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Identification of WILDlife Crop Depredation

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Figure 1. Farmland makes up about two-thirds of the land area in Indiana and is by far the dominant land use in the state.

Introduction

The industry of agriculture is the dominant use of land throughout the Indiana landscape (Figure 1). Over 65 percent of Indiana's land area is farmland (USDA National Agricultural Statistics Service 2002). In 2004 and 2005, producers in Indiana harvested approximately 900 million bushels of corn and 275 million bushels of soybeans each year (USDA National Agricultural Statistics Service 2006).

Even so, wildlife is important to the economy and social fabric of Indiana (Figure 2). According to the 2001 National Survey of Fishing, Hunting, and Wildlife-associated Recreation, over 1.78 million Hoosiers took part in wildlife watching (U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau). In 2001, state residents and nonresidents spent $1.5 billion on wildlife recreation in Indiana, and 284,000 hunters spent approximately 279 million dollars on hunting equipment, travel expenses, and other items.

Given the economic and social importance of both wildlife-related activities and agriculture in Indiana, balancing the relationship between wildlife species and agricultural production is critical if the needs of all of the respective interest groups involved with these commodities are to be met.

Agricultural damage by wildlife species in the United States, however, can be substantial and widespread, and such damage is a serious concern to many agricultural producers (Figure 3). Conover (2002) estimated that wildlife-related, economic losses to farmers and ranchers in the United States exceed 4.5 billion dollars annually. Furthermore, results of nationwide surveys conducted in 1993 and 1994 indicated that 80 percent of farmers and ranchers suffered wildlife damage in the prior year, and 53 percent suffered damage that exceeded their tolerance (Conover 1998).

Figure 2. The value of wildlife to us all is difficult to measure. Billions of dollars are spent annually in the United States on wildlife-related expenses such as travel, hunting equipment, bird feeders, binoculars, and more.

Misconceptions held by landowners regarding wildlife damage clearly can affect their willingness to manage

Figure 3. Wildlife crop damage often can be frustrating to farmers. In most cases, damage is light to moderate. However, severe damage occurs on occasion.

for wildlife on their properties (Conover 1998). Seventy-eight percent of producers in the Upper Wabash River Basin reported having ≥1 crop type damaged by wildlife within the previous 12 months. Groundhog *(Marmota monax)* and white-tailed deer *(Odocoileus virginianus)* were reported to damage soybeans most frequently (11 percent and 9 percent, respectively), while white-tailed deer and raccoon *(Procyon lotor)* were most often blamed for damage to corn (23 percent and 12 percent, respectively) (Humberg et al. 2005). Interestingly, however, field research in northcentral Indiana revealed that raccoons actually caused 87 percent of the damage to corn (>73,000 damaged corn plants were identified), while only 10 percent of the damage was attributable to deer (Humberg et al. 2005).

Similar misconceptions occur with wild turkey *(Meleagris gallopavo).* With the increased presence of wild turkey in Indiana and other agricultural regions, the number of perceived conflicts between wild turkey and agricultural producers over crop damage also has increased (Payer and Craven 1995). Actually, most complaints of wild turkey crop damage are caused by other wildlife species (Swanson et al. 2001). Confirmed crop damage caused by wild turkey is limited both in scale and frequency over the majority of their range in North America (Tefft et al. 2005). For example, wild turkeys in Indiana were estimated to cause ≤$10,000 of agricultural damage annually during 1996-1999 (Tefft et al. 2005). In comparison, overall wildlife damage to harvestable field corn in Indiana was estimated at $1.8 billion for Indiana during 1993 (Wywialowski 1996).

Negative feelings held by landowners toward wildlife species believed to cause crop damage may deter them from making sound decisions regarding the management of those species on their lands. Thus, the misidentification of wildlife damage to field crops can cause conflicts between farmers and wildlife that result in negative consequences for both. Farmers may implement improper management strategies, thereby wasting time and money, in an attempt to control wildlife that is not at fault. At that same time, wildlife species would be subjected to unnecessary and unwarranted management practices. To formulate effective and cost-efficient integrated pest management systems, landowners and wildlife managers need to identify what types of crop damage wildlife species cause, the economic impact of crop depredation by key species, and the local and landscape characteristics that contribute to wildlife crop depredation.

About This Guide

Because economic losses to agricultural producers often are the primary focus of crop depredation issues concerning vertebrates, the priorities of wildlife management professionals in agricultural regions are influenced by the perceptions of agricultural producers toward crop damage. Thus, the welfare of wildlife populations throughout much of the United States is tied inescapably to the perceptions of agricultural producers concerning crop depredation. An improved understanding of the factors underlying crop depredation problems must precede the development of more robust and affordable strategies to reduce crop losses to wildlife. The first step is the proper identification of the species causing the damage. This publication was

Figure 4. Technicians regularly surveyed fields along transects for wildlife damage and recorded the location of damage within the corn and soybean fields, number of plants damaged, wildlife species responsible, amount of leaf area damaged, amount of seed damage, height of damage, and growth stage of plant at the time of damage.

developed to assist landowners and professionals in the accurate identification of wildlife damage to corn and soybeans throughout each of the growth and reproductive stages of plant development.

Information in this guide was developed from a study conducted by Purdue University during 2002-2005 in partnership with the Indiana Department of Natural Resources and the National Wild Turkey Federation. Researchers and technicians spent thousands of hours surveying 160 corn and soybean fields in portions of the Upper Wabash River Basin (Figure 4).

The images and descriptions in this guide summarize the most important and most common types of wildlife damage that were encountered and observed in corn and soybean fields in Indiana. Some of the images depicted in this guide show plants and/or soil with orange paint. Field technicians used orange paint to mark damage events to avoid double counting plants during subsequent surveys and consequently biasing the number of damage events observed. Producers in the area were surveyed regarding the amount of wildlife crop depredation on their property, the subsequent economic losses, the wildlife species perceived to be responsible, and their general attitudes toward wildlife. In addition, over 300 hours were spent in blinds observing the feeding behavior of wildlife in crop fields (Figure 5). Researchers trapped wild turkey, raccoon, and white-tailed deer during the course of the study and observed the movement behavior of each of these species during the crop growing season using radio telemetry (Figure 6). Radio transmitters, each emitting a unique radio frequency, were fitted to animals (Figure 7), and their locations were determined several times per week throughout the growing seasons of 2003 and 2004.

Figure 5. In addition to surveying wildlife damage to 160 corn and soybean fields over two years, researchers spent over 300 hours observing wildlife feeding behavior in corn and soybean fields from blinds.

Figure 6. A total of 92 wild turkeys, 83 raccoons, and 20 white-tailed deer were captured during the study. Each animal was fitted with a radio transmitter and tracked throughout the study period to assess daily and seasonal habitat use and movements.

Figure 7. Radio transmitters that emitted unique frequency beacons were affixed to wild turkeys, deer, and raccoons. Their movements were tracked regularly throughout the year. This allowed researchers to calculate habitat use and home ranges for individual animals.

Crop Development and Wildlife Damage

The timing of wildlife damage and the part of the plant damaged play a critical role in the actual yield loss to corn and soybean plants. For example, a corn plant bitten off at ground level will have little to no effect on yield early in development when the stem apex (growing point) is still below the soil surface (Figure 8). Alternatively, deer biting off corn silks can result in 0 to 100 percent loss in yield, depending upon the number of silks that already had been pollinated. A young soybean plant that is bitten off at the main stem will produce branches if the damage occurs above at least one axillary bud (Figure 9). However, repeated damage on a soybean plant significantly affects yield.

The information presented below about corn and soybean plant development was adapted from Nielsen (2002), Ritchie et al. (1997*a*, 1997*b*) and the Purdue University Department of Agronomy Crop Management CDs. (http://www.agry.purdue.edu/ext/pubs/CropMgmtCDs.html). All corn and soybean plants follow the same general pattern of development, but the specific time interval between growth stages and total leaf numbers will vary among hybrids. Rate of growth is primarily temperature dependent (growing degree days). Environmental stress, including that caused by wildlife, can increase time between vegetative stages of development, but also can decrease time between reproductive stages of development. For the purposes of this publication, the information presented below is provided in a generally non-technical manner. For more detailed information, see the resources listed above.

Figure 8. Damage above the growing point does not kill the plant even if the entire aboveground biomass is removed. The plants marked with orange flagging (top) were damaged above ground during V2. The plant marked with pink flagging (bottom) was dug out and ceased to develop.

Figure 9. This soybean plant is at emergence (VE). The cotyledons supply the plant with nutrients during the first 7 to 10 days after emergence. Loss of the cotyledons will reduce yield 8-9 percent. The unifoliate leaves, above the cotyledons, have not completely unfolded.

Corn Development

Development of corn plants is divided into two major portions—vegetative and reproductive (Table 1). Vegetative leaf stages are defined according to the uppermost leaf whose leaf collar is visible. In corn, the growing point (stem apex) is below the soil surface at emergence and also during early vegetative growth. Damage to leaves during these stages will have little to no effect on yield (Figure 8). The growing point and tassel are not above ground level until the V6 stage.

During the V12 stage, the number of rows of kernels per ear is determined. Determination of the number of kernels per row begins during the V12 stage and continues until one week prior to silking. Since ear size and number of ovules (kernels) are being determined, environmental stresses at this point in plant development, including wildlife damage, can have an impact on the number of seeds produced and the size of ears harvested.

The V15 stage begins about 10 to 12 days before silking. Silks begin to develop on the upper ears during the V15 stage. This is the start of the most crucial period of corn plant development in terms of seed yield. Pollen shed begins at the tassel stage (VT) when the last branch of the tassel is completely visible and the silks have not yet emerged.

The reproductive stages of development begin after VT. At this time, resources are shifted from primarily vegetative growth to seed growth and development. The silk stage (R1) begins once any silks are visible. Silks will emerge and continue to elongate until pollination in 2 to 3 days. The numbers of ovules that will be fertilized are being determined at this stage. Ovules that are not fertilized will not produce kernels. Thus, damage to silks prior to fertilization will result in a loss of yield. The silks dry out after completing their flowering function; hot, dry weather results in darker silks. As the kernels mature, the amount of yield loss from environmental stress lessens.

Eighteen to 22 days after silking, the milk stage (R3) begins. The kernels are highly palatable during this period and the majority of wildlife damage occurs during this development stage. Physiological maturity (R6) occurs about two months after silking. Harvest occurs after the crop partially dries in the field.

Soybean Development

Growth and development of soybean plants is similar to corn in that it is categorized into vegetative stages and reproductive stages (Table 2). Vegetative stages after the cotyledon stage are defined by the uppermost fully developed leaf node (i.e., a leaf node that has a leaf above it with unrolled/unfolded leaflets). Loss of both cotyledons (Figure 9) at or soon after VE will reduce the yield for that plant 8 to 9 percent; the cotyledons supply the plant with nutrients 7 to 10 days after emergence (Ritchie et al. 1997*b*). Unlike corn plants, the axillary buds of soybean plants allow a tremendous capacity to recuperate and overcome substantial vegetative damage. If the stem apex (growing point) is broken off, the remaining axillary buds are released from dominance and branches grow (Figure 10). These branches have the capacity to produce leaflets, axillaries, flowers, and pods. Severing plants below the cotyledonary node is terminal because no axillary buds occur below this node.

Figure 10. Wildlife severed the stem early in this soybean plant's development.

Reproductive stages of development in soybeans begin once a flower opens at any node on the main stem (R1, beginning bloom), but vegetative growth continues for approximately another month until partway through seed development (R5). At the beginning pod stage (R3), developing pods, withering flowers, open flowers, and flower buds all can occur on the same plant. Most (60 to 70 percent) flowers abort and do not contribute to yield. This characteristic allows soybeans to compensate for stresses during stages R1 through R3 because flowering occurs through the R5 stage. Increases in yield generally result from increases in the number of pods per plant. Stress from R4 to shortly after initiation of R6 can impact yield (decrease in number pods per plant) more than any period of soybean development. Midway through R5, soybean plants attain full size. Leaf loss during the early portion of the R5 stage can result in substantial yield losses because plants redistribute nutrients from vegetative plant parts to the beans during this period. As the plants mature through R7 and R8, defoliation and other stresses have minimal effect on yield.

Identification of Wildlife Damage—Corn

White-tailed Deer

White-tailed deer can feed on corn throughout the growing season, but feeding is concentrated during certain growth stages. At emergence (VE) plants are susceptible to both trampling (Figure 11) and feeding damage (Figure 12). Entire plants may be pulled from the ground, especially in loose or moist soils (Figure 13). As long as the growing point is undamaged, the plant will continue to develop; from VE to V5, the growing point is below the soil surface (Table 1). The plant characteristics at the point of damage will usually have a rough appearance (Figure 14) since deer lack upper incisors.

Throughout the remaining vegetative growth stages (V6 until prior to tassel), deer may browse leaves of corn (Figure 15). Deer damage during this period, however, often is a complete bite of the stalk below the tassel and at the center of the growth whorl (Figure 16); deer also may bite off the tassel later in development (Figure 17). Damage to ears early in their development will result in a telescoping husk as they mature (Figure 18). Feeding on young ears late during vegetative growth (V12 to V15) will result in almost 100 percent loss of yield for that plant.

Figure 11. Trampling damage by white-tailed deer.

Figure 12. Deer damage to corn.

Figure 13. Occasionally in loose soils, deer can pull an entire corn plant from the soil.

Figure 14. Deer leave behind a rough cut since they lack upper incisors.

Figure 15. Deer may browse the upper most leaves of corn or the end of the stalk.

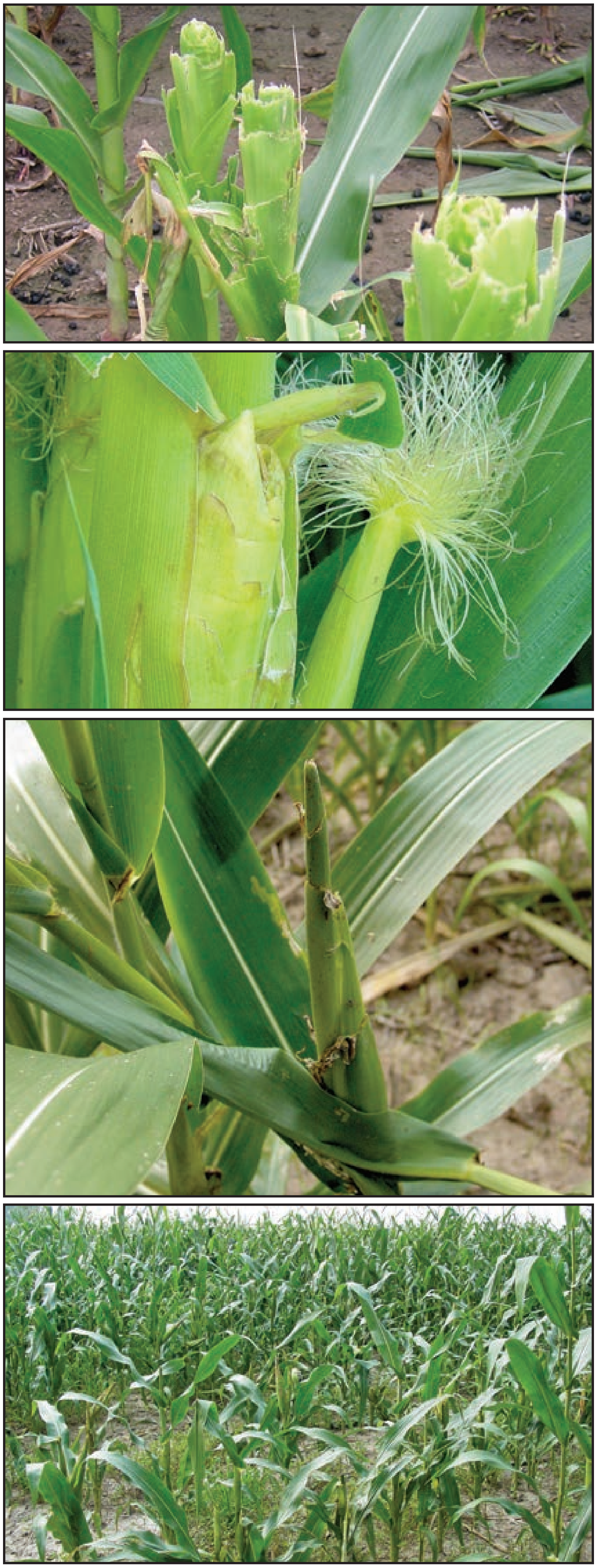


Figure 16. During late-vegetative growth, deer can bite off the stalk below the tassel at the center of the growth whorl.

Figure 17. Deer can bite off the tassel prior to pollen shed.

Figure 18. Deer damage to developing ears results in a telescoping husk.

Figure 19. Deer bite off the moist silks during the silking stage (R1). Yield loss depends on the number of ovules fertilized prior to the damage.

Figure 20. Deer can bite off the end of an ear.

During reproductive stages of development, deer damage to corn is concentrated during the silk stage (R1), milk stage (R3), and maturity (R6). During the silk stage, deer bite the tender, succulent corn silks (Figure 19). The impact on yield from the removal of the corn silks will depend on the timing of damage relative to pollination. Damage occurring prior to the pollination of all silks will impact yield. This is usually the case with damage of this type since the silks dry out after pollination of the kernels. Damage occurring midway through pollination results in an ear with a bare tip. Pollination occurs from the base of the ear toward the tip. Removal of the silks prior to complete pollination results in unpollinated kernels at the tip; the overall proportion of unpollinated kernels is dependant upon the timing of the damage. Deer may bite off the end of an ear (Figure 20), or completely pull the entire ear from the plant (Figure 21). Biting the tip of an ear off after pollination is completed results in minimal yield loss. Deer often remove kernels by using their lower incisors to scrape an ear along its length (Figure 22). Deer damage to corn during the milk stage commonly results in corn smut or other fungal diseases (Figure 23).

Deer can knock down stalks of corn. Signs of deer damage include a small number of stalks (usually 12 or less) knocked down, and all lying in the same direction (Figure 24). Usually, damage of this type is caused by deer running through the area rather than from deer feeding behavior. Deer bedding in cornfields results in few if any corn stalks knocked down. Areas with a large number of stalks knocked down are caused by raccoons (see below) and not by deer bedding down. Occasionally, deer feed on plants that they have knocked down (Figure 25).

Figure 21. Deer can completely remove an ear from the stalk.

Figure 22. Deer can scrape an ear along its length with its lower incisors.

Figure 23. Deer damage to corn during the milk stage can lead to ear rotting caused by various fungal pathogens.

Figure 24. Deer can knock down stalks of corn. Note that relatively few stalks are knocked down, and they tend to lay in the same direction.

Tip. Deer are relatively large animals and often will leave signs that alert us to their presence. Deer droppings and tracks are easily identifiable by most people. The presence of a deer sign clearly indicates that a deer was present in a field, but it does not necessarily mean that deer have caused the primary damage to corn plants in the field. Inspect the characteristics of the damage incurred to corn plants and ears. Deer often frequent sites damaged by raccoons (see below), and damage caused by raccoons often is incorrectly attributed to deer since the physical signs left by raccoons can be overlooked, whereas a deer sign is usually conspicuous.

Figure 25. Deer sometimes feed on stalks that they knock down.

Figure 26. The plant on the left was damaged by deer. The plant on the right had no wildlife damage.

Deer feed on corn sparingly after the milk stage until the crop matures. Stalks are more easily knocked down during maturity and deer will feed readily on kernels on the cob and those on the ground. While stalks are on the ground (whether or not deer knocked them down) deer may scrape the ear along its length using its bottom incisors.

At maturity, some corn plants have reddening of leaves and/or the stalk (Figure 26). Reddening of corn plants is the result of accumulated sugars in plant tissue (Nielsen 2002). The presence of ears that are missing all or part of their kernels or the loss of an entire ear will result in reduced translocation of sugars from the leaves of the affected corn plant. The oversupply of sugars triggers the formation of red pigmentation. Red stalks can be a clue to past wildlife damage, but not all corn plants with red stalks and/or leaves are caused by wildlife damage. Feeding at the stalk node by European corn borers can result in reddening of the attached leaf at the location of damage (Nielsen 2002). Corn plants with purple-colored stalks in August to September often are indicative of damage caused by deer.

Deer will readily scrape kernels off the cobs of mature corn plants, generally causing little or no physical damage to the corn stalk. Deer may still knock down stalks as they go through a field, especially if the stalks are weakened by European corn borer damage. Removal of kernels after maturity in the fall results in red cobs. Damage caused earlier in the growing season results in dirty brown cobs.

Figure 27. Most raccoon damage occurs during the milk stage when the kernels are sweet and moist.

Raccoon

Most raccoon damage to corn is concentrated during the milk stage of development (R3) (Figure 27), but some damage also occurs before and after the milk stage on into maturity. Prior to the milk stage, raccoons may visit fields during the evening to "test" a few ears. Once the plants in a corn field reach the milk stage, raccoons will dramatically increase their rate of feeding for extended periods in that field each evening. Even though the milk stage for individual plants lasts only 7 to 10 days (the number will depend on environmental influences, see pg. 5), the corn plants in an entire field may not progress through development simultaneously. Thus, the availability of ears in the milk stage of development in a particular field may extend longer than 7 to 10 days.

Raccoon damage often is associated with portions of fields bordered by woodlots, especially if the edge is near water (Figure 28). Competition for nutrients and sunlight from nearby trees can delay corn development along the edges of fields that border woodlots, so raccoons may initially feed on ears many rows into the field from the wooded edge. The raccoons will then follow the progression of corn development into the milk stage from the inner rows out toward the edge of the field. Some raccoon damage is characterized by downed stalks along a two- to three-row band (Figure 29).

Depending on the size of individual raccoons and the height of the ear above ground level, raccoons will either stand on their hind legs and feed on the lower hanging ears on the stalk, or climb the stalk to reach the ear. In either case, the corn stalk will usually break (Figure 30). This method of feeding by raccoons results in a haphazard array of broken corn stalks, often lying in different directions (Figure 31). Some may describe this pattern as a very chaotic picture. Damage of this type often results in yield losses of 90 to 100 percent for the damaged area. Grain remaining on ears lying on the ground that is not consumed will rot, be eaten by other wildlife, or not be harvested by the combine. With the exception of beaver, no other species of wildlife will cause damage to corn that consistently approaches as complete a loss in yield as will raccoons.

Raccoons do not bite through the husk, but rather pull the husks open with their teeth and claws to expose the kernels. Husks will have a shredded appearance and cobs will appear masticated with many torn seed coats remaining on the cob (Figure 32). Corn cobs fed upon by raccoons on the ground often will have a muddied appearance (Figure 33). Upon close inspection, raccoon tracks may be visible on the leaves and husks—a result of mud or the milky corn residue covering their paws (Figure 34). Claw marks also may be visible on the stalk, leaves and ears (Figure 35).

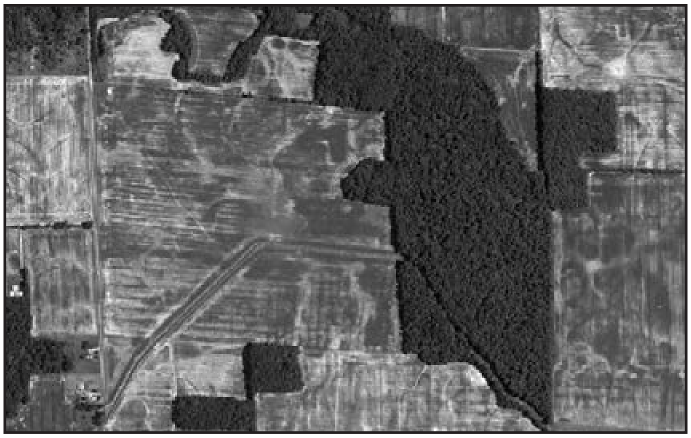


Figure 28. Raccoon damage to corn is limited mostly to field edges bordered by woodlots.

Figure 29. Sometimes, raccoons damage a section of corn two to three rows in width.

Figure 30. Raccoons may climb stalks or pull on ears and feed on them while standing on their hind legs. Most damage results in stalks knocked down.

Figure 31. Raccoon damage results in a haphazard display of downed corn.

Figure 32. Raccoon damage results in ears with torn seed coats, masticated cobs, and shredded husks.

Figure 33. Ears damaged by raccoons often appear dirty or muddied.

Figure 34. Upon close inspection, raccoon tracks may be visible on the down corn.

Figure 35. Raccoon claw marks on corn plants.

Squirrels and Other Small Mammals

It is difficult to distinguish between damage caused by fox squirrels and 13-lined ground squirrels. While their habitats differ substantially, the sign they leave behind does not. Damage caused by squirrels is concentrated at both the early- and late-developmental growth stages of corn plants. Unlike birds, squirrels and other mammals have a keen sense of smell. Squirrels dig up seed prior to emergence or pull seedlings shortly after emergence (Figure 36). They feed only on the remaining seed and leave the rest of the plant (Figure 37). Generally, when squirrel damage occurs, the soil will be dug to one side (Figure 38), and significantly reduced stand densities occur along the field edge where damage has taken place (Figure 39). Damage by squirrels is almost entirely limited to field edges adjacent to quality squirrel habitat (Figure 40). Chipmunk and most other small mammals are too small to excavate a large hole all at once. Consequently, they will dig around a plant to expose the remaining attached seed (Figure 41). Some corn plants will survive feeding by small mammals after the V3 stage (Figure 42). While the seminal root system grows directly from the seed, growth of these roots is virtually non-existent by the V3 stage, at which point the nodal root development increases (Ritchie et al.1997*a*).

At or near maturity, squirrels and smaller rodents will feed on kernels from intact ears. Parts of kernels often are visibly scattered on the leaves and ground below individual plants (Figure 43), and squirrels may pull entire ears of corn to the edge of a field. In either case, small mammals most often will consume only the hearts of the kernels of mature corn (Figure 44).

Birds

Blackbirds and grackles will damage corn early in the vegetative stages of development as well as during the reproductive stages. Bird damage to corn can occur throughout a corn field, and is not necessarily concentrated along the edges. Birds have a poor sense of smell and cannot easily find buried seeds by smelling them; thus, bird damage to recently emerged corn may be confused with that caused by squirrels and vice versa. Birds will dig around a seedling with their bill. The damage will look very similar to digging by chipmunk. However, with bird damage, entire seedlings may be pulled from the ground and the resulting hole will generally be shallower than those dug by mammals (Figure 45). During drier conditions

Figure 36. Squirrels dig up corn seeds prior to emergence or dig plants after emergence.

Figure 37. Squirrels only feed on the remaining seed and leave the plant.

Figure 38. Squirrels pull the soil to one side when digging.

Figure 39. Squirrel damage can result in reduced stand density.

Figure 40. Squirrel damage is limited to areas adjacent to quality squirrel habitat.

Figure 41. Small mammals such as chipmunk dig around a corn seedling to expose the remaining seed.

Figure 42. In a few cases, damage by small mammals does not result in plant mortality.

Figure 43. At or near maturity, rodents will feed on kernels of intact ears.

Figure 44. Rodents typically limit feeding to the hearts of kernels.

specifically in fields with soils of high clay content, seedlings often are broken off by birds (Figure 46). Broken seedlings generally leave the plant growing point intact, and thus the corn plant will continue to grow and develop.

During the reproductive stages of corn development, blackbirds peel the husks from the tip of the ear back toward the base in very thin strips (Figure 47). They are not able to grab and pull large sections of husk because of their small bill size. The husks of corn ears damaged by birds often are described as having a "firecracker" appearance because they have an exploded look to them. During the blister (R2) and milk (R3) stages, birds peck out the kernels and leave a cup-shaped shell (Figure 48).

Figure 45. Holes dug by birds will be shallow.

Figure 46. In dry, tight soils, seedlings may be broken off by birds.

Figure 47. Bird damage to corn around the milk stage is characterized by thin pieces of husk peeled back. Ears will often have a "firecracker" appearance.

Figure 48. Birds will peck out the kernel and leave a cup-shaped shell remaining.

Wild Turkey

Feeding on corn by wild turkey is primarily limited to the consumption of waste grain during the winter and spring. Wild turkeys may feed on mature corn after damage by other wildlife has exposed ears (Figure 49). Some damage to stored silage corn has been documented in Indiana and northern parts of the turkey's range (Tefft et al. 2005). Wild turkeys do not knock down stalks of corn.

Figure 49. Damage caused by other wildlife expose kernels that become available to wild turkey.

Beaver

Damage caused by beaver is limited to areas where fields are relatively close to water. Many people are familiar with the lodges beaver construct within ponds, but beavers also excavate bank dens along rivers and streams. The timing of damage to corn by beavers is limited to just prior to the tassel stage (at about V15 to V18 when plants are >48 in tall) until just prior to browning/maturity of the stalk. Damage to corn caused by beaver is easily identified. Stalks are cleanly cut close to ground level at approximately a 45-degree angle (Figure 50). No other animal will cause this type of damage. Beavers usually drag the cut stalks along a conspicuous path, or "beaver run," toward the water (Figure 51). Some cut stalks may be visible along the water's edge (Figure 52).

Figure 50. Beaver damage corn beginning late in vegetative development. Stalks are cut near the ground at clean 45-degree angles.

Figure 51. Beaver run. Raccoon and beaver damage was observed in this corn field.

Figure 52. Beaver often drag cut stalks of corn to the water's edge.

Identification of Wildlife Damage—Soybeans

White-tailed Deer

White-tailed deer feed on soybeans throughout the growing season as long as the plants are green and succulent. Feeding activity occurs throughout the evening, but peaks at dusk and dawn. After emergence, deer bite off soybean plants down to a stub (Figure 53). The specific location of the damage will determine the resulting yield loss. Damage occurring above the first node will release the remaining axillary buds and will not result in yield loss. The resultant growth from this type of damage is a double-stemmed plant (Figure 54). Damage occurring below the first node effectively kills the plant. At this stage of plant development, damage caused by deer can be confused with damaged caused by other species. Because deer lack upper incisors, the bitten stem almost always will have a rough appearance, which can only be observed upon close inspection (Figure 55). Damage caused by rabbits, groundhogs, and other mammals will always be a clean, angled cut (Figure 65).

Deer damage to soybean plants from the V4 stage of development and throughout the reproductive stages of growth, while the soybean plants are still green and succulent, is limited to the uppermost leaflets and not the soybean pods (Figure 56). At the R6 stage through harvest, limited deer damage to pods can occur.

Most damage to soybeans by white-tailed deer occurs as light to moderate browsing spread out over large portions of the field. Deer tend to move through a field as they feed and do not typically stand in a single spot for long periods of time. Except during the very early stages of soybean plant development, deer feed only on part of the plant and move on. This random browsing generally results in only light to moderate yield loss. However, in rare cases where local deer densities are unusually high, repeated feeding by deer in a specific field, translating to repeated damage to individual plants, can result in severe damage to individual plants with those plants producing minimal yield.

Groundhog

Groundhog damage is concentrated around burrows, with peak feeding occurring at dawn and dusk (evenings are spent within their burrows). The area of damage appears as a semi-circle around the edge of the field (Figure 57) where the groundhogs emerge from their burrows (Figure 58). Groundhogs begin damaging

Figure 53. Deer damage to soybeans (VE). Note the roughly cut stems and the branching at the cotyledonary nodes.

Figure 54. Double-stemmed soybean plant after deer damage during VE.

Figure 55. Deer damage resulting in roughly cut stems.

Figure 56. Deer damage to soybeans is limited primarily to the uppermost leaflets.

soybean plants soon after emergence and continue damaging plants throughout the growing season as long as the plants are green and succulent. The area of damage will grow larger through time as the groundhogs seek out new growth further from their burrow.

Groundhog damage to newly emerged soybeans may result in missing plants (due to shoot removal below the cotyledons; Figure 59). Most groundhog damage is characterized by sharply cut stems at an angle. Groundhogs, like all rodents, have sharp incisors so they bite cleanly through the plant when they feed. Plants often are fed on repeatedly as soybean plants continue to sprout new leaflets (Figure 60). Weeds often dominate areas of groundhog damage due to the open space (caused by continual feeding on soybean plants in the area) and reduced competition for light and nutrients from soybean plants (Figure 61).

While white-tailed deer may damage more individual soybean plants than do groundhogs, groundhog damage generally results in higher yield loss per plant than does that caused by deer. Groundhogs concentrate their feeding around den sites and do not travel far from the safety of their dens. Thus, groundhogs feed more extensively on individual plants than do deer. Individual plants repeatedly damaged by groundhogs often will have few leaflets remaining, with plants closer to the burrow having fewer leaflets and stunted growth compared to those farther from the burrow.

Wild Turkey

Concern over crop damage caused by wild turkey has grown in recent years. However, over the two years during which this research was conducted, observing wildlife in the field and surveying crop fields for damage, research crews did not observe any measurable damage caused by wild turkey. This is consistent with research findings from other states. Turkeys in soybean fields feed primarily on insects, and any feeding on crops that takes place is minimal to negligible.

July is a peak time for complaints about turkeys and soybean damage in Indiana. This period coincides with Japanese beetle outbreaks and is a period when many other insect species upon which turkeys feed also are available in soybean fields (Figure 62). Dusting in soybean fields by wild turkeys can cause minimal damage (Figure 63). In a couple fields, turkeys were found to feed on newly emerged soybeans (Figure 64). Turkeys bit off the cotyledons from the main stem (Figure 64). More developed soybean plants (VC) also occurred in the field, but turkeys did not feed on these and apparently selectively fed on soybean plants that recently broke through the soil.

Figure 57. Soybean fields with groundhog damage. The area of damage is semi-circular in shape and adjacent to or nearby a burrow entrance.

Figure 58. Path used by groundhog to enter and exit field (top) and burrow entrances (bottom).

Figure 59. Groundhog damage resulting in reduced stand density.

Figure 60. Groundhog damage usually results in stems with few remaining leaflets. Cut stems have a clean, angled cut.

Figure 61. Areas with groundhog damage are often dominated by weeds.

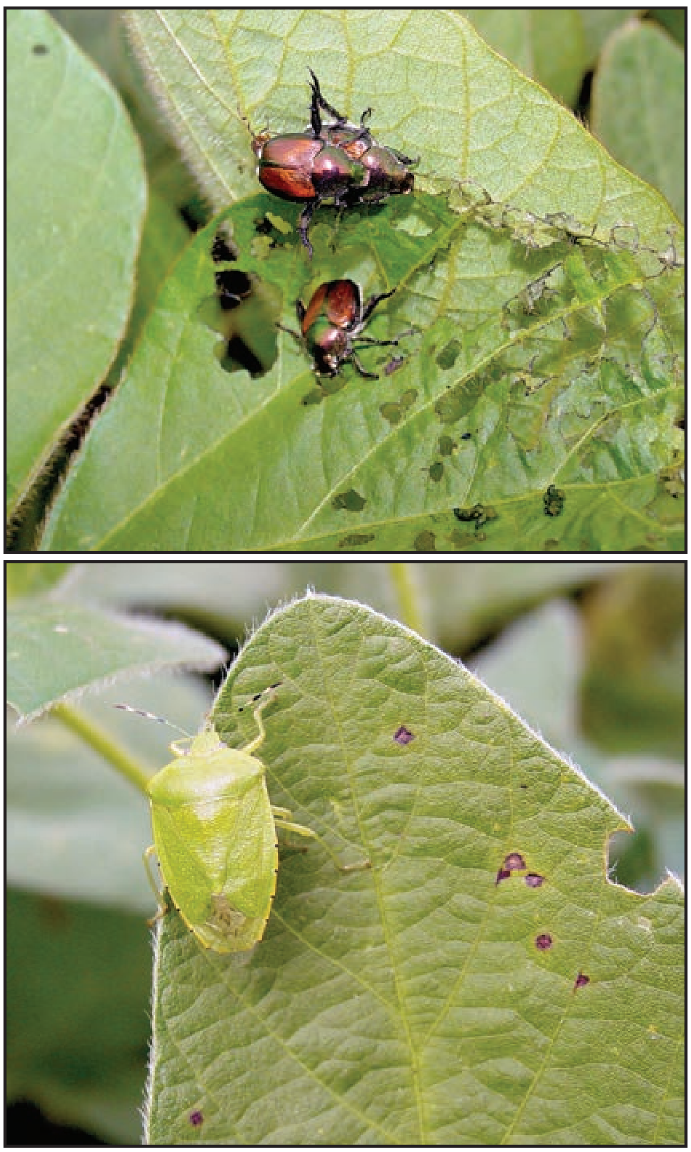


Figure 62. Wild turkeys feed on insects in soybean fields.

Figure 63. Dusting by wild turkey results in minimal damage to soybeans.

Figure 64. In a couple fields, wild turkeys fed on newly emerged soybeans (top). Damage caused by turkeys (bottom, left) compared to damage by deer (bottom, right).

Cottontail Rabbit

Rabbits cause some damage to soybeans, although the amount is trivial compared to damage by deer and groundhogs. Like rodents, rabbits will leave a clean 45 degree edge on cut stems (Figure 65). Rabbit damage is strongly concentrated along the edge of fields in a linear rather than semi-circular shape (Figure 66). Most rabbit damage occurs early in soybean plant development (from emergence (VE) through V6), but damage can occur until full seed (R6).

Canada Goose

Damage to soybeans by Canada Geese is limited to areas adjacent to or near an open body of water (Figure 67). Geese are grazers and are attracted to new succulent growth. While vegetative growth of soybeans continues until midway during the beginning seed stage (R5), most goose damage occurs after emergence (VE) to V6 or when the plants are about 1-ft tall. Canada Geese focus their feeding in open areas where they can easily detect predators. While geese are graceful swimmers and fliers, they are quite clumsy on land so they avoid areas where predators can hide and ambush them. Geese will only feed in soybean fields early in the growing season when their vision is unobstructed (Figure 68).

Geese feed by grabbing and pulling on the soybean plants; therefore, damaged leaflets may be torn or the plant may be broken off at the stem (Figure 69). In addition to being easily observed during the day, geese usually will leave behind signs of their presence such as droppings or tracks (Figure 70).

Figure 65. Rabbit damage results in clean, angular cut stems.

Figure 66. Rabbit damage is concentrated along the edge of fields.

Figure 67. Open water source across the road from a soybean field damaged by Canada Geese.

Figure 68. Damage to soybeans by geese is limited to during the early growing season.

Figure 69. Goose damage to soybeans.

Figure 70. Goose tracks in a soybean field.

Table 1. Summary of developmental stages of growth for corn plants. Vegetative leaf stages (VN) are defined according to the uppermost leaf whose leaf collar is visible. Information adapted from Ritchie et al. 1997a)

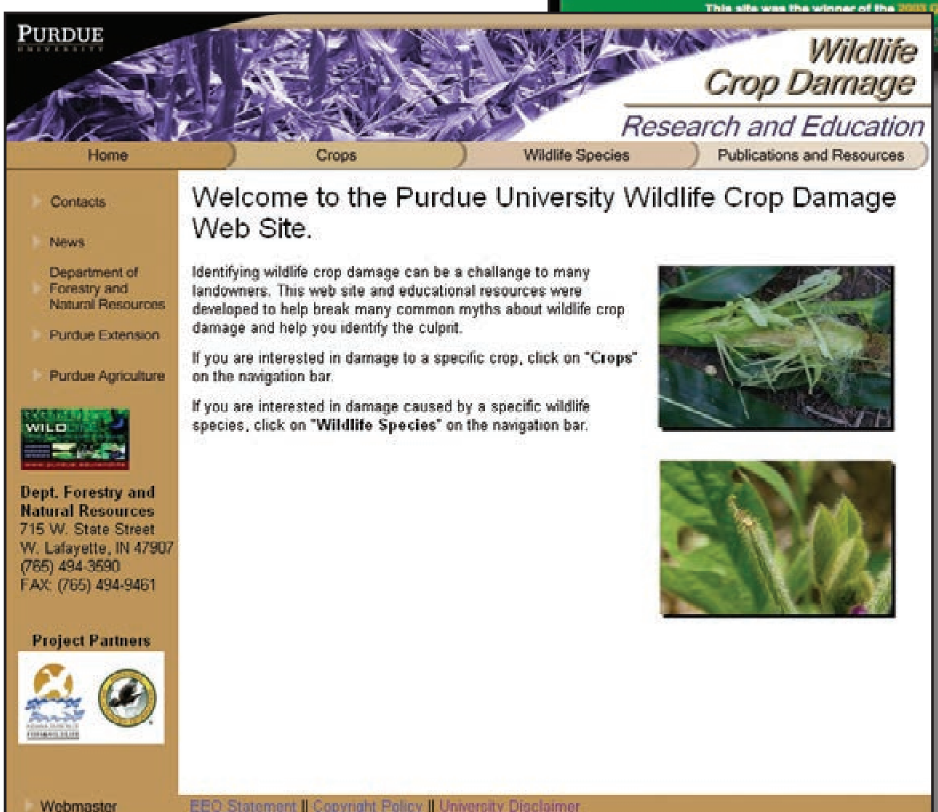
	Selected Developmental Growth Stages							
	Emergence				Tassel	Silking	Milk	Maturity
	VE	V6	V12	V15	VT	R1	R3	R6
Plant Character-istics	Growing point below soil surface	Growing point now above ground level	Number of rows of kernels per ear is determined and continues until ~1 week before silking	Silks begin to develop on upper ear (although they have not yet emerged)	Pollen shed begins when last branch of tassel if visible and silks have not emerged	Begins when any silks are visible outside of husk (~2-3 days required for all to be exposed and pollinated)	Begins ~3 weeks after silking; kernels are moist and fluid is white from starch	Kernels reach maximum dry matter accum-ulation; crop has to dry prior to harvest
Impact on Yield	Low if plant is broken off; high if plant is pulled or remaining seed is dug out and consumed	Damage to stalk above growing point will result in high yield loss	Damage to developing ears can cause high yield loss	Damage to developing ears can cause high yield loss	Timing of pollen shed with silking crucial for pollination of ovules	Any silks damaged prior to pollination will result in those kernels not contributing to yield	Much wildlife damage occurs during R3; effect on yield is variable	Kernels pulled from the cob easily; red cob remains; yield loss variable

Table 2. Summary of developmental stages of growth for soybean plants. Vegetative stages after the cotyledon stage are defined by the uppermost fully developed leaf node (Ritchie et al. 1997b)

	Selected Developmental Growth Stages						
	Emergence	Cotyledon		Blooming	Pod	Seed	Maturity
	VE	VC	V1 to VN	R1 & R2	R3 & R4	R5 & R6	R7 & R8
Plant Character-istics	Cotyledons supply plant nutrition for 7-10 days after emergence	Begins when unifoliate leaves have unrolled	Axillary buds are located at the junction between the main stem and each leaf petiole.	Flowering begins during R1; rapid uptake of nutrients during R2 (stored in vegetative parts at first)	Pods begin, flowering still continues	All vegetative growth ends during R5; seeds begin period of dry wt. & nutrient accumulation	Seeds are completing their dry weight accumulation; yellowing of leaves and pods occur
Impact on Yield	Damage to both cotyledons will reduce yield 8-9percent; severing plant below cotyledonary node will terminate plant	Damage to both cotyledons will reduce yield 8-9percent; severing plant below cotyledonary node will terminate plant	Damage to leaflets results in developing branches from axillary buds. Light browsing results in very minimal yield loss; for example, 50percent leaf loss at V6 results in ~3percent reduction in yield	Damage to leaflets results in variable yield loss; repeated damage to single plants increases loss	Ability to compen-sate for damage is less than blooming stages; over half the flowers and pods abort and never contribute to yield	By midway through R5, plants cannot compensate for damage; light damage after this time can cause moderate yield losses per plant	Potential for yield loss due to stress declines after R6 until maturity

Summary

This guide depicts the most common wildlife damage situations for corn and soybean fields found in Indiana and throughout much of the Midwest. It should be useful for the identification of wildlife damage caused to these crops throughout much of the Midwest. Properly identifying the species causing damage is the first step in solving human-wildlife conflicts. For more information about wildlife crop damage, visit the Purdue University Wildlife Crop Damage Web site at www.purdue.edu/cropdamage. For all of your wildlife information needs, visit Everything *WILD*life at www.purdue.edu/wildlife.



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