland, 30% of the total (Conserv. Tillage Inf. Cent. 1985). Growth is expected to continue; projections estimate that 50 to 95% of cropland will be in some form of conservation tillage by year 2010 and that up to 55% will be in no-tillage (USDA 1975, Grosson 1981). Agricultural advantages of these systems include fewer labor and energy inputs, improved moisture conservation, reduced soil erosion, and increased and more stable dryland crop yields (Fenster and Wicks 1977, Crosson 1981). Moreover, plant residues on the soil surface provide suitable habitat for ring-necked pheasants (Phasianus colchicus), mourning doves (Zenaida macroura), and other ground-nesting birds (Basore et al. 1986). However, these systems are not without problems. The foremost vertebrate pest problem is damage resulting when rodents dig and consume newly planted corn. Rodent predators, particularly badgers and rattlesnakes, cause problems at times, but bird damage such as from sprout-pulling has not been reported for conservation-tillage fields.

This paper presents an overview of wildlife damage in conservation-tillage agriculture, with primary emphasis on rodent problems. Potential controls and research/information needs are described.

WHAT IS CONSERVATION-TILLAGE?

Various definitions have been used to describe conservation-tillage but they generally indicate any tillage system that reduces loss of soil or water compared to conventional (moldboard plow) tillage (Crosson 1981, Mannering and Fenster 1983). At least 30% of the soil surface is covered by plant residues after planting in conservation-tillage systems; various system types (no-till, ridge-till, strip-till, mulch-till or reduced-till) maintain different amounts of such residues (Conser. Tillage Inf. Cent. 1985). No-tillage systems involve minimal soil disturbance and plant residues remain high, about 90% soil surface coverage. Herbicides replace tillage for weed control, and planting is usually accomplished by opening a small slit in the soil for seed placement; otherwise the soil is undisturbed (Mannering and Fenster 1983). Plant residues change the habitat structure, and lack of tillage allows undisturbed bird nesting and rodent burrow establishment, aspects that affect wildlife use (Johnson et al. 1982, Warburton and Klimstra 1984, Castrale 1985). Studies of wildlife in conservation-tillage agriculture have generally focused on no-tillage fields (Holm 1984, Wooley et al. 1985, Basore et al. 1986), probably in part because they represent the greatest differences from conventional tillage.

SMALL MAMMALS IN CONSERVATION-TILLAGE SYSTEMS

Understanding rodent damage in conservation-tillage fields and developing appropriate control measures requires knowledge of what species are present in the fields and how the population characteristics compare to other conventional systems. A study of no-tillage cornfields in Nebraska resulted in captures of ten small mammal species: nine rodents and one shrew (Holm 1984; Table 1). An Iowa study, which compared tillage practices, resulted in captures of ten small mammal species in no-tillage

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cornfields (corn planted into corn stubble or into sod); these captures included eight rodent and two shrew species (Young 1984). Five rodent species were captured in Illinois no-tillage cornfields (Beasley and McKibben 1976, Warburton and Klimstra 1984), and Castrale (1984, 1985) captured three species in Indiana no-tillage cornfields (Table 1) and a fourth (Microtus ochrogaster) in no-tillage soybeans. The differences in species composition among these studies may relate to geographical location, trapping effort or techniques, field differences, and other factors. Although species compositions are not comparable among these studies, species captured establish a baseline of small mammals currently known to occur in no-tillage cornfield communities.

Table 1. Small mammal species captured in no-tillage cornfields in Nebraska (NE; Holm 1984), Iowa (IA; Young 1984), Illinois (IL; Beasley and McKibben 1976, Warburton and Klimstra 1984) or Indiana (IN; Castrale 1984, 1985).

Species	Location			
Deer mouse (Peromyscus maniculatus)	NE	IA	IL	IN
Northern grasshopper mouse (Onychomys leucogaster)	NE	IA		
White-footed mouse (Peromyscus leucopus)	NE	IA	IL	IN
Hispid pocket mouse (Perognathus hispidus)	NE			
Thirteen-lined ground squirrel (Spermophilus tridecemlineatus)	NE	IA		
Ord's kangaroo rat (Dipodomys ordi)	NE			
Western harvest mouse (Reithrodontomys megalotis)	NE	IA		
House mouse (Mus musculus)	NE	IA	IL	IN
Meadow jumping mouse (Zapus hudsonius)		IA		
Meadow vole (Microtus pennsylvanicus)		IA		
Prairie vole (Microtus ochrogaster)			IL	
Voles (Microtus spp.)	NE			
Bog lemmings (Synaptomys cooperi)			IL	
Short-tailed shrew (Blarina brevicauda)	NE	IA		
Masked shrew (Sorex cinereus)		IA		

Deer mice were the most abundant species captured in each of these studies, comprising 83% of all captures in Nebraska (Holm 1984), about 71% of all captures in Iowa (Young and Clark 1983), Young 1984), 93% of no-tillage captures in Illinois (Warburton and Kilmstra 1984), and 73% of all captures in Indiana (Castrale 1985). Warburton and Klimstra (1984) compared a no-tillage cornfield to one with conventional tillage and found higher densities of deer mice in the no-tillage field. However, Young (1984) and Castrale (1985) reported comparable deer mouse densities in no-tillage and conventionally tilled fields. Moreover, Fleharty and Navo (1983) captured nine rodent species in conventionally tilled, center-pivot-irrigated cornfields and reported mean captures per 1000 trap-nights of 61 (Seasonal range; 13-81) for northern grasshopper mice (Onychomys leucogaster), 18 (range; 4-32) for deer mice, and 13 (range: 2-23) for house mice (Mus musculus). They concluded that conventionally tilled cornfields were viable habitats for many species of small mammals. Examples of captures per 1000 trap-nights from no-tillage cornfields in Nebraska include 132 (range: 43-200) for deer mice, 8 (range: 1-18) for grasshopper mice, and 7 (range: 0-27) for white-footed mice (Peromyscus leucopus) (Holm 1984). Overall, there is no clear evidence to indicate increased densities of small mammals in no-tillage as compared to conventionally-tilled cornfields.

Rodent (and damage) locations within fields should be considered in damage control programs. For example, control efforts targeted at field edges only are unlikely to be effective if the damage-causing species is located throughout the field. Deer mice were captured throughout study fields in Nebraska, but Ord's kangaroo rats (Dipodomys ordi) were always captured near field borders (Holm 1984). Other species showed no clear distribution patterns within fields, in part because of too few captures. In Iowa fields, Young (1984) captured similar numbers of deer mice and thirteen-lined ground squirrels (Spermophilus tridecemlineatus) in plots at field middle and edge locations. House mice were captured in higher proportions at edges but grasshopper mice were more prevalent in the middle. Castrale (1985) and Warburton and Klimstra (1984) apparently found deer mice throughout no-tillage fields. Castrale

(1985) reported house mice occurring in some no-tillage cornfields with large amounts of residue, but in tilled fields, house mice were captured most often near edges. Fleharty and Navo (1983) suggested that edge habitats may serve as important habitat components or refugia for some species. Overall, it appears that some species such as deer mice are likely to be found throughout no-tillage fields while other species such as kangaroo rats may be more restricted to edges. However, rodent distributions within fields may vary seasonally (Castrale 1985), as well as with field condition, geographical location, and other factors.

The diversity and stability of small mammal populations have also been considered. Young (1984) found higher diversity in small mammal populations of no-tillage fields in Iowa compared to those of conventionally tilled fields. He also concluded that stable population levels occurred in all his field types with little evidence of encroachment from surrounding areas (Young 1984). Warburton and Klimstra (1984) found less turnover of adult deer mice in a no-tillage as compared to a conventional-tillage field and felt that the no-tillage population was more stable. Fleharty and Navo (1983) reported an influx of grasshopper mice into a cornfield in July and suggested that the influx was in response to a time when excellent food and cover resources were available. Overall, there is some evidence that small mammal populations in no-tillage fields may be more diverse, and possibly more stable (less turnover in adults) than in conventionally tilled fields, but further data are needed. The degree of diversity or stability may affect rodent damage control results. For example, greater stability may enhance "training" a population to avoid planted grain through use of repellents and conditioned aversion learning (Rogers 1978, Johnson 1986).

BIRDS

Ring-necked pheasants and a number of other bird species nest at higher densities in no-tillage fields than in fields conventionally tilled (Wooley et al. 1985, Basore et al. 1986). Pheasants are a desirable game species and their presence on farms is usually welcomed. However, pheasants may also at times damage young corn plants in conventionally tilled fields by sprout-pulling (Stine and Mott 1973). Although higher numbers of pheasants in no-tillage fields may imply higher damage levels, this does not seem to be the case. There appear to be no documented cases of sprout-pulling by pheasants or other birds in conservation-tillage fields. There may be several explanations for this including the availability of methiocarb repellents to control such damage.

Another possibility is that alternate invertebrate foods for pheasants may be more plentiful in no-tillage fields. Populations of invertebrates are reportedly higher and more diverse in no-tillage fields than in conventionally tilled fields (Blumberg and Crossley 1983, Warburton and Klimstra 1984). Moreover, no-tillage fields in spring tend to be wetter and cooler because of the residue cover, thus they may have delayed emergence or be planted later (Fenster and Wicks 1977, Crosson 1981) so that sprouts are up when insects are more plentiful.

RODENT PREDATORS

Prairie rattlesnakes occur in western portions of Nebraska and, according to reports from farmers and other field observers, appear to be more prevalent in no-tillage fields than in conventionally tilled fields. The residue cover, lack of disturbance, and rodent food supply in no-tillage fields apparently provide a suitable habitat for these snakes. No formal documentation of rattlesnake use of no-tillage fields has been made, and the likelihood of problems from snakebite are probably minor. However, rattlesnakes are poisonous and represent a potential hazard to people, including field researchers, in some no-tillage fields. Solutions usually involve avoiding or dispatching individual snakes, wearing protective clothing such as snake-guards, or minimizing foot travel in problem fields.

Badgers have been reported by some farmers and others as causing problems in certain no-tillage fields by digging holes, apparently to capture rodents for food. The holes were large enough to pose problems for farming equipment. Badger use of no-tillage fields and associated problems have not been documented, but appear to be minor and to occur only in some areas. Moreover, badger digging may be no greater problem for no-tillage than for conventional-tillage systems. If needed, control usually involves trapping and removing the offending animal (R. Kelly, pers. comm.).

RODENT DAMAGE

Damage Levels

Various rodents that thrive in conservation-tillage fields cause damage in some years by digging and consuming newly planted seeds and kernels attached to seedlings. This damage, which occurs for approximately three weeks after planting, may result in stand losses of ≥ 25% in some fields (Johnson et al. 1982), but average stand losses are lower and variable. Holm et al. (1983) and Holm (1984) reported mean corn stand losses in Nebraska of 4.7% (range: 0.3-10.5%) and 8.3% (range: 5.0-10.3%) in eastern and western Nebraska, respectively, in 1983, but < 1% overall in the same areas in 1984. Stand loss from rodent damage was 24.2% in one south-central Nebraska cornfield (Nuckolls County) in 1983 (K. Holm and Johnson, unpubl. data), and Beasley and McKibben (1974, 1976) reported losses in test plots in Illinois as high as 80% within 10 days of planting. Young (1984) found losses in Iowa of about 1.6% (range: 0-5.1%) in one no-tillage system (corn planted into sod) and less in other study fields (corn planted into corn residue or conventionally tilled). However, earlier observational reports from Iowa and other states indicated rodent damage severe enough to necessitate replanting (Johnson et al. 1982). This damage problem, although variable among years and locations, is at times substantial, and is likely to increase along with increased use of conservation- or no-tillage systems. Similar damage levels have

not been reported from conventionally tilled fields except for some damage along field edges. Young (1984) found negligible damage (about 0.17%) in his conventionally tilled fields, and Fleharty and Navo (1983) noted no rodent damage in their conventionally tilled fields in Kansas.

Rodent Species that Cause Damage

Five of the nine rodent species captured in Nebraska by Holm (1984) were implicated as causing damage to newly planted-corn. These species (deer mice, northern grasshopper mice, white-footed mice, Ord's kangaroo rats, and hispid pocket mice (*Perognathus hispidus*); had corn in their stomachs during the post-emergence period when damage to corn was occurring. Because all of Holm's study fields had been rotated from a different crop grown in the previous year, the only corn available at post-emergence time was the planted grain. In addition, thirteen-lined ground squirrels are known from other studies to damage newly planted corn (Johnson et al. 1985) and still other species, particularly voles and house mice, are suspected of contributing to this damage problem (Johnson et al. 1982).

Although several kinds of rodents may each cause some damage to newly planted corn, the overall amount of damage caused by each species is unknown. An important need is data on the proportion of damage caused by each of the various species. Such information would help in development of effective control techniques targeted on rodents causing the most damage. For example, various species may respond differently to toxic bait formulations or to repellent seed treatments.

Economic Impact of Rodent Damage

Evaluating the economic impact of rodent damage in conservation-tillage fields is difficult, particularly because of the variability in damage levels that have been reported. However, such an assessment is helpful in understanding the economic importance of the problem to agriculture. Nebraska had 1.5 million ha (3.8 million acres) under conservation tillage in 1984, of which 76 thousand (188 thousand acres) were under no-tillage systems (Conserv. Tillage Inf. Cent. 1985). If no-tillage systems incurred 4% stand losses from rodent damage, and other conservation tillage acres 2%, yields were 198 bu/ha (80 bu/acre), and corn value $2.50/bu, the outcome would be a $16 million loss. In 1983, average damage levels in Nebraska study fields were relatively high (4.7% east, 8.3% west) (Holm 1984), and $16 million or higher losses may have occurred. This estimate is speculative because insufficient data are available, but it is not totally unreasonable based on current information. Additional data on amount of stand loss, possible compensation in corn production from undamaged plants, possible replanting costs, and other economic factors are needed.

There is a clear need for further evaluation and assessment of rodent damage in conservation-tillage farming systems. Ideally, damage should be monitored over several growing seasons and in several geographical areas. Such data would be most valuable if accompanied by information on rodents, soils, weather, residue amounts, field size, surrounding edge habitats, and other factors potentially affecting damage levels, directly or indirectly.

Beneficial Aspects of Rodents

On the beneficial side, rodents that occur in conservation-tillage fields consume weed seeds; crop-damaging insects (Zimmerman 1965, Whitaker 1966, Beasley and McKibben 1976, Holm 1984, Young 1984) including grasshoppers, wireworms and cutworms (Gillette 1889, Orcutt and Aldrich 1892, Fitzpatrick 1925, Holm 1984), and waste grain that could produce unwanted volunteer crops during the following growing season. One cutworm may damage 3 to 4 corn seedlings (Archer and Musick 1977, Clement and McCartney 1982) so each cutworm consumed by rodents may represent the saving of several corn plants. Quantification of beneficial impacts that may result from rodent consumption of corn-damaging insect larvae such as cutworms or wireworms may be a difficult but potentially valuable project. Damage control programs should include consideration of these potentially beneficial aspects in estimating the costs and benefits of control.

RODENT DAMAGE CONTROL

Currently, there appear to be no satisfactory control measures for rodent damage in conservation-tillage fields. Potential controls are currently not well tested, not registered, or both. Regulations for use of toxic grain baits in cropland for rodent control have recently changed; many labels have new added use restrictions and some uses or products have been suspended or cancelled. Currently there are no toxic grain baits registered for rodent control use on cropland in Nebraska, and such registrations apparently are not available in other states that have large amounts of conservation-tillage corn. However, a new 2% zinc phosphide pelleted grain bait is being developed for use in no-till corn; it would be applied below ground during the planting operation (E. Marshall, pers, comm.). Applying zinc phosphide baits below ground provided effective rodent control in test plots in Illinois, and below ground application minimized possibilities of poisoning nontarget species (Beasley and McKibben 1974, 1975, 1976).

For spot-treatment of certain burrows at field edges, some fumigants or certain strychnine baits may be available. This use is probably of limited value for rodent problems in conservation-tillage crop fields because the damage may occur throughout the field rather than just at edges.

As indicated earlier, rodents may provide benefits to agriculture during early corn growth through their consumption of corn-damaging insect larvae such as cutworms and wireworms. Use of lethal controls such as toxic baits or fumigants would negate those reported beneficial aspects.

Planting early (e.g., May 1) rather than late (e.g., May 15 or June 1) has been suggested as a cultural control where thirteen-lined ground squirrels were causing the damage (Johnson et al. 1982). This suggestion was based on increasingly higher damage levels to experimental plots with the later planting dates, which corresponded with increased ground squirrel activity. However, Young (1984) suggested the opposite, indicating that late planting may minimize corn damage because alternative foods such as insects or green vegetation become more plentiful. The different suggestions may relate to the species involved or other factors.

Alternate feeding is a technique that some farmers in Nebraska and elsewhere (Anon. 1983) reported effectively controls damage to newly planted corn in no-tillage fields. The procedure involves scattering grain such as corn or wheat, preferably water-soaked, on the soil surface at planting time. The seed is scattered by hand or by attaching an extra planter box behind the regular corn planter. Use of alternate foods has successfully reduced small mammal damage to conifer seedlings (Sullivan 1978, Sullivan and Sullivan 1982). Although alternate feeding is currently untested in no-tillage cornfields, sufficient evidence of its potential usefulness is available to warrant evaluating it.

Repellents and conditioned aversion learning offer promising techniques for controlling rodent damage in newly planted corn while, at the same time, maintaining beneficial aspects of the rodents (Johnson 1986). Recent experiments with thirteen-lined ground squirrels (Zurcher et al. 1983) and deer mice (Holm 1985) have found that certain rates of both thiram or methiocarb repel rodents under some laboratory conditions. In large field enclosures with planted corn, thiram at 1.25% active ingredient by weight of corn seed repelled thirteen-lined ground squirrels, but 0.5% methiocarb hopper-box treater formulation was ineffective in four of five trials (Koehler 1983, Johnson et al. 1985). More recent laboratory trials with deer mice (Holm 1985) indicate that adding an odor cue to methiocarb treatments may enhance the repellency response. Although further research is needed, repellents if understood and properly applied, may offer an effective control technique.

CONCLUSION

A point often noted by biologists is that much of our wildlife resources depend on agricultural farmland for survival (Dumke et al. 1981). In view of this, studies are often made to document or evaluate the impacts of agricultural systems on wildlife (McCorkle and Halver 1982, Young 1984, Rodgers and Wooley 1983, Wooley et al. 1985, Basore et al. 1986). Although such studies are valuable, the reverse approach, studies of wildlife impacts on agricultural production, is perhaps too infrequent. From the view of a farmer whose livelihood depends on agricultural production, it seems that the latter approach may be of greater importance. If we in the wildlife profession wish to encourage adoption of farming practices that benefit desirable wildlife, we must better understand the impacts of wildlife on agricultural production systems, including documentation of both positive and negative impacts and development of techniques to help farmers safely and effectively minimize the negative.

Conservation-tillage and especially no-tillage systems apparently provide benefits to desirable ground-nesting birds (Baxter 1982, Warburton and Klimstra 1984, Basore et al. 1986) but also have wildlife damage problems. This paper, which provides an overview of wildlife damage in conservation-tillage systems, describes economically important levels of rodent damage to newly planted corn and includes food habits information that indicate potential economic benefits to crop production.

Further studies are needed to better understand the complicated biological interactions that occur in conservation-tillage systems, so that wildlife resources in these systems can best be managed for the benefit of farmers as well as desirable wildlife. Wildlife damage problems in conservation-tillage agriculture, particularly rodent problems, challenge further research to better quantify associated impacts, both positive and negative, and to develop appropriate control measures.

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