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Strategies for Evading Blackbird Damage

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CHAPTER 10

Strategies for Evading Blackbird Damage

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Foraging blackbird flocks have great mobility as they search for food that is plentiful, is easily accessed, and has a high nutritional value. Ripening corn, rice, and sunflower fit those criteria, as does seeded rice. The birds will move from field to field to find the ideal combination of energy spent to discover food versus the energy value of the food (Pyke et al. 1977). An extraordinary effort is often needed to actively move the birds from a foraging location with a high positive value (e.g., close to roost and early ripening sunflower) versus a location with a low value (e.g., far from roost and mature corn). Indeed, Handegard (1988) relayed that despite the intense use of low-flying aircraft and live shot-shell ammunition, field specialists were not able to move blackbirds from sunflower fields located near cattail-dominated (*Typha* spp.) wetland roosts. In this case, birds were also undergoing their annual feather molt, which hampered flight and increased the energetic cost of moving to a new foraging site (Linz et al. 1983).

For this reason, we believe that harvest advancement through desiccation (i.e., crop phenology), wildlife conservation food plots (WCFP), and habitat management should form the foundation of

any blackbird management scheme that might include a suite of potential damage control options. These methods help reduce damage by manipulating the environment within and surrounding crop fields.

10.1 CULTURAL PRACTICES

An obvious bird management strategy is to abandon a bird-susceptible crop and substitute other crops (e.g., soybeans, flax) that are not damaged by blackbirds. Dedicated growers, however, recognize the value of bird-susceptible crops (e.g., sunflower, rice, and corn) in their crop rotation and have opted to use time-tested and new cultural practices to keep damage at economically acceptable levels (generally $\leq 5\%$; Linz and Homan 2011; Dolbeer and Linz 2016). Savvy growers plant less vulnerable crops near known wetland roost sites, coordinate planting time with neighbors to eliminate early and late ripening fields, plant large fields to spread damage over more heads so remaining seeds can undergo compensatory growth, leave harvested fields untilled to provide alternate food sources, create vehicle pathways to facilitate bird hazing efforts with pyrotechnics and shotguns, and control weeds and insects that attract birds (Sedgwick et al. 1986; Wilson et al. 1989; Dolbeer 1990; Linz et al. 2011; Dolbeer and Linz 2016).

Finally, although an untested concept, short-stature (SS) sunflower that provide less height than standard hybrids for birds to scan their surroundings for predators, especially birds of prey, might reduce the suitability of the foraging site. Short-stature sunflower also might allow for more effective use of scare devices (e.g., propane cannons, pyrotechnics, unmanned aircraft systems, shotgun shells), because the sound is not muffled. Additionally, high-clearance ground spray equipment can more easily apply bird repellents and other pesticides (Figure 10.1). Currently, improved SS sunflower varieties are not available for widespread planting in northern sunflower growing areas in North America. However, sunflower breeders are rapidly developing SS sunflower that is comparable to standard-height sunflower for such agro-economic characteristics as days to maturity, yield, oil content, and disease tolerance (Mullally 2013; Linz and Hanzel 2015).

Figure 10.1 Short-stature sunflower allows high-clearance ground sprayers to easily apply bird repellents and desiccants as part of a bird damage management program. (Courtesy of USDA Wildlife Services.)

10.2 ADVANCING HARVEST DATE

Advancing harvest date can reduce bird damage and even out the grower's harvest schedule. This strategy works particularly well for ripening sunflowers, which require about 38 days from last anther to physiological maturity (R9) when the seeds contain about 35% moisture (Putman et al. 1990). Sunflowers are mature long before they are dry enough for combining and long-term storage. Thus, the grower must wait for natural desiccation, which usually occurs after freezing temperatures, or dry the seeds before storing in bins, which can be costly. Natural desiccation can be slow and uneven, and inclement weather can reduce quality and yield through stem breakage and shattering. Waiting for natural desiccation also increases the time that sunflowers are susceptible to predation by blackbirds. Artificially advancing the harvest date reduces the amount of time that the crop is susceptible to blackbird predation, especially by late-migrating blackbirds.

Growers can use paraquat, sodium chloride, saflufenacil, or a tank mix of glyphosate and saflufenacil herbicides to desiccate physiologically mature non-genetically modified organism (GMO) crops and advance harvest as much as 20 days over nondesiccated sunflowers (Dow AgroSciences 2016). The latter is a particularly popular option because glyphosate kills grass, and saflufenacil, which is a broad-leafed herbicide, dries down sunflower faster than a glyphosate application alone. Paraquat is an effective desiccant but changes the cell structure of the head, allowing moisture to enter during a precipitation event, which could result in a delayed harvest. Use of sodium chloride declined with the introduction of glyphosate as a harvest aid because it is relatively expensive and must be applied at high volumes with a ground sprayer (Linz et al. 2011).

10.3 WILDLIFE CONSERVATION FOOD PLOTS

Linz et al. (2004) coined the moniker *wildlife conservation sunflower plots* to emphasize that sunflower plots can be planted with the needs of all wildlife in mind, in particular providing a refuge for local and migrating birds, including blackbirds dispersed from ripening crops such as sunflower. Here, we generalize the term *wildlife conservation sunflower plots* to *wildlife conservation food plots* (WCFP) to include all food varieties provided to attract wildlife. WCFP (also known as lure, decoy, food, trap, supplemental feeding, and diversionary plots) typically are small acreages (0.8–1.6 ha) strategically placed to provide food for wildlife (Cummings et al. 1987; Hagy et al. 2008, 2010; Tranel et al. 2008; U.S. Department of Agriculture 2013; Kubasiewicz et al. 2016). Entire fields are sometimes planted to a bird-susceptible crop (e.g., wheat, sunflower, corn, rice) or planted to attract wildlife that might otherwise forage in commercial crops (Gustad 1979; Cummings et al. 1987; Knittle and Porter 1988). Aside from reducing damage in a commercial field where damage >5% is economically important, food remaining in WCFP is available for both migrating birds and resident animals (Tranel et al. 2008; Galle et al. 2009; Hagy et al. 2010). Additionally, WCFP might be considered to support a population of an endangered species (Ewen et al. 2015).

The U.S. Department of Agriculture Wildlife Services program supports the use of lure crops (i.e., WCFP) to divert wildlife from damaging agricultural resources, especially where crop damage is recurrent (e.g., near historical roosts) and other methods are deemed ineffective (U.S. Department of Agriculture 2003).

Avery (2003) advised that blackbirds with no alternative quality food will endure otherwise effective repellents (i.e., blackbirds need to eat to survive). That notion can be expanded to include mechanical scare devices, pyrotechnics, and bird-resistant crops (Dolbeer et al. 1984; Linz et al. 2011). The keys to successful use of WCFP are location close to roosts, protection from predators, and caloric content (Linz et al. 2008). Here, we present a case history on the use of WCFP to reduce blackbird damage to sunflower and advocate the continued development of perennial sunflower as a potential cost-effective approach to developing a long-term management scheme to reduce damage

to grain crops (Glover et al. 2010; Kantar et al. 2012, 2014; Linz et al. 2014; Linz and Hanzel 2015). This approach could attract the support of private conservation groups, state and federal resource agencies, and agriculturalists.

In the early 1980s, Cummings et al. (1987) offered alternative feeding locations to reduce blackbird damage to ripening sunflower. Cooperating growers planted nine 10-ha oilseed sunflower plots and one 14-ha field planted with both corn and sunflower near commercial fields (Cummings et al. 1987). Blackbirds used the lure fields heavily, and the economic analysis indicated that commercial fields had attained an average positive cost–benefit ratio of 1.0:4.0 (i.e., one unit of cost provided four units of benefit). Although the results were promising, no government entities were willing to formally implement a WCFP program.

Hagy et al. (2007, 2008, 2010) revisited the use of WCFP as a bird management tool in 2004 and 2005. Scientists offered candidate sunflower producers US\$375.00/ha to plant 35 8-ha WCFP near cattail-dominated wetlands with histories of elevated blackbird damage (Figure 10.2). Blackbird damage in the WCFP plots was highly variable, ranging from 0% to 100%. Across both years of the study, WCFP produced an average of 1,290 kg/ha and birds removed 435 kg/ha, valued at US\$160.95/ha (US\$0.37/kg). Hagy et al. (2007, 2008, 2010) assumed, as did Cummings et al. (1987), that birds feeding in the fields would have caused the same amount of damage to commercial sunflower fields. In comparison to the research by Cummings et al. (1987), Hagy et al. (2008) concluded that the cost–benefit ratio was 3.4:1.0, indicating a negative economic return. The cost–benefit ratio did not include the intrinsic values of WCFP, such as use of the plots by 34 nonblackbird species (Hagy et al. 2010).

Given the expense of annually planting WCFP plots, Hagy et al. (2008) concluded that WCFP are best used to protect high-value oil and confectionery sunflower varieties planted either near roosts or under flight lines of blackbirds emanating from roosts. Planting of oilseed sunflower WCFP near commercial confectionery sunflower, the latter being much more valuable, could offset field planting costs if blackbird damage in the WCFP was $\geq 12\%$, a level of damage found in 74% of the WCFP (Hagy et al. 2008). Additionally, planting less valuable crops (e.g., corn, perennial sunflower, millet) near wetlands also might serve as alternative feeding sites and lower sunflower damage. This strategy might be especially effective if sunflower growers are actively dispersing (e.g., via pyrotechnics, shotgun shells, airplanes) the birds from their crop (Avery 2003).

Figure 10.2 Wildlife conservation food plots provides alternative food for blackbirds and other wildlife. (Courtesy of Heath Hagy, North Dakota State University.)

However, the behavior of blackbirds foraging under stressful conditions associated with harassment has not been assessed.

Since Hagy et al. (2008, 2010) conducted their study, collaborating scientists at the University of Minnesota and USDA Agricultural Research Service (USDA-ARS) have advanced the development of a perennial sunflower that could reduce planting costs for WCFP and serve as a potential tool to alleviate blackbird damage in commercial (i.e., annual) sunflower (Linz et al. 2011; Kantar et al. 2012, 2014). Perennial sunflower fits the notion of WCFP because this cultivar would provide a pesticide-free food source for beneficial insects, such as honeybees (*Apis mellifera*), help stabilize highly erodible lands with low production potential near wetlands, and offer year-round habitat for wildlife (Cox et al. 2010; Glover et al. 2010; U.S. Department of Agriculture 2015). Initial plantings on a working farm in North Dakota showed that the perennial habit was retained through two years, but additional development is needed to improve agronomic qualities such as oil quality and head and achene size (Linz et al. 2014; Figure 10.3). This research is ongoing with further field testing likely as the hybrid is improved (R. Stupar, personal communication).

Sunflowers growers often contend that, in addition to planting costs, WCFP take valuable agricultural land out of production. On the other hand, the grower might suffer high damage if steps are not taken to ameliorate damage—a catch-22. We suggest that growers can harvest the WCFP and recover planting costs if blackbirds do not use the plot. In some situations planting WCFP on federal and state wildlife lands is a viable alternative to planting on private lands. Landowners also can plant small food plots on a portion of Conservation Reserve Program lands to benefit all wildlife, including blackbirds dispersed from nearby fields (U.S. Department of Agriculture 2013).

Current WCFP planting recommendations differ little from previous research (Cummings et al. 1987; Hagy et al. 2008), including planting plots near cattail-dominated wetlands, which are favored as night roosts, and near, but not immediately adjacent to, commercial fields (Figure 10.4; Linz et al. 2008). Planting varieties that ripen earlier than nearby commercial fields may habituate birds to the plots, thereby further increasing the efficacy of WCFP. The use of other less valuable but desirable crops to further buffer sunflower should also be explored. Finally, additional research is needed on the best planting practices, including economic evaluation, selection of plot locations, planting times, field size, and variety selection (Cummings et al. 1987; Hagy et al. 2008, Ewen et al. 2015).

Figure 10.3 Perennial sunflower developed by University of Minnesota scientists planted in North Dakota. Perennial grain crops have the potential of providing cost-effective alternative food sources for wildlife. (Courtesy of USDA Wildlife Services.)

Figure 10.4 Wildlife conservation food plots preferred by blackbirds (e.g., sunflower, corn, millet, rice) should be planted between roost sites and bird-susceptible crops to provide alternative food sources. Areal coverage of plot is dependent on anticipated seed production and number of blackbirds. (Linz et al. 2008.)

10.4 MANAGEMENT OF WETLAND ROOST SITES

In late summer, after the nesting season, blackbirds begin roosting in wetlands dominated by cattails (*Typha × glauca*) and phragmites (*Phragmites australis*) when available because they offer protection from predators and inclement weather (Meanley 1965; Yasukawa and Searcy 1995; Linz and Homan 2011). Although native common cattail (*Typha latifolia*) can be found in the United States, almost all of the cattails in the Prairie Pothole Region are a hybrid between the invasive exotic narrow-leaved cattail (*Typha angustifolia* L.) and common cattail (Kantrud 1990). Hybrid cattails are a fast-growing and robust cattail that forms dense homogeneous stands that tolerate seasonal water draw-downs and inundation (Weller 1975; van der Valk and Davis 1978). Likewise, the native *Phragmites* subspecies (*Phragmites australis americanus*) can be found in isolated locations in North America, but again almost all *Phragmites* is a non-native subspecies (*Phragmites australis australis*) originating in Europe (Tulbure et al. 2007). The aggressive habits of both the cattail hybrid and the nonnative *Phragmites* allow them to outcompete and displace native plants important to animals dependent on wetlands for survival and reproduction.

Otis and Kilburn (1988) found that the main predictor of the severity of blackbird damage to sunflower is the presence or absence of nearby wetlands, with fields located near wetlands receiving two to four times more damage. Choosing the closest available high-quality food source (e.g., rice, sunflower, corn) fits the optimal foraging theory, suggesting that birds seek food to enhance their probability of surviving and reproducing (Pyke et al. 1977). Commercial sunflower provides blackbirds with the energy to replace feathers during their annual molt and helps them accumulate energy reserves for migration (Linz et al. 1983).

Growers planting within the foraging range (≤ 8 km) of wetland blackbird roosts absorb most of the losses (Dolbeer 1990; Klosterman et al. 2013). In southern winter roosts, Meanley (1965) reported that blackbirds readily use cattails and phragmites, with some roosts harboring a million individuals. Many of these roosts were located near rice-growing areas, providing access to planted rice in the spring and ripening rice in late summer.

Linz et al. (1992a, 1992b) proposed that breaking the link between wetland roosts and ripening crops was a reasonable approach for reducing damage. Attempts at controlling cattail and phragmites in wetlands with mechanical methods such as grazing, mowing, burning, and disking produces poor results because both of these species have a large rhizome root system that allows the plant to regenerate quickly (Tu et al. 2001). Additionally, these methods are nearly

Figure 10.5 Color infrared photo showing strips of live cattail (red) and open water (white) created by an aerial application of glyphosate herbicide to reduce blackbird roost substrate and improve habitat for waterfowl. (Courtesy of USDA Wildlife Services.)

useless where soils are water-saturated or there is standing water. To overcome these drawbacks, scientists from the USDA-APHIS-WS National Wildlife Research Center (NWRC) and North Dakota State University (NDSU) proposed the use of glyphosate, a systemic herbicide, to fragment cattail-dominated wetlands and reduce blackbird roosting habitat (Linz et al. 1992a; Linz and Homan 2011; Figure 10.5).

This idea followed research by Solberg and Higgins (1993) of South Dakota State University (SDSU) showing that glyphosate could be used to manage cattails to enhance waterfowl production. Over the next decade, the NWRC, NDSU, SDSU, and USFWS cooperated on a multifaceted series of studies to assess the efficacy, cost-benefits, and environmental effects of using an aquatic herbicide to reduce blackbird roosting habitat by fragmenting cattail-dominated wetlands (Linz et al. 1992b; Henry et al. 1994; Leitch et al. 1997; Linz and Homan 2011). Here, we briefly summarize key findings of these studies.

10.4.1 Glyphosate Herbicide

Glyphosate (*N*-(phosphonomethyl)glycine) is a systemic, broad-spectrum, post-emergence herbicide that was discovered by John E. Franz in the early 1970s, while working for Monsanto (St. Louis, MO). Today, numerous companies formulate and distribute glyphosate herbicides approved for use in aquatic environments. Glyphosate blocks the shikimic acid pathway, which is essential for protein synthesis, and as a result kills the plant (Cole 1985; Linz and Homan 2011). Applications are most effective in late summer when cattails are actively metabolizing and transporting carbohydrates to their rhizomes. Glyphosate is rapidly adsorbed by soil particles and sediment (Bronstad and Friestad 1985).

10.4.2 Ecological Effects

Glyphosate, formulated for aquatic use and applied at labelled rates, does not adversely affect aquatic invertebrates, which are a critical part of waterfowl diets during the reproductive season (Henry et al. 1994). We caution that glyphosate formulations containing polyoxyethylene tallow amine surfactant are not registered for use in wetlands because of toxic effects on aquatic organisms (Henry et al. 1994; Relyea 2005). Glyphosate applied to dense cattail stands results in massive amounts of decaying vegetation that could result in low dissolved oxygen (DO) levels, decreasing invertebrate populations and affecting invertebrate survival. However, Linz et al. (1999) showed that DO levels were similar between glyphosate-treated and reference wetlands, thus corroborating

with the conclusion by Cole (1985) that wind-driven waves and spray in open areas of wetlands increase the absorptive surface at the air–water interface, offsetting any reduction in DO from decomposition.

Linz et al. (1996a, 1996b) also investigated the effects of eliminating cattails (and presumably *Phragmites*) on the density of birds requiring emergent vegetation as nest substrate and cover from predators. They found that herbicide applications in cattail marshes resulted in fewer nesting marsh wrens (*Cistothorus palustris*), red-winged blackbirds, and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) but more waterfowl, agreeing with the conclusion of Solberg and Higgins (1993) that creating openings in wetlands was beneficial for waterfowl.

10.4.3 Economics

Linz and Homan (2011) reported treatment costs, including glyphosate, surfactant, and helicopter application, of about US\$95/ha in North Dakota. The use of helicopters essentially eliminates complaints about chemical drift onto shoreline vegetation. Linz and Homan (2011) recommended that cattails be treated with an aqueous solution containing 2.2 kg/ha glyphosate and 1% v/v surfactant. For our discussion on the economics of glyphosate applications, we assume that current application costs are similar across the United States for both cattails and phragmites. Growers are encouraged to consult with state and federal wildlife and agriculture officials to obtain information on wetland regulations prior to engaging in a wetland management program.

Here, we present an example for sunflower (US\$0.55/kg), which is a high-value crop compared to corn at US\$0.21/kg and rice at US\$0.32/kg. We assume that daily sunflower consumption by one blackbird is 0.009 kg/day and each bird will damage 0.27 kg over a 30-day damage period (Peer et al. 2003). With sunflower's 5-year (2011–2015) market price valued at US\$0.55/kg (National Agricultural Statistics Service 2016), a single blackbird (combining sexes and species) damages about US\$0.15 of sunflower/year. Thus, growers must anticipate an average of 633 blackbirds/ha (US\$95/ha) of cattail to justify treatment costs. Regrowth of cattail following treatment is contingent on water levels. If water depths remain stable at >30 cm, there should be few living cattails for at least 4 years and perhaps up to 6 years post-treatment (Linz and Homan 2011). A treatment that is effective for at least 4 years requires only 158 blackbirds/day/ha of cattail to justify costs, provided that sunflower is planted every year on lands somewhere near the treated wetland. Wetlands and grain crops planted in juxtaposition are scattered throughout the United States, with roosts containing a few hundred to several million blackbirds (Meanley 1965; Dolbeer 1990; Linz et al. 2003).

10.4.4 Operational Program

From 1991 to 2010, the USDA-APHIS-WS conducted a cattail management demonstration program in North Dakota and South Dakota. During that time, the USDA-APHIS-WS annually sprayed <1% (1,500 ha) of cattail-dominated wetlands in the Dakotas using aerial applications of glyphosate herbicide (Ralston et al. 2007; Linz and Homan 2011). WS sprayed about 70% of the emergent vegetation (largely cattails), which was sufficient to minimize or reduce roosting blackbirds but provide cover and nesting substrate for other birds. This limited spray coverage, combined with the findings of numerous field studies on ecological and environmental effects, led Linz and Homan (2011) to conclude that glyphosate has minimal impact on wetland fauna. Indeed, numerous wetland species benefited from the treatment, including waterfowl, an economically important species in North Dakota. Although statistical evidence is lacking, managing cattails appears to help sunflower producers disperse blackbirds and thus reduce the severity of damage sustained in fields located near cattail-dominated wetlands (Linz et al. 1995).

The USDA-APHIS-WS cattail management program appears to meet the requirements of wildlife interests and agriculture (McEnroe 1992; Stromstad 1992). Fragmenting dense cattail stands

returns wetlands to their original configuration, which promotes avian diversity while preventing the formation of large roosting aggregations of blackbirds. The federally funded USDA-APHIS-WS cattail management program ended in 2010. However, individual growers can use the techniques developed over 25 years of research and operational experience.

10.5 MANAGEMENT OF UPLAND ROOST SITES

In areas of the United States where wetlands dominated by emergent vegetation are relatively uncommon, blackbirds establish large roosts that can number in the millions in dense tree stands in urban and rural environments (Mott 1984; Glahn et al. 1994). The U.S. Fish and Wildlife Service conducted national winter roost surveys in 1974–1975 and 1976–1977 and found 825 roosts, with 54% harboring over 1 million birds each. These large roosts were commonly found in conifers (33%), hardwoods (23%), wetlands (12%), cane (12%), and 21% in other habitats (Glahn et al. 1994). The most important attributes of a roost site are high tree densities and dense canopy that afford the birds protection from predators and adverse weather (Meanley 1965, 1971; Lyon and Caccamise 1981).

In these circumstances, the public sometimes seeks help from wildlife agencies because of agricultural damage (e.g., rice), health risks (e.g., histoplasmosis), and general aesthetic problems (e.g., fecal matter on sidewalks and backyards; Heisterberg et al. 1987) caused by large roosts. Options for resolving conflicts with blackbirds include no action, moving the roost by modifying habitat, dispersing birds with mechanical repellents (e.g., pyrotechnics, distress calls, shooting, lasers, and propane cannons), and population reduction (Garner 1978; Booth 1994; Conover 2002).

In urban environments, thinning tree canopies might be an effective first step in moving roosting populations to more desirable rural locations. Loud sound resulting from pyrotechnics (e.g., shell crackers) and firing shotgun shells can be effective if used when the birds first start arriving at the roost in the late afternoon and continuing until dark. A persistent effort occurring over a week or more might be needed to force the birds to move from a well-established roost.

In agricultural areas, local population management might be achieved by broadcasting avicide-laced baits (Linz et al. 2015). Glahn and Wilson (1992) broadcast rice baits treated with DRC-1339 avicide (a.i., 3-chloro-p-toluidine hydrochloride, also 3-chloro-4-methylbenzenamine hydrochloride) near a large spring blackbird roost in Louisiana and killed an estimated 4 million blackbirds. A subsequent survey of rice producers estimated that damage to sprouting rice was reduced 83% compared to previous years. This suggested that lethal control of local blackbird populations might reduce local crop damage, but Glahn and Wilson (1992) concluded that such toxic baiting programs should only be used after other methods have failed. Finally, Linz et al. (2015) conducted a comprehensive review of attempts to reduce crop damage using various population management strategies and found no situation in North America or South America where lethal control, as a stand-alone tactic, met the criteria of practicality, environmental safety, cost-effectiveness, and wildlife stewardship.

10.6 BIRD-RESISTANT CROPS

The search for bird-resistant crops peaked in the 1980s, when a concerted effort was made to discover and develop bird-resistant corn and sunflower varieties (Dolbeer et al. 1982, 1984, 1986a, 1986b; Seiler and Rogers 1987; Mah et al. 1990; Mah and Nuechterlein 1991). The efficacy of bird-resistant crops and many other bird management techniques (e.g., mechanical and chemical repellents) is largely contingent on the availability of quality alternative food sources, a practice encouraged by Dolbeer et al. (1984) and Avery (2003). Here, we present research aimed at the discovery of bird-resistant corn and sunflower.

10.6.1 Corn

It takes about 60 days for corn kernels to become physiologically mature after pollination (Nielsen 2013). Blackbirds can severely damage corn during the milk (R3) and dough (R4) developmental stages, a period of 3–4 weeks when kernel moisture content is about 80% and 70%, respectively (Dolbeer 1990). After that time, the corn kernel hardens, reducing its attractiveness to blackbirds, particularly female red-winged blackbirds and yellow-headed blackbirds (Yasukawa and Searcy 1995). Male blackbirds can damage field corn for several more weeks as the kernels mature and dry down to 25% at harvest maturity (Linz et al. 1983; Nielsen 2013). Further, birds open the protective husks that allows mold, fungus, and insects to inflict additional damage and cause economic losses (Nielsen 2009).

Linehan (1967) showed that corn hybrids vary widely in their susceptibility to bird damage. Dolbeer et al. (1982, 1986a) quantified the importance of numerous corn traits in aviary tests and concluded that long and heavy husks were the most difficult for birds to access the kernels. In field tests, however, these characteristics were not important predictors of bird damage, leading Dolbeer et al. (1984) to conclude that the yield and timing of maturity were the most important factors influencing damage levels.

Dolbeer et al. (1986b) reasoned that there is little incentive for corn seed companies to develop new lines solely for bird resistance because the number of fields with economically important bird damage was small. Their fallback position was to suggest that a bird-resistance rating system should be developed for commercially marketed seed corn hybrids. Farmers in high damage areas would have the option of considering bird resistance along with other important agronomic characteristics such as yield, maturation time, stem durability, and dry-down in selecting a hybrid. With profit margins historically narrow, present-day corn growers are unlikely to give up yield in exchange for bird resistance unless anticipated bird damage is overwhelming (>15%), in which case planting a less susceptible crop such as soybean near known roost sites is another alternative.

10.6.2 Sunflower

In 1979, sunflower breeders from NDSU, with technical assistance from the USDA-ARS and private industry, were funded by the Denver Wildlife Research Center (now the National Wildlife Research Center) to assess various chemical and morphological traits that might thwart blackbird feeding on sunflower achenes (Guarino 1984). The goal was to develop a bird-resistant sunflower while maintaining palatability, yield, and oil content. Scientists surmised the features needed to inhibit perch-feeding and seed access included a flat or concave head shape, tightly held achenes, thick fibrous hulls, hulls with high levels of anthocyanins, long chaffs, long wrap around bracts, a head-to-stem distance of more than 15 cm, and ground-facing flowers (Parfitt 1984; Seiler and Rogers 1987; Gross and Hanzel 1991). Additionally, the percentage of oil, which is correlated with hull thickness, was thought to be a key reason for birds selecting particular varieties of sunflower (Mason et al. 1991). Mason et al. (1991) conducted a series of experiments to determine whether red-winged blackbirds were in fact capable of discerning the difference in oil content among sunflower varieties. Indeed, they found that low oil content associated with heavy hulled achenes reduced red-winged blackbird feeding when given a choice of achenes with higher oil content. Thus, the birds rejected some varieties of sunflower over others not because of bird-resistant features but because of the oil content. Resistant genotypes developed at NDSU were similar to confectionery varieties that feature heavy hulls with large seeds and low oil content. Compared to oil seed varieties, confectionery varieties are difficult for small birds (e.g., female yellow-headed blackbirds and red-winged blackbirds) to extract and dehull, especially after the achenes hardens at physiological maturity (Linz et al. 1983; Twedt et al. 1991). Thus, the oil content must be a controlled variable to test for true bird resistance.

In the early 1990s, the bird-resistant sunflower-breeding program was abandoned because of the prohibitive technical challenges involved in developing a commercially competitive hybrid that would have the combination of bird-resistant traits and high oil content and yield. Since then, the development of doubled-haploid technology might revive the quest for bird-resistant varieties by allowing plant breeders to rapidly develop and evaluate new cultivars for specific plant traits (Maluszynski 2003; Jan et al. 2011; Lilliboe 2011). Conventional plant inbreeding procedures might take multiple generations to evaluate a particular plant trait, whereas doubled-haploid technology achieves the same aim in one generation at presumably reduced costs. Doubled-haploid technology is used to develop plant characteristics, such as disease resistance, drought tolerance, and yield, in many crops (e.g., corn, small grains, fruits, and vegetables; Maluszynski 2003). Future commercial sunflower and corn varieties might also be developed that have some bird-resistant qualities while maintaining oil content (sunflower) and yield. In the meantime, we suggest that the new double-haploid technology could help with the development of a perennial sunflower and improvement of the agronomics of SS sunflower. Both of these products will likely meet better success for managing bird damage to sunflower.

10.7 SUMMARY

Blackbirds are highly mobile and undergo local movements in search of suitable roosting habitat and food sources. Blackbirds also can delay migration in northern areas if weather conditions are benign and ample food is available (T. Turner, National Sunflower Association of Canada, personal communication). Whereas simply planting crops not susceptible to blackbird damage (e.g., soybeans, flax) is an obvious bird management strategy, it may not be the best economic decision when damage levels are relatively low (<5%). Advancing crop harvest by artificially drying the crop ahead of normal is another plausible tactic. Growers might consider managing cattail-dominated wetlands and thinning tree canopies to reduce their attractiveness to roosting blackbirds. Another option is to plant WCFP near favored roost sites to serve as a buffer around an economically valuable crop. Finally, researchers need to investigate blackbird feeding behavior when presented with SS and perennial sunflower as well as response to hazing devices, especially unmanned aircraft systems (Ampatzidis et al. 2015). Regardless, using these evading strategies in combination with other bird management tactics could result in an effective integrated pest management plan.

REFERENCES

- Ampatzidis, Y., J. Ward, and O. Samara. 2015. Autonomous system for pest bird control in specialty crops using unmanned aerial vehicles. *American Society of Agricultural and Biological Engineers (ASABE) 2015 Annual International Meeting*, Paper No. 152181748. <http://elibrary.asabe.org/azdez.asp?IID=5&AID=45793&CID=nor12015&v=&i=&T=1&refer=7&access=&dabs=Y> (accessed March 19, 2016).
- Avery, M. L. 2003. Avian repellents. In *Encyclopedia of Agrochemicals, Vol. 1*, ed. J. R. Plimmer, pp. 122–128, Wiley, New York.
- Booth, T. W. 1994. Bird dispersal techniques dispersal techniques. In *Prevention and Control of Wildlife Damage*, eds. S. E. Hygnstrom, R. M. Timm, and G. E. Larson, pp. E19–E24. University of Nebraska Cooperative Extension Service, Lincoln, NE.
- Bronstad, H. O., and J. D. Friestad. 1985. Behavior of glyphosate in the aquatic environment. In *The Herbicide Glyphosate*, eds. E. Grossbard and D. Atkinson, pp. 200–205. Butterworth, London, UK.
- Cole, D. J. 1985. Mode of action of glyphosate – A literature analysis. In *The Herbicide Glyphosate*, eds. E. Grossbard and D. Atkinson, pp. 48–74. Butterworth, London, UK.
- Conover, M. R. 2002. *Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management*. CRC Press, Boca Raton, FL.

- Cox, T. S., D. L. Van Tassel, C. M. Cox, and L. R. DeHaan. 2010. Progress in breeding perennial grains. *Crop Pasture Science* 61:513–521.
- Cummings, J. L., J. L. Guarino, C. E. Knittle, and W. C. Royal, Jr. 1987. Decoy plantings for reducing blackbird damage to nearby commercial sunflower fields. *Crop Protection* 6:56–60.
- Dolbeer, R. A. 1981. Cost-benefit determination of blackbird damage control for cornfields. *Wildlife Society Bulletin* 9:44–51.
- Dolbeer, R. A. 1990. Ornithology and integrated pest management: Red-winged blackbirds *Agelaius phoeniceus* and corn. *Ibis* 132:309–322.
- Dolbeer, R. A., and G. M. Linz. 2016. *Blackbirds*. Wildlife Damage Management Technical Series, U.S. Department of Agriculture, Animal & Plant Health Inspection Service, Wildlife Services, Washington, DC.
- Dolbeer, R. A., P. P. Woronecki, and R. A. Stehn. 1982. Effect of husk and ear characteristics on resistance of maize to blackbird (*Agelaius phoeniceus*) damage in Ohio, USA. *Crop Protection* 4:127–139.
- Dolbeer, R. A., P. P. Woronecki, and R. A. Stehn. 1984. Blackbird (*Agelaius phoeniceus*) damage to maize: Crop phenology and hybrid resistance. *Protection Ecology* 7:43–63.
- Dolbeer, R. A., P. P. Woronecki, and R. A. Stehn. 1986b. Blackbird-resistant hybrid corn reduces damage but does not increase yield. *Wildlife Society Bulletin* 14:298–301.
- Dolbeer, R. A., P. P. Woronecki, R. A. Stehn, G. J. Fox, J. J. Hanzel, and G. M. Linz. 1986a. Field trials of sunflower resistant to bird depredation. *North Dakota Farm Research Journal* 43:21–24, 28.
- Dow AgroSciences. 2016. *Sunflower Harvesting: Maturity is Critical for Desiccation and Harvest*. Agronomy Bulletin 50, Indianapolis, IN. <http://agronomy.mycogen.com/bulletin/maturity-is-critical-for-desiccation-and-harvest> (accessed November 12, 2015).
- Ewen, J. G., L. Walker, S. Canessa, and J. J. Groombridge. 2015. Improving supplementary feeding in species conservation. *Conservation Biology* 29:341–349.
- Galle, A. M., G. M. Linz, H. J. Homan, and W. J. Bleier. 2009. Avian use of harvested crop fields in North Dakota during spring migration. *Western North America Naturalist* 69:491–500.
- Garner, K. M. 1978. Management of blackbird and starling winter roost problems in Kentucky and Tennessee. *Vertebrate Pest Conference* 8:54–59.
- Glahn, J. F., R. D. Flynt, and E. P. Hill. 1994. Historical use of bamboo/cane as blackbird and starling roosting habitat: Implications for roost management. *Journal of Field Ornithology* 65:237–246.
- Glahn, J. F., and E. A. Wilson. 1992. Effectiveness of DRC-1339 baiting for reducing blackbird damage to sprouting rice. *Eastern Wildlife Damage Control Conference* 5:117–123.
- Glover, J. D., J. P. Reganold, L. W. Bell, et al. 2010. Increased food and ecosystem security via perennial grains. *Science* 328:1638–1639.
- Gross, P. L., and J. J. Hanzel. 1991. Stability of morphological traits conferring bird resistance to sunflower across different environments. *Crop Science* 31:997–1000.
- Guarino, J. L. 1984. Current status of research on the blackbird-sunflower problem in North Dakota. *Vertebrate Pest Conference* 11:211–216.
- Gustad, O. C. 1979. New approaches to alleviating migratory bird damage. *Great Plains Wildlife Damage Control Workshop Proceedings* 4:166–175.
- Hagy, H. M., G. M. Linz, and W. J. Bleier. 2007. Are sunflower fields for the birds? *Wildlife Damage Management Conference* 12:61–71.
- Hagy, H. M., G. M. Linz, and W. J. Bleier. 2008. Optimizing the use of decoy plots for blackbird control in commercial sunflower. *Crop Protection* 27:1442–1447.
- Hagy, H. M., G. M. Linz, and W. J. Bleier. 2010. Wildlife conservation sunflower plots and croplands as fall habitat for migratory birds. *American Midland Naturalist* 164:119–135.
- Handegard, L. L. 1988. Using aircraft for controlling blackbird/sunflower depredations. *Vertebrate Pest Conference* 13:293–294.
- Heisterberg, J. F., A. R. Stickley, Jr., K. M. Garner, and P. D. Foster, Jr. 1987. Controlling blackbirds and starlings at winter roosts using PA-14. *Eastern Wildlife Damage Control Conference* 3:350–356.
- Henry, C. J., K. F. Higgins, and K. J. Buhl. 1994. Acute toxicity and hazard assessment of Rodeo®, X-77 Spreader®, and Chem-Trol® to aquatic invertebrates. *Archives of Environmental Contamination and Toxicology* 27:392–399.
- Jan, C. C., L. Qi, B. Hulke, and X. Fu. 2011. Present and future plans of the sunflower “doubled haploid” project. *Sunflower Magazine*, Mandan, ND. www.sunflowernsa.com/uploads/resources/561/jan_present.futureplansdoubledhaploid.pdf (accessed February 5, 2016).

- Kantar, M., K. Betts, B. S. Hulke, R. M. Stupar, and D. Wyse. 2012. Breaking tuber dormancy in *Helianthus tuberosus* L. and interspecific hybrids of *Helianthus annuus* L. x *Helianthus tuberosus*. *Horticultural Science* 47:1342–1346.
- Kantar, M. B., K. Betts, J. Michno, et al. 2014. Evaluating an interspecific *Helianthus annuus* x *Helianthus tuberosus* population for use in a perennial sunflower breeding program. *Field Crops Research* 155:254–264.
- Kantrud, H. A. 1990. *Effects of Vegetation Manipulation on Breeding Waterfowl in Prairie Wetlands—A Literature Review*. U.S. Fish and Wildlife Technical Report 3, U.S. Department of Interior, Fish and Wildlife Service, Washington, DC.
- Klosterman, M. E., G. M. Linz, A. A. Slowik, and H. J. Homan. 2013. Comparisons between blackbird damage to corn and sunflower in North Dakota. *Crop Protection* 53:1–5.
- Knittle, C. E., and R. D. Porter. 1988. *Waterfowl Damage and Control Methods in Ripening Grain: An Overview*. U. S. Fish and Wildlife Service Technical Report 14, U.S. Department of Interior, Fish and Wildlife Service, Washington, DC.
- Kubasiewicz, L. M., N. Bunnefeld, A. I. T. Tulloch, C. P. Quine, and K. J. Park. 2016. Diversionary feeding: An effective management strategy for conservation conflict? *Biodiversity and Conservation* 25:1–22.
- Leitch, J. A., G. M. Linz, and J. F. Baltezare. 1997. Economics of cattail (*Typha* spp.) control to reduce blackbird damage to sunflower. *Agriculture, Ecosystems & Environment* 65:141–149.
- Lilliboe, D. 2011. Doubled Haploids. *Sunflower Magazine*, Mandan, ND. <http://www.sunflowernsa.com/magazine/articles/default.aspx?articleID=3368> (accessed June 16, 2016).
- Linehan, J. T. 1967. Measuring bird damage to corn. *Vertebrate Pest Conference* 3:50–53.
- Linz, G. M., D. L. Bergman, and W. J. Bleier. 1992a. Evaluating Rodeo herbicide for managing cattail-choked marshes: Objectives and methods. In *Proceedings of a Cattail Management Symposium*, ed. G. M. Linz, pp. 21–27. U.S. Department of Agriculture and U.S. Department of Interior, Fargo, ND. https://www.aphis.usda.gov/wildlife_damage/nwrc/publications/92pubs/92-72.pdf (accessed June 28, 2016).
- Linz, G. M., D. L. Bergman, and W. J. Bleier. 1992b. Progress on managing cattail marshes with Rodeo® herbicide to disperse roosting blackbirds. *Vertebrate Pest Conference* 15:56–61.
- Linz, G. M., D. L. Bergman, H. J. Homan, and W. J. Bleier. 1995. Effects of herbicide-induced habitat alterations on blackbird damage to sunflower. *Crop Protection* 14:625–629.
- Linz, G. M., W. J. Bleier, J. D. Overland, and H. J. Homan. 1999. Response of invertebrates to glyphosate-induced habitat alterations in wetlands. *Wetlands* 19:220–227.
- Linz, G. M., S. B. Bolin, and J. F. Cassel. 1983. Postnuptial and postjuvenile molts of red-winged blackbirds in Cass County, North Dakota. *Auk* 100:206–209.
- Linz, G. M., D. C. Blixt, D. L. Bergman, and W. J. Bleier. 1996a. Responses of red-winged blackbirds, yellow-headed blackbirds and marsh wrens to glyphosate-induced alterations in cattail density. *Journal of Field Ornithology* 67:167–176.
- Linz, G. M., D. C. Blixt, D. L. Bergman, and W. J. Bleier. 1996b. Response of ducks to glyphosate-induced habitat alterations in wetlands. *Wetlands* 16:38–44.
- Linz, G. M., E. H. Bucher, S. B. Canavelli, E. Rodriguez, and M. L. Avery. 2015. Limitations of population suppression for protecting crops from bird depredation: A review. *Crop Protection* 76:46–52.
- Linz, G. M., and J. J. Hanzel. 2015. Sunflower and bird pests. In *Sunflower: Chemistry, Production, Processing, and Utilization*, eds. E. M. Force, N. T. Dunford, and J. J. Salas, pp. 175–186. AOCS Press, Urbana, IL.
- Linz, G. M., and H. J. Homan. 2011. Use of glyphosate for managing invasive cattail (*Typha* spp.) to protect crops near blackbird (*Icteridae*) roosts. *Crop Protection* 30:98–104.
- Linz, G. M., H. J. Homan, H. M. Hagy, J. M. Raetzman, L. B. Penry, and W. J. Bleier. 2008. *A Grower's Guide for Planting Wildlife Conservation Food Plots*. National Sunflower Association, Mandan, ND. <https://www.sunflowernsa.com/Research/searchable-database-of-forum-papers/> (accessed October 23, 2016)
- Linz, G. M., H. J. Homan, S. J. Werner, H. M. Hagy, and W. J. Bleier. 2011. Assessment of blackbird management strategies to protect sunflower. *BioScience* 61:960–970.
- Linz, G., B. S. Hulke, M. B. Kantar, J. Homan, R. M. Stupar, and D. L. Wyse. 2014. Potential use of perennial sunflower to reduce blackbird damage to sunflower. *Vertebrate Pest Conference* 26:356–359.
- Linz, G. M., R. A. Sawin, M. W. Lutman, H. J. Homan, L. B. Penry, and W. J. Bleier. 2003. Characteristics of spring and fall blackbird roosts in the northern Great Plains. *Wildlife Damage Management Conference* 10:220–228.
- Linz, G. M., D. A. Schaaf, P. Mastrangelo, H. J. Homan, L. B. Penry, and W. J. Bleier. 2004. Wildlife conservation sunflower plots as a dual-purpose wildlife management strategy. *Vertebrate Pest Conference* 21:294–294.

- Lyon, L. A., and D. F. Caccamise. 1981. Habitat selection by roosting blackbirds and starlings: Management implications. *Journal of Wildlife Management* 45:435–443.
- Mah, J., G. M. Linz, and J. J. Hanzel. 1990. Relative effectiveness of individual sunflower traits for reducing red-winged blackbird depredation. *Crop Protection* 9:359–362.
- Mah, J., and G. L. Nuechterlein. 1991. Feeding behavior of red-winged blackbirds on bird-resistant sunflowers. *Wildlife Society Bulletin* 19:39–46.
- Maluszynski, M., K. J. Kasha, B. P. Forster, and I. Szarejko. 2003. *Doubled haploid production in crop plants: A manual*. Kluwer Academic, Dordrecht, The Netherlands.
- Mason, J. R., G. Nuechterlein, G. Linz, R. A. Dolbeer, and D. L. Otis. 1991. Oil concentration differences among sunflower achenes and feeding preferences of red-winged blackbirds. *Crop Protection* 10:299–304.
- McEnroe, M. 1992. Cattail management: Views of the U.S. Fish and Wildlife Service. In *Proceedings of a Cattail Management Symposium*, ed. G. M. Linz, pp. 42–44. U.S. Department of Agriculture and U.S. Department of Interior, Fargo, ND. https://www.aphis.usda.gov/wildlife_damage/nwrc/publications/92pubs/92-72.pdf (accessed August 2, 2016).
- Meanley, B. 1965. The roosting behavior of the red-winged blackbird in the southern United States. *Wilson Bulletin* 77:217–228.
- Meanley, B. 1971. *Blackbirds and the Southern Rice Crop*. U.S. Department of Interior, U.S. Fish and Wildlife Service, Resource Publication 100. U.S. Government Print Office, Washington, DC. <http://pubs.usgs.gov/rp/100/report.pdf> (accessed February 3, 2016).
- Mott, D. F. 1984. Research on winter roosting blackbirds and starlings in the southeastern United States. *Vertebrate Pest Conference* 11:183–187.
- Mullally, S. 2013. Options growing with short-stature hybrids. *Sunflower Magazine*, Mandan, ND. <http://www.sunflowernsa.com/magazine/articles/default.aspx?articleID=3509> (Accessed September 25, 2016).
- Nielsen, (B.) R. L. 2009. Corn ear damage caused by bird feeding. *Corny News Network*. Cooperative Extension Service, Purdue University, West Lafayette, IN. <https://extension.entm.purdue.edu/pestcrop/2009/issue24> (accessed February 5, 2016).
- Nielsen, R. L. 2013. Grain fill stages in corn. *Corny News Network*. Agronomy Department, Purdue University, West Lafayette, IN. <https://www.agry.purdue.edu/ext/corn/news/timeless/grainfill.html> (accessed March 12, 2016).
- Otis, D. L., and C. M. Kilburn. 1988. *Influence of Environmental Factors on Blackbird Damage to Sunflower*. U.S. Fish and Wildlife Service Technical Report 16. Washington, DC.
- Parfitt, D. E. 1984. Relationship of morphological plant characteristics of sunflower to bird feeding. *Canadian Journal of Plant Science* 64:37–42.
- Peer, B. D., H. J. Homan, G. M. Linz, and W. J. Bleier. 2003. Impact of blackbird damage to sunflower: Bioenergetic and economic models. *Ecological Applications* 13:248–256.
- Putman, D. H., E. S. Oplinger, D. R. Hicks, et al. 1990. *Sunflower. Alternative Field Crops Manual*, University of Wisconsin, Madison, WI. <http://corn.agronomy.wisc.edu/Crops/Sunflower.aspx> (accessed June 23, 2016).
- Pyke, G. H., H. R. Pulliam, and E. L. Charnov. 1977. Optimal foraging: A selective review of theory and tests. *The Quarterly Review of Biology* 52:137–154.
- Ralston, S. T., G. M. Linz., W. J. Bleier, and H. J. Homan. 2007. Cattail distribution and abundance in North Dakota. *Journal of Aquatic Plant Management* 45:21–24.
- Relyea, R. A. 2005. The lethal impact of roundup on aquatic and terrestrial amphibians. *Ecological Applications* 15:1118–1124.
- Sedgwick, J. A., J. L. Oldemeyer, and E. L. Swenson. 1986. Shrinkage and growth compensation in common sunflowers: Refining estimates of damage. *Journal of Wildlife Management* 50:513–520.
- Seiler, G. J., and C. E. Rogers. 1987. Influence of sunflower morphological characteristics on achene depredation by birds. *Agricultural, Ecosystems, and Environment* 20:59–70.
- Solberg, K. L., and K. F. Higgins. 1993. Effects of glyphosate herbicide on cattails, invertebrates, and waterfowl in South Dakota wetlands. *Wildlife Society Bulletin* 21:299–307.
- Stromstad, R. 1992. Cattail management: The North Dakota Game and Fish department perspective. In *Proceedings of a Cattail Management Symposium*, ed. G. M. Linz, pp. 38–41. U.S. Department of Agriculture and U.S. Department of Interior, Fargo, ND. https://www.aphis.usda.gov/wildlife_damage/nwrc/publications/92pubs/92-72.pdf (accessed June 28, 2016).

- Tranel, M. A., W. Bailey, and K. Haroldson. 2008. Functions of food plots for wildlife management on Minnesota's wildlife management areas. In *Summaries of wildlife research findings 2007*, eds. M. W. DonCarlos, R. O. Kimmel J. S. Lawrence, M. S. Lenarz, pp. 70–79. Minnesota Department of Natural Resources, St. Paul, MN. <https://www.leg.state.mn.us/docs/2008/mandated/080748.pdf> (accessed June 28, 2016).
- Tu, M., C. Hurd, and J. M. Randall. 2001. *Weed control methods handbook: Tools and techniques for use in natural areas*. The Nature Conservancy, Arlington, VA. <http://www.invasive.org/gist/products/handbook/methods-handbook.pdf> (accessed February 5, 2016).
- Tulbure, M. G., C. A. Johnston, and D. L. Auger. 2007. Rapid invasive of Great Lakes coastal wetland by non-native *Phragmites australis* and *Typha*. *Journal of Great Lakes Research* 33:269–279.
- Twedt, D. J., W. J. Bleier, and G. M. Linz. 1991. Geographic and temporal variation in the diet of yellow-headed blackbirds. *Condor* 93:975–986.
- U. S. Department of Agriculture. 2003. WS Directive 2.460 06/11/03 *LURE CROPS*, Washington, DC. https://www.aphis.usda.gov/wildlife_damage/directives/2.460_lure_crops.pdf (accessed June 23, 2016).
- U. S. Department of Agriculture. 2013. *Fact Sheet: Conservation Reserve Program Sign-Up 45 Environmental Benefits Index (EBI)*, 7 pp. www.fsa.usda.gov/Internet/FSA_File/su45ebifactsheet.pdf (accessed February 5, 2016).
- U. S. Department of Agriculture. 2015. *Colony Collapse Disorder and Honey Bee Health Action Plan*. CCD and Honey Bee Health Steering Committee, Washington, DC. http://www.ree.usda.gov/ree/news/CCD-HBH_Action_Plan_05-19-2015-Dated-FINAL.pdf (accessed August 2, 2016).
- U.S. Department of Agriculture. 2016. *National Agricultural Statistics Service*, Washington, DC. <http://www.nass.usda.gov> (accessed February 5, 2016).
- Van der Valk, A. G., and C. B. Davis. 1978. The role seed banks in the vegetation dynamics of prairie glacial marshes. *Ecology* 59:322–335.
- Weller, M. W. 1975. Studies of cattail in relation to management for marsh wildlife. *Iowa State Journal of Research* 49:383–412.
- Wilson, E. A., E. A. LeBoeuf, K. M. Weaver, and D. J. LeBlanc. 1989. Delayed seeding for reducing blackbird damage to sprouting rice in southwestern Louisiana. *Wildlife Society Bulletin* 17:165–171.
- Yasukawa, K., and W. A. Searcy. 1995. Red-winged blackbird (*Agelaius phoeniceus*). No. 184. *The Birds of North America*, ed. P. G. Rodewald. Cornell Lab of Ornithology, Ithaca, NY. <https://birdsna.org/Species-Account/bna/species/rewbla> (accessed September 25, 2016).