Wildlife Habitat Management Institute

# CONSERVATION TILLAGE AND TERRESTRIAL WILDLIFE

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As the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) develops Outcome-Oriented Performance Measures for Conservation Tillage, it is important to document the impacts that this conservation practice has on wildlife habitat and populations within the agricultural landscape. A landscape where wildlife habitat has decreased as cropland monoculture replaced the once small fields that produced a diversity of crops such as small grain, hay, and pasture (Vance 1976, Taylor et al. 1978). An additional purpose for this review is to provide technical information to NRCS personnel and others who provide conservation technical assistance to landowners.

Most of the papers in the wildlife literature concerning tillage fall into 2 categories, those that compare conservation tillage with conventional tillage or those that use conventional tillage, reduced tillage and no-tillage for comparison. Conservation tillage is a system that leaves crop residue on the soil surface. Conventional tillage turns the soil and crop residue under with a moldboard plow. This is usually done in the fall, followed by disking in the spring, which leaves a residue-free surface (Best 1985). Best (1986) explains the differences between conventional, reduced and no-tillage systems. The differences noted are the amount of residue left on the soil surface, the timing of residue disturbance (fall vs. spring), and the number of equipment passes in a cropping cycle.

There has been limited research on the impacts of conservation tillage on terrestrial wildlife, and much of the work is summarized in several excellent reviews (Rodgers and Wooley 1983, Best 1985, Wooley et al. 1985, Nicholson and Richmond 1985, Best 1986, Best 1995). These reviews were relied upon greatly for this work, but the original publications were reviewed in most cases.

For the most part, research on wildlife impacts of conservation tillage has centered on birds and small mammals. The studies on birds are, generally, subdivided further into works that assess impacts on waterfowl and shore birds, upland game birds, and passerines. Papers concerning small mammals were few, with most information centered on 3 species; the deer mouse (*Peromyscus maniculatus),* the house mouse (*Mus musculus*) and the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*). Numerous studies (e.g., Blumburg and Crossley 1983, Warburton and Klimstra 1984) documented arthropod abundance in conservation and conventionally tilled fields, but for this review arthropods are only mentioned in the context of serving as food resources for birds and/or small mammals.

Literature concerning wildlife/conservation tillage is primarily from the midwest and northern plains. In these regions, where corn, soybeans, or wheat dominate the landscape, wildlife habitat is often considered marginal in quality, but this is in instances where cropland is the only available wildlife habitat. Several papers that investigated the impacts of conservation tillage on wildlife in other regions also are included in this review.

Effects of tillage practices on terrestrial wildlife are found to fall into 4 categories: amount of residue left for cover, amount of residue that provides food, relative disturbance caused by tillage operations, and effects of pesticides (Best 1985, Castrale 1985). This review is organized to show how the available literature addresses each of these issues.

## Effects of residue on cover

*Birds*--The early effects of cleaner farming practices on some wildlife were documented by Harmon and Nelson (1973) when they noted that ring-necked pheasant (*Phasianus colchicus*) harvest in midwestern states had dropped from 10 million birds in the mid-1940's to less than 4 million birds by the late 1960's. This decline triggered research to evaluate the habitat quality of these more intensively used lands. Higgins (1975) documented the low nesting densities and success of game birds and shorebirds in intensively cultivated areas of the prairie pothole region of North Dakota. In that same area, duck nest densities were 12 times greater and hatched-clutch densities were 16 greater on untilled upland areas than on annually tilled croplands (Higgins 1977).

Rodgers (1983), noting earlier studies that showed surface tillage for spring weed control in the wheat-fallow system destroyed nests, studied the value of post-harvest undercutting in Kansas. This study noted that mourning dove (*Zenaida macroura*) fared particularly well, with nest success in the undercut stubble being 47.9%. The nest survival of the doves and 6 other bird species found to nest in the stubble was attributed to the quantity of cover, not the concealment quality of the residue. The large area of uniform stubble (residue) made predator searches more difficult even when the cover quality was less than undisturbed habitat. The additional nesting cover provided by no-till fields also was beneficial to waterfowl. In Manitoba, Cowan (1982) found that nest density was 1.4 to1.5 times greater on zero tillage farms than on those that used conventional tillage. Nest success on the zero tillage farms was 42% compared to 13% on the conventionally tilled farms. In North Dakota, nest success in no-till winter wheat was 27% for 5 duck species, which averaged 7 nests per 100 hectares (Duebbert and Kantrud 1987). Lokemoen and Beiser (1997) reported low overall hatching success in a North Dakota study examining conventional, minimum-tillage and organic croplands, but when predation was not considered, success was greater in minimum tillage fields.

In areas where corn and soybeans are the major crops, conservation tillage can provide better nesting cover for numerous bird species than fields using conventional tillage (Best 1985, Warburton and Klimstra 1984, Wooley et al. 1985). Basore et al. (1986) compared no-till corn and soybean with conventionally tilled row crops and reported that 12 species

nested in no-till fields with a 36 nests/100 ha. Only 4 species, averaging 4 nests/100 ha used conventionally tilled fields.

Residue is the major factor attracting birds to no-till fields (Rodenhouse and Best 1983), and amount of residue left by the various tillage practices attracts different species of birds. As amount of residue decreases, the diversity and density of nesting birds decreases. Species such as the ring-necked pheasant, grasshopper sparrow (A*mmodramous savannarum*), and meadowlark (*Sturnella neglecta*), which traditionally nest in grass cover, are restricted to the maximum residues left in no-till fields. Killdeer (*Charadrius vociferas*) and vesper sparrow (*Pooecetes gramineus*) are attracted to reduced tillage fields with less residue than no-till, and the horned lark (*Eremophila alpestris*) may prefer minimal residue (Basore et al. 1986). Wooley et al. (1985) noted that even nests in conventionally tilled fields tended to be concentrated in areas where some residue remained. Flickinger and Pendleton (1994) reported similar results in the Texas panhandle.

Although the increased residues provided by conservation tillage improved the habitat for some species in croplands, Basore et al. (1986) concluded that nesting densities in no-till fields were probably less than required to sustain the population. The exception was killdeer, which were nesting in great densities in no-till fields. Both Wooley et al. (1985) and Basore et al. (1986) calculated the contribution of projected increases in no-till acreage to the Iowa pheasant population. They concluded that a large increase in no-till cropland would contribute to the population, but by itself would not replace the loss of grassland and strip habit on the agricultural landscape. Nest densities in herbaceous strip cover (e.g., grass waterways, fencerows, roadside ditches) were 10 times that of no-tillage cropfields (Basore et al. 1986). The value of linear habitats for some species also was demonstrated by Best (1983), where as many as 30 species of birds were documented using fencerows. Minser and Dimmick (1988) also noted that no-till croplands provided additional nesting habitat for northern bobwhite (*Colinus virginianus)* in western Tennessee, but were no substitute for idle land, thickets and fencerows.

*Mammals*--Small mammals generally benefit from the increased habitat complexity provided by the residues of conservation tillage (Rodgers and Wooley 1983, Warburton and Klimstra 1984). However, extensive data is not available and most studies have been in midwestern corn and soybean fields comparing conventional or conservation tillage. Wooley et al. (1985) noted that deer mice, white-footed mice (*Peromyscus leucopus*), house mice, thirteen-lined ground squirrels and other small rodents are widespread in agricultural ecosystems. Of these, the deer mouse is predominant in most of the United States and generally the sole permanent resident in agricultural fields (Castrale 1985).

The effects of conservation tillage on the deer mouse are inconclusive. Warburton and Klimstra (1984) reported a greater number of recaptures in no-till fields (76%) than in conventionally tilled fields (41%), indicating that the increased cover and food supply supported a stable population. In Indiana, deer mice showed a negative relationship with residue coverage in row crop fields, with the house mouse population more dependent on the greater amount of residues in no-till fields (Castrale 1985). Clark and Young (1986) showed no relationship between deer mouse abundance and the differing residue amounts in conventional and no-till fields.

A major concern of producers considering or using reduced tillage is the impact of small mammals on the their crop production. Best (1985) did point out that damage to corn by thirteen lined ground squirrels was increased when corn was no-tilled into pasture land or hay fields. But, in continuously cropped fields, Clark and Young (1986) found that rodents damaged 0.16% of the corn seedlings in disked fields and 0.12% in no-till fields. The study concluded that increased residue tended to increase the diversity rather than the abundance of small mammals. Another sustainable agriculture system, strip intercropping, was tested in Iowa and yielded a similar conclusion—concerns over crop damage by small mammals are not warranted (Stallman and Best 1996).

Effects of residue on food

During fall, winter and early spring, availability of food and cover affect wildlife use of crop fields. The waste grain is an important source of energy for many wildlife species (Baldassarre et al. 1983). The amount of waste grain is affected by numerous factors, such as consumption by wildlife and deterioration caused by weather, but the type of tillage system used is the most important factor. Moldboard plowing in the fall eliminated 99% of the waste grain available for wildlife use after harvest and intermediate forms of tillage were only slightly better than plowing (Warner et al. 1985, Warner et al. 1989). However, in corn residue, the intermediate forms of tillage did shatter corn ears, thereby making them more available to smaller birds (Baldassarre et al. 1983). As a general rule, no-till, the practice that leaves the most residue, particularly standing residue, will be most beneficial for providing food and feeding cover for wildlife, but conventional fields left unplowed until spring have comparable availability of waste grain (Best 1985, Warner et al. 1985). In years of heavy snow, the increased residue may be detrimental, as the stubble catches more snow and makes the grain unavailable (Castrale 1985, Rodgers and Wooley 1983).

Crop residues also harbor arthropods, an important food source for birds and mammals. Several studies have documented that no-till fields have a greater abundance and diversity of arthropods than conventionally tilled fields. It also was found that the increased diversity came from beneficial insects (Blumberg and Crossley 1983, Warburton and Klimstra 1984). In contrast, Basore et al. (1987) found no difference in insect numbers between no-till and conventional fields during the pheasant brood rearing period in Iowa.

Castrale (1985) found 31 species of birds using corn and soy bean fields for feeding in fall and winter. The number of species using corn residue fields was twice that of soybean residue and tilled fields. In all likelihood this is based on the greater availability of waste corn (60 to 431 kg/ha) than waste soybeans (34 to 63 kg/ha) and the structure of the residue (Warner et al. 1985, Warner et al. 1989). In contrast, Best (1985) noted that in Iowa, corn and soybean fields had experienced little bird use during winter.

Effects of disturbance caused by tillage operations

A major concern for wildlife using croplands is mortality, nest abandonment and nest destruction from tillage operations. Although Basore et al. (1986) and Puckett et al. (1995) indicated that nest destruction by farm equipment is not always the most important mortality factor, any reduction in equipment passes has the potential to benefit wildlife (Rodenhouse and Best 1983, Rodgers and Wooly 1983, Snyder 1984, Best 1985). Rodgers (1983) documented the attractiveness as nesting habitat of the residue in the wheat-fallow system. He also showed the potential for the wheat stubble to be an ecological trap, because of the tillage necessary to control weeds for moisture conservation. The study pointed out that surface tillage was the practice most destructive to nesting birds, followed by the use of undercutters with mulch treaders. Using the undercutter without the mulch treader saved 53% of the nests and avoided killing flightless young and incubating hens. Complete tillage or flattening of wheat stubble prior to pheasant nesting season could shift attempts to green wheat early enough to complete incubation before harvest. A better option for improving pheasant nesting in the croplands of the high plains region is using no-till, which minimizes disturbance and provides stubble and green wheat for nesting and brood-rearing (Snyder 1984).

Attracting nesting birds to the residues left by reduced tillage and no-till corn and soybeans also has the potential to be an ecological trap. Reduced tillage fields appear to be better nesting habitat than the more barren conventionally tilled fields, but the frequency and timing of the equipment passes are not much different than conventional tillage. Best (1986) concluded that an increase in no-till has the potential to have a positive impact on bird productivity in croplands, but some forms of reduced tillage could have negative impacts. Direct mortality and nest destruction caused by of the various tillage practices depend on the nest position in relation to the row crop, length of the nesting cycle, duration of the breeding season and propensity to renest, timing of the breeding season, and the timing of equipment operations.

Effects of pesticides

One of the major concerns of early studies of wildlife and conservation tillage was the question of increased pesticide use for weed and insect control (Rodgers and Wooley 1983, Warburton and Klimstra 1984). Although herbicides are potentially less harmful than insecticides, Best (1985), Castrale (1985) and Nicholson and Richmond (1985) demonstrated the adverse effects that the contact herbicide paraquat had on such species as mallards, northern bobwhite, ring-necked pheasant and deer mice. Wooley et al. (1985) also noted the potential for increased chemical exposure to birds caused by contact transfer from adults, direct spraying of eggs and young, and contamination through poisoned arthropods.

Although the increased attractiveness of no-till crop fields as nesting and brood rearing habitat was shown to have potential pesticide exposure, Little (1987) pointed out that greater usage of herbicides was not necessarily required for no-till or reduced tillage farming. Flickinger and Pendleton (1994) reached the same conclusion in a Texas study that measured the use of herbicides in reduced and conventionally tilled fields.

In addition to conservation tillage not having to greatly increase the use of herbicides and insecticides above those used in conventional tillage, some work has shown that less

toxic choices also are available. Some herbicides such as glyphosate are very low in toxicity and have little direct impact on nests (Cowan 1982, Castrale 1985, Nicholson and Richmond 1985). Although insecticides also are of concern, Best (1985) noted that insecticide use had more to do with cropping sequence than tillage practices. Also, recent studies of the impacts of direct spraying and the consumption of poisoned insects on bobwhite quail chicks in North Carolina, showed that modern insecticides are less toxic than those used in the past (Palmer et al. 1998).

Conclusion

Although the available literature indicates that conservation tillage provides additional nesting and feeding cover and food resources in croplands, Wooley et al. (1985) noted that conservation tillage is only beneficial to wildlife if it replaces more intensive forms of tillage. Best (1986) and Basore et al. (1986) also expressed concern that the ability of no-till practices to conserve soil might lead to the conversion of pastureland, hayland, natural grass cover, or strip practices (grassed waterways, terraces, fencerows, and roadside ditches) to additional rowcrop production. And, even if the additional cropland were no-till, the loss of these other landuses would be detrimental to wildlife.

Summary bullets

***RESIDUE FOR COVER***

- Diversity and density of nesting birds (36 nests of 12 species/100ha in no-till vs. 4 nests of 4 species/100 ha in conventional tillage) diminishes as amount and structure of soil surface residue decreases (Basore et al.1986)
- Ring-necked pheasant, grasshopper sparrow, and meadowlark restrict nesting to no-till when nesting in croplands (Basore et al.1986)
- Killdeer and vesper sparrow are attracted to the intermediate forms of reduced tillage (Basore et al.1986, Flickinger and Pendleton 1994)
- Horned larks will nest on plowed ground with minimal residue (Basore et al.1986, Flickinger and Pendleton 1994)
- Increased residue amounts tend to increase diversity rather than density of small mammals. (Warburton and Klimstra 1984, Clark and Young 1986)
- Effects of conservation tillage on arthropod density are mixed, but increased residues seem to increase diversity including beneficial insects (Blumberg and Crossley 1983, Warburton and Klimstra 1984).
- In the northern prairies, waterfowl production was 3.8 times greater on no-till small grain farms than on conventional tillage farms (Cowan 1982)
- Five duck species averaged 7 nests/100 ha and 27% produced young in no-till winter wheat (Duebbert and Kantrud 1987)

***RESIDUE FOR FOOD***

- As a general rule, no-till, the practice that leaves the most residue, particularly standing residue, will be most beneficial for providing food and feeding cover for

wildlife, but conventional fields left unplowed until spring have comparable availability of waste grain (Best 1985, Warner et al. 1985)

- Fall tillage with a moldboard plow eliminates 99% of the waste corn and soybeans, whereas intermediate forms (disking and chisel plowing) of fall tillage leave 65-80% less grain than untilled fields (Warner et al. 1989)
- Thirty-three species of birds use crop fields in winter, with untilled fields receiving the greatest use followed by disked fields, chisel plowed and moldboard plowed respectively (Castrale 1985)

***DISTURBANCE***

- Any reduction in number of equipment passes during the nesting season has the potential to benefit wildlife (Rodenhouse and Best 1983, Rodgers and Wooly 1983, Best 1985)
- Attracting nesting birds to the residues left by conservation tillage may be an ecological trap, because of the timing and frequency of equipment passes (Rodgers 1983, Snyder 1984, Best 1986)
- No-till has the potential to have a positive impact on bird productivity, whereas reduced tillage, because the number of equipment passes is comparable to conventional tillage, may have negative impacts (Best 1986)

***PESTICIDES***

- Nesting and brood rearing in croplands increases the potential for chemical exposure to birds caused by contact transfer from adults, direct spraying of eggs and young, and ingestion of poisoned arthropods (Wooley et al. 1985)
- Pesticide use does not need to be greater in reduced tillage cropland than it is in conventionally tilled croplands (Little 1987, Flickinger and Pendleton 1994)
- Low toxicity herbicides such as glyphosate have little direct impact on nests (Cowan 1982, Castrale 1985, Nicholson and Richmond 1985)
- Modern insecticides are of concern, but studies of the impacts of direct spraying and consumption of poisoned insects on bobwhite quail chicks demonstrated the lower toxicity (Palmer et al. 1998)

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