Sandhill and Whooping Cranes

Figure 1. An adult sandhill crane (*Grus canadensis)* with 1-week old chick.

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Overview of Damage Prevention and Control Methods

Habitat Modification

- Lure crops and artificial feeding

Exclusion

- Not practical

Frightening Devices

- Propane cannons and associated pyrotechnics

Repellents

- 9,10 Anthraquinone (AQ), registered as Avipel

Reproductive Control

- None registered

Toxicants

- None registered

Trapping

- Impractical in most situations

Shooting

- Take permits for sandhill cranes through USFWS

Species Profile

The sandhill crane (*Grus canadensis*, Figure 1) is a long-lived, member of the crane family

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(Gruidae) and the most numerous of the 15 crane species known world-wide. Over the last 50 years, the species has grown from a rarity, requiring extensive protection, to an abundant widespread species. In their abundance, sandhill cranes have come into more frequent conflict with humans and thus, are the focus of this chapter.

With less than 500 individuals remaining, the whooping crane (*Grus americana*, Figure 2) is one of the most critically endangered species in North America.

Figure 2. A banded adult whooping crane (*G. Americana*).

Identification

Cranes are among the largest birds in North American. Greater sandhill cranes stand nearly 5 feet tall and whooping cranes are even taller. They fly with their necks stretched out forward and feet stretched out backward. They stand and roost on the ground rather than perching in trees.

Physical Description

In spring, lean male greater sandhill cranes in Wisconsin weigh an average of 11.7 pounds while females weigh an average 10.1 pounds. In fall, greater sandhill cranes can increase their body mass by about 3 pounds by acquiring fat. The arctic-breeding lesser sandhill cranes, are the smallest, weighing 6 to 7 pounds and standing 3 to 3.6 feet tall. Lean male whooping cranes average 13 pounds and females weigh about 11 pounds.

The plumage of all sandhill cranes is gray, but it often takes on a rusty color in early spring from iron-rich mud that they preen into their feathers. Sandhill cranes in some areas, such as the Pacific Northwest, remain gray all year because they are not exposed to iron. Rusty colored plumage of spring gradually is molted through the summer, so by fall most sandhill cranes appear gray. Adult sandhills have red skin on the top of the head and white feathers on the cheek.

Whooping cranes are mostly white, with black and red markings on the head. Their wings have black primaries that are very noticeable in flight, but are not visible when the wings are folded. Unlike sandhill cranes, whooping cranes do not preen wetland soils into their feathers. Thus, their plumage appears white year-round.

Range

Migratory populations of sandhill cranes breed from arctic to temperate environments and range as breeding birds from eastern Siberia through most of Alaska, Canada, and the northern third of the US (Figure 3). Non-migratory sandhill populations breed in Florida, southern Mississippi, southern Georgia (Okeefenokee Swamp), and Cuba.

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Figure 3. Distribution of populations of sandhill cranes in North America.

In winter, most sandhill cranes can be found in the southeastern US from southern Indiana to the Gulf and Atlantic Coasts. In the West, most sandhills winter in more distinct groups that range across northern Mexico, California, Arizona, New Mexico, and Texas.

Historically, whooping cranes nested in three distinct ecosystems: the sub-arctic and taiga, the upper tallgrass prairie in temperate North America, and the coastal plain of the Gulf of Mexico. Of these breeding areas, only the migratory population that breeds in Wood Buffalo National Park, Canada, and winters at Aransas National Wildlife Refuge, Texas (Figure 4) survived a severe bottle-neck in the 1940s when this population was reduced to 14 or 15 birds. Since then, the remnant migratory population has increased, and 3 of 4 reintroduction projects that have been attempted are still extant, although none is self-sustaining yet. An Eastern Migratory Population (EMP) currently breeds in southern Wisconsin and winters in the southeastern US. In addition, a non-migratory population is being re-established in the coastal plain of Louisiana. A different non-migratory population also was reintroduced to Florida during the 1990s, but reintroduction efforts in this area have ceased with the population being declared unsustainable.

Figure 4. Distribution of current populations of whooping cranes in North America.

Voice and Sounds

Both crane species have 2 distinctive calls that are heard easily at a distance. Males or females in flight or on the ground give a guard call, while a bonded pair gives the unison call in a synchronized duet only while on the ground. The guard call of sandhill cranes is a loud rattle that carries up to 1.5 miles; a bird uses it when it is disturbed or feels threatened. For

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whooping cranes, the guard call is a 2-noted blast that sounds like “whoop.” For sandhills, the unison call is a duet where the male begins with a 1-note rattle and the female quickly follows with a 2-note, higher-pitched bark. The male to female cycle of calling is repeated several times as part of 1 synchronous vocalization. Unison calls from both the male and female sound as if they are from a single bird. It is given to form or maintain pair bonds and as territorial defense. The unison call for whooping cranes sounds like a series of whoops rather than rattles typical of the sandhill cranes.

Tracks and Sign

The footprint of a sandhill or whooping crane is easy to distinguish from that of a turkey or other large bird that perches in trees. Cranes are adapted to walking on the ground and have a reduced back toe (hallux) that prevents them from perching in trees. Crane tracks reflect the 3 forward toes without an extensive imprint from the hallux (Figure 5). Turkeys and herons, on the other hand, have footprints with 3 anterior toes and 1 large hallux.

General Biology

Reproduction

Both sandhill and whooping cranes reach sexual maturity at 2 to 3 years of age. In dense breeding populations of either species, however, the age that birds can obtain a territory, and thus successfully breed, often is 5 to 7 years. Cranes typically lay 2 eggs in initial nests of the season and 1 egg in replacement nests if the first nest is lost, especially early in incubation. When 2 chicks hatch from the same nest, 1 chick typically starves, is killed by a predator, or is killed by its sibling before fledging. Only one clutch is raised per year.

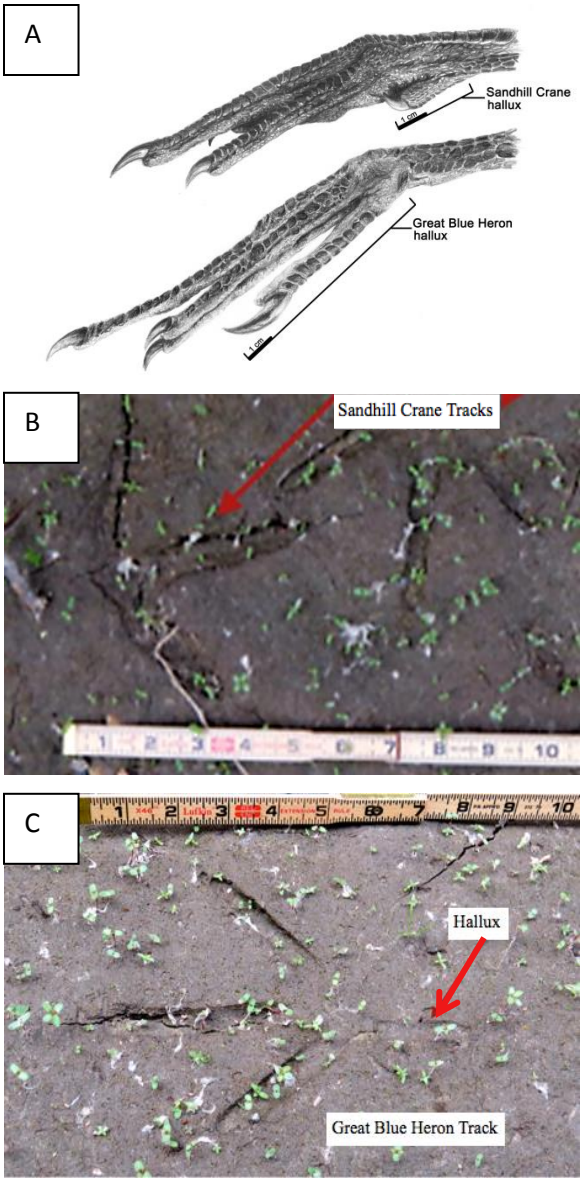

Figure 5 The rear toe (hallux) of a mature sandhill crane is less than half the length of a great blue heron (A). As a result, tracks from sandhill cranes do not show the imprint of the hallux (B), whereas it is present for the heron (C).

Nesting Cover

Cranes build their nests in emergent wetlands, but sandhill cranes sometimes nest in uplands. Crane nests typically are low mounds built of dominant vegetation in the area.

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Mortality

Annual mortality rates for adult sandhill cranes average 8.3% per year in the eastern population (EP) and does not differ between males and females. The annual mortality rate in the EMP of adult whooping cranes is about 10%. Cranes have higher mortality rates during their first year of independence than during following years as adults. Primary causes of adult mortality include predation, poisoning (i.e., mycotoxins from peanut fields), collisions with powerlines, illegal shooting, and disease.

Population Status

Populations of sandhill cranes were dramatically reduced or eliminated in the early 20th Century but some of these populations have recovered to healthy levels. Recovery was most dramatic where wetlands remained and cranes adapted to foraging in agricultural fields. The frequency and severity of crop damage rose as populations recovered.

Sandhill cranes are abundant throughout much of North America, numbering 600,000 to 700,000, although some non-migratory subspecies are considered critically endangered (Mississippi sandhill crane, *G. c. pulla;* and Cuban sandhill crane, *G. c. nesiotes*) or near threatened (Florida sandhill crane, *G. c. pratensis*) under the Endangered Species Act. A few migratory populations are still small (i.e., Colorado River Valley Population of greater sandhill cranes) and are thus of concern.

Whooping cranes number only 400 to 500 birds in the wild and are located in 4 groups: 1) the EMP is a reintroduced, migratory flock of about 100 birds that resides east of the Mississippi River and summers primarily in Wisconsin and winters in Illinois through Florida; 2) a flock of about 30 non-migratory birds is being reintroduced into Louisiana; 3) about 15 birds remain of a non-migratory flock that was established in Florida; and 4) a wild, remnant population of 280 to 300 birds survives and is growing slowly in a flyway linking Wood Buffalo National Park (Alberta and Northwest Territories, Canada) and Aransas National Wildlife Refuge (Texas).

Habitat

Most sandhill cranes are migratory. In summer, ideal habitat includes a mix of shallow emergent wetlands that are located near upland areas. Cranes prefer uplands dominated by short vegetation, less than 1.5 feet in height. In spring, agricultural fields near wetlands where cranes nest offer excellent upland habitat and are used heavily. Cranes build their nests in emergent wetlands and usually roost at night in open water portions of these same wetlands. Although both territorial and non-territorial birds forage in uplands and wetlands during the day, territorial birds typically feed in uplands adjacent to their nesting wetlands, while non-territorial birds fly out 1 to 2 miles from nighttime roosts to upland fields.

Cranes are relatively safe from predators in agricultural fields where the low vegetation makes it difficult for predators to approach undetected. The open space of upland fields also provides a place for crane socialization, an activity that is especially important to non-territorial birds.

In winter, cranes roost in shallow, open river streams or open wetlands and often fly out to agricultural fields during the day. Cornfields are the most common habitat that cranes forage in during the day, but migrating cranes also forage

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for animal materials in wet meadows and pastures. Cranes return to open water areas to roost at mid-day. During winter, cranes forage up to 10 miles from wetlands where they roost, and home ranges can be up to 70 square miles.

In summer, whooping cranes use similar types of wetlands but tend to spend more time in wetlands than do sandhills. Whooping cranes occasionally feed in uplands, especially agricultural areas up to 12 miles from nesting territories. Whooping cranes also forage in agricultural fields after harvest during fall and winter. Whooping cranes tend to be territorial during winter in the Aransas National Wildlife Refuge and forage predominantly in estuarine areas, although they sometimes fly out from winter territories for fresh water or non-wetland foods such as acorns or wolfberries.

Behavior

Sandhill and whooping cranes are intelligent, territorial, and long-lived omnivores that are highly philopatric, meaning they return in subsequent years to the area in which they hatched. Both species are diurnal throughout their annual cycle. Although North American cranes are excellent flyers, they spend most of their time on the ground. Territorial cranes develop home ranges that are predictable and relatively small (0.4 to 0.8 square miles for sandhills and 0.8 to 1.2 square miles for whooping cranes). Non-territorial birds are much more mobile and have home ranges of 4 to 6 square miles. During summer, non-territorial cranes congregate in flocks that vary from 1 to 100 individuals. In spring, most non-territorial cranes are found within 3/4 mile of a roosting wetland, but individual birds often will fly up to 3 miles from a wetland to feed. Non-territorial birds select habitats on any given day in an unpredictable manner, covering areas up to 5 to 10 times larger than areas frequented by territorial birds. Non-territorial sandhill cranes account for about half of the overall summer population of this species. Whooping cranes in the EMP fly up to 12 miles from their nesting territory on a daily basis, occasionally during incubation and frequently after losing their nest.

Non-territorial birds select habitats on any given day in an unpredictable manner. At night, both species of crane prefer to roost in shallow wetlands or rivers. Occasionally either species will roost in shallowly flooded agricultural fields and even in dry agricultural fields if vegetation is sparse.

Food Habits

Sandhill and whooping cranes eat similar foods. While in upland fields, cranes feed on seeds such as corn left over from the previous year's crop, insects, earthworms, planted seeds, tubers, snakes, rodents, and eggs and young birds. Corn, wheat, barley, rice, and sunflower seeds are desirable foods. In wetlands, sandhill and whooping cranes eat a variety of animals, including: birds (mostly nestlings and eggs), rodents, snakes, frogs (adults and tadpoles), insects, fish, snails, mussels, crayfish, and turtles. In addition, cranes eat a wide array of plant materials, including tubers, rhizomes, seeds, berries, and flowers. Since whooping cranes spend more time in wetland habitats, they tend to eat more of these foods than do sandhill cranes.

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Legal Status

Both sandhill and whooping cranes are protected under the Migratory Bird Treaty Act (MBTA) of 1918. The US Fish and Wildlife Service (USFWS) can issue depredation permits under this act to shoot sandhill cranes that cause agricultural damage.

State laws also apply to various populations of sandhill cranes. For example, the small breeding population of sandhill cranes in Ohio still is considered a species of management concern even though it belongs to the EP, which is a large and growing population with over 70,000 birds. Other state laws also may apply. For example, in Florida it is illegal to feed whooping or sandhill cranes artificially. Check with the appropriate regulatory agencies in individual states for a more comprehensive analysis of state laws.

Whooping cranes and some subspecies of sandhill cranes (Mississippi, Florida, and Cuban) also are protected under the Endangered Species Act (ESA). Under this statute, the wild migratory population of whooping cranes in central North America is fully protected anywhere it occurs in Canada or the US. The extant reintroduced populations, however, are classified as "experimental and non-essential" under the ESA. This classification provides more flexibility in dealing with management issues that occur during reintroduction efforts. The experimental, non-essential designation applies to whooping cranes in the EMP and in non-migratory populations of Louisiana and Florida.

Federal and state permits are required to capture and possess cranes or crane parts, such as feathers. The USFWS is responsible for all permits obtained under either the MBTA or the ESA. In at least some states, the USFWS, in close cooperation with the USDA, administers take permits for removing sandhill cranes involved in agricultural damage. Obtain state permits for capture of cranes through state natural resource agency offices.

Human-Wildlife Conflicts

The behavioral characteristics and habitat needs of these beautiful birds set the stage for conflict between agricultural producers and cranes. These same traits also offer our best opportunity to resolve human-wildlife conflicts effectively and sustainably. In particular, recognizing which social group of cranes (territorial vs. non-territorial) is causing the damage can greatly improve the effectiveness of any management effort.

Crops

Of all conflicts with cranes, the most frequent and economically significant damage come from cranes eating planted seeds, especially corn. In spring, damage can be intense, as cranes select cornfields that are germinating. Cranes do not feed on seedlings, but rather the planted seeds, which are vulnerable until the endosperm is fully metabolized by the plant. The period of vulnerability depends on soil temperature and typically occurs from the time of planting to about 17 days after germination. Cranes will continue to forage in these fields, however, even after the plants are no longer susceptible to damage.

Non-territorial sandhill cranes are unpredictable in their habitat use and can disperse across a landscape of 10 to 25,000 acres. When a cornfield becomes susceptible to damage, dispersed sandhill cranes can quickly

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concentrate in flocks of 50 to 100 birds and cause significant damage in a short time. Non-territorial sandhill cranes cause most of the damage to planted cornfields.

In spring, a crane eats on average about 400 kernels of corn per day. Some cranes will not feed in agricultural fields, while other individuals will consume little else but corn and up to 800 kernels per day. A flock of 100 cranes foraging in a planted cornfield for 3 days can eat about 240,000 kernels or 100% of about 8 acres. Damage, however, typically is spread out over the entire field and includes about 20 to 30% of the planted seeds (Figure 6).

Figure 6. Stand reduction in a cornfield caused by sandhill cranes. The extensive brown areas of the field (left and below the dashed line) have virtually no seedlings.

Damage levels occasionally reach 50 to 60%. Often, entire fields must be replanted, at significant cost to the grower.

The timing of planting is important in determining patterns of damage. If several fields are planted at the same time, damage may be spread out over a large area and be relatively minor in any 1 field. Fields planted much earlier or later than the average planting date are more susceptible to damage. This is especially true for late-planted fields because cranes become conditioned to feeding on planted corn that is in diminishing supply.

Territorial sandhill cranes seldom cause significant damage because their density is low. They damage field edges located near wetlands in which they are nesting, but little else. Whooping cranes have been observed eating planted corn seed. Those involved in human conflicts typically are birds that have been costume-reared for reintroduction.

Landscapes

Sandhill cranes occasionally damage lawns by digging in the soil for beetle or other insect larvae (Figure 7). This problem most often occurs with newly seeded lawns, especially where old fields are converted to turfgrass.

Figure 7. Damage to a new lawn by cranes digging for insect larvae.

Structures

Cranes can damage private homes, automobiles, and commercial buildings. Although lawns that surround structures likely are the primary attractant, reflective surfaces such as windows, sliding glass doors, and automobiles provide an additional allure. A territorial crane looking at a reflective surface sees an intruding crane and responds as it

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would to any potential competitor. The reflected threat displays escalate, leading to an attack by the territorial crane, sometimes resulting in damage to the property and injury to the bird (Figure 8). Non-territorial birds do not respond to reflections in a similar manner.

Figure 8. Reflective surfaces can attract sandhill cranes, occasionally resulting in damage to the structure and the crane as well.

Power lines pose a significant threat to cranes. Cranes often collide with the upper static wire of lines located near flight paths, resulting in damage to both the birds and the lines.

Human Health and Safety

Cranes can be a threat to people and property through collisions with aircraft. Territorial cranes can cause long-term problems at airports near wetlands because they defend specific areas and are attracted to the open, short-grass habitat around runways.

It is now illegal to feed sandhill or whooping cranes in Florida. This law was developed because extensive development in previously rural areas brought nesting cranes and humans into close contact. Cranes were habituating to humans through their handouts and habituation can lead to uncommon but possibly serious injuries. Cranes can become aggressive, especially when defending young. This degree of habituation can occur anywhere. As both cranes and cities expand their distribution, the problem may become more widespread.

Damage Identification

Cranes probe for food in loose soil. When the first leaf of a corn plant emerges, the endosperm still remains in the seed. The leaf provides a visual cue that leads foraging birds to precisely and efficiently find planted kernels that lay just below the soil surface. Birds readily extract planted seeds and discard attached adjacent to empty, seedless holes (Figure 9). Planted seeds are vulnerable to being eaten by foraging cranes until the endosperm is fully metabolized by the plant. Depending upon soil temperature, the period of vulnerability for corn occurs from the time of planting to no more than 17 days following germination.

Figure 9. Small leaves of corn seedlings lay adjacent to holes where cranes have removed the seeds.

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Crane damage to planted seed in agricultural fields is easy to distinguish from damage caused by pheasants or turkeys because cranes are the only species that probe for seeds rather than scratch the soil surface to expose seeds. Cranes can efficiently extract planted seeds that occur in a row at predictable intervals (Figure 10). Sometimes a small amount of soil is mounded to the side of a single hole where the bird has dug with its beak. Although cranes can dig in any soil, they prefer loose soils such as sand or silt. Cranes damage turf by digging with their bills rather than probing (Figure 7). Feathers often are seen near probe holes.

Figure 10. Holes left by a sandhill crane probing for planted seeds.

Reflective surfaces, such as windows, that are attacked by cranes often have extensive smears of blood on the surface or adjacent areas (Figure 11). These encounters are stressful for both the bird and people. Collisions of small birds with windows occasionally produce small blood smears.

Figure 11. Bloodied sash and window where a sandhill crane attacked its reflection.

Wildlife Damage Prevention and Control Methods

Solutions for both agricultural and non-agricultural damage tend to be more effective if the social status of the offending cranes is considered. Methods that exclude or disperse birds over long periods are more difficult to use against territorial cranes because they have a strong incentive to adapt to disturbances. Territorial birds cannot breed if they have no territory. Non-territorial birds are more flexible in their habitat use and usually are more easily deterred.

Though many different control methods have been used to prevent damage caused by cranes, few have been effective, especially in large geographic or long temporal scales. Cranes are intelligent, long-lived birds that often acclimate to tools designed to prevent cranes from using highly desirable resources.

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Prevention and control methods for sandhill and whooping cranes are similar. Management approaches often differ, however, since whooping cranes are listed as federally Endangered Species in some areas.

Habitat Modification

Two forms of habitat modification can be applied in crane damage situations: 1) modify property to reduce destructive behavior by cranes and 2) feed cranes to lure them away from valued resources.

Structural Modification

Anything that creates a life-sized reflection of a crane is susceptible to attack by territorial cranes. Remove or cover the reflective surface that is causing the problem. Park cars in garages or use a car cover. Install shutters or opaque tarps over windows. Attach decals or long strips of bird tape to windows. Cranes, however, may persist in attacking reflections visible through screens and other physical barriers. Cranes may not leave the area because they tenaciously maintain their territories.

Powerlines kill cranes that collide with them and are subject to damage, especially when installed in areas with high crane use, such as between night roosts and daytime feeding areas. Reroute or bury lines in high crane-use areas if possible.

Supplemental Feeding and Lure Crops

Extensive supplemental feeding programs have been used worldwide to prevent migrating and wintering cranes from damaging fall or winter-seeded fields and standing cornfields, as well as to support tourism. For example: in Israel, to keep staging or wintering Eurasian cranes in the Agamon wetland from damaging nearby agricultural fields; in northern Germany to protect germinating winter wheat fields during fall migration; in Japan to support overwintering red-crowned, white-naped, and hooded cranes; and in Spain were excess seeding is done to provide food for wintering Eurasian cranes while allowing some seed to germinate. In all cases, the feeding programs attracted cranes and reduced foraging in outlying areas as long as the supplemental food was available. On a longer term basis, however, crane numbers increased dramatically over several years, resulting in a decreased effectiveness of lure crops while the resources invested in supplemental feeding increased significantly. Where supplemental food supplies did not keep pace with population increases, cranes expanded foraging flights out from the treatment area and damage resumed, often at a greater rate than before supplemental feeding began.

Extensive feeding programs are expensive. In some places, the cost of feeding is offset by income from tourists who come to see the birds or farmers who receive the damage. To be sustainable in the long-term, tourism or farm income needs to be linked with the feeding expense such as is done to some extent in the Hula Valley in Israel (Figure 12).

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Figure 12. Habituation of cranes to tractors used for feeding (top) and viewing (bottom) cranes in the Hula Valley, Israel.

Frightening Devices

Frightening devices are perhaps the most common method applied to deter human-crane conflicts worldwide. Propane cannons, flags and streamers, powerline diverters, and pyrotechnics all are designed to elicit fright or avoidance responses. These devices range greatly in their effectiveness, manner of deployment, and duration of effectiveness. Frightening devices often move birds from one field to the next, so damage is dispersed rather than eliminated. Though it can be argued that dispersing the problem may decrease the damage for any one field or farmer, with intelligent, long-lived, philopatric cranes, the likelihood is high that cranes will habituate to field disturbances and damage will quickly resume, often in less than a day.

Auditory Techniques

Propane cannons and associated pyrotechnics have been used to disperse cranes from cropfields and airports. These devices are effective when the individual cranes that encounter them are naïve to the cannons. Any deterrence is soon lost, however, especially if the resources of concern are highly preferred by cranes. Auditory frightening devices work best on cranes at staging areas where stop-over times often are short.

Visual Techniques

Powerline diverters make powerlines easier to detect by flying cranes during reduced-visibility conditions such as foggy weather or where forested areas create backdrops that make lines difficult to see. Powerline diverters come in a variety of forms that differ in ease of attachment, longevity, and function. Firefly units move and reflect light at wavelengths that are readily seen by birds. The units, however, are deployed vertically and may fall within the blind spot of cranes (directly forward). Pigtail diverters (Figure 13), are horizontally oriented and more readily seen by cranes. Diverters can reduce, but not eliminate, the risk for lines that are already in place.

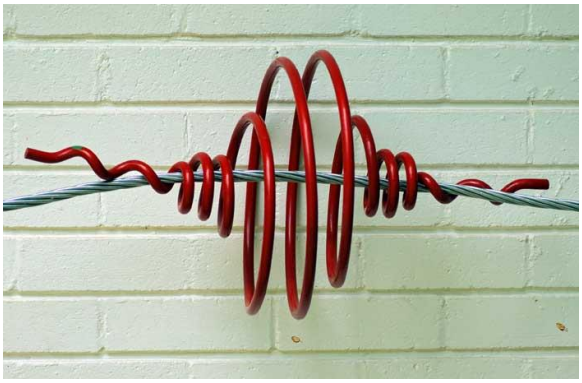

Figure 13. A close up view of a pigtail diverter used on a powerline.

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Reflective streamers attached to fences may divert cranes from small fields, but if they must be deployed at high densities, they may only be cost-effective for high-value crops. Lasers have been used to disperse some species of birds at night, but they have not been used to reduce or prevent damage by cranes.

Biological Techniques

Guard dogs can be used to patrol sensitive areas, but they are labor intensive and have a limited area of effectiveness. Where individual fields tend to be smaller, dogs may provide a viable deterrence.

Repellents

Registered as Avipel®, 9,10 anthraquinone (AQ), can be applied to planted seeds of most grain crops. Anthraquinone causes distress in the gut of birds that ingest treated seed, which leads to an aversion to the food. While gut receptors are sensitive to AQ, other receptors likely also function to facilitate aversion. Tested birds have the ability to detect AQ through taste, sight, and smell. Researchers observed marked cranes foraging in treated corn fields, and saw birds that sampled planted kernels in treated rows shake their heads and spit out the kernels. The same birds quickly moved to foraging on waste corn and insects between rows.

Some plants express AQ during the maturation process to aid in seed dispersal. High concentrations of anthraquinone in unripe fruit are thought to deter consumption by birds. Once ripe, the plant draws AQ from the fruit and birds consume and disperse the now-viable seeds. Some insects also concentrate anthraquinones that are acquired from plants in their bodies, which is thought to deter bird predation.

Anthraquinone currently is registered for row crop seed treatment in 26 states on an experimental basis, mostly under a US Environmental Protection Agency (EPA) Section 24(c) Special Local Need registration. The manufacturer, Arkion Life Sciences, LLC, is seeking a full EPA Section 3 label. Follow all label requirements when applying Avipel®. Anthraquinone is the only product that can be legally used in the US to repel cranes from planted agricultural seed. Both methyl anthranilate and limonene were field-tested as seed treatments but neither was effective.

Anthraquinone has no known long- or short-term negative effects on cranes and is considered non-toxic to birds. Field studies of a marked population of sandhill cranes over more than 2 decades indicate that no long-term, accumulative effects are caused by widespread annual use of AQ. One study of marked cranes over a 16,000-acre study area in Wisconsin indicated that use of AQ for 8 years had no apparent effect on mortality or productivity rates compared to cranes in habitats that were not treated with AQ.

Treatment of seeds to be planted with a repellent works at a smaller geographic scale of selection than do lure crops, propane cannons, or other devices designed to move birds from 1 field to another. Cranes with an aversion to planted seeds can separate 1 food item from another and can forage on other food items in the same cropfield without causing damage. Therefore, it is not necessary to disperse cranes from AQ-treated fields. Allowing birds to stay in the same field that they are selecting for, but preventing damage to the planted crop, reduces

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the chance that cranes will acclimate to the repellent and prevents the problem from being moved elsewhere. Since cranes inevitably switch their diet from seeds to other foods as seedlings grow, the repellent simply changes the timing of when corn or other crops become unavailable.

Trapping

Trapping of cranes is impractical in most situations. Most populations of sandhill cranes are too large for trapping to alter population size significantly. It can be used to remove individual cranes when they cause or threaten significant harm to people or property, such as at airports. Whooping cranes have been removed from problem areas three times: near an ethanol plant where a crane endangered itself by frequenting construction areas, near an airport were a crane on a runway caused safety concerns, and in a zoo where officials were concerned that a free-flighted male would become aggressive toward zoo visitors. In all three cases, the captured birds were part of reintroduced flocks that were classified under the Endangered Species Act as experimental and non-essential.

Shooting

Regulated hunting of sandhill cranes currently is allowed in 15 states. Most hunting proposals for sandhill cranes list the need to control crop damage as a justification. Documentation is inadequate, however, to assess whether hunting reduces crop damage.

The Migratory Bird Treaty Act of 1918 provides for the issuance of depredation permits to kill specified numbers of sandhill cranes causing damage, but only after non-lethal options have been tried and failed. Most depredation permits allow the use of rifles or shotguns to take cranes. All laws, regulations, and ordinances pertaining to use of firearms and ammunition apply and vary by jurisdiction. In Wisconsin, where a majority of the EP of greater sandhill cranes breed and where a majority of crop damage complaints due to cranes arise, the USFWS issues take permits after USDA Wildlife Services confirms that damage is occurring and non-lethal means have failed to alleviate the problem. Systems for issuing agricultural damage tags differ in other states. Take permits for whooping cranes are rarely issued.

Handling

Relocation

Capture and relocation is not practical or effective, and thus is not recommended.

Translocation

Captured cranes typically are placed in captivity because of concerns that they would revert to their previous conflict behaviors if released.

Euthanasia

Shooting is the most common method of humane killing for cranes.

Disposal

Unless specific exemptions are provided, such as using killed birds as deterrents, all shot cranes should be buried or incinerated.

Economics of Wildlife Damage Prevention and Control

With territorial and non-territorial components of the summer population of cranes, the success or failure of any technique to prevent

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crop damage will depend upon addressing a complicated crane social structure. In an average year for Wisconsin, about 2.8 million acres of corn are within ¾ mile of emergent wetlands potentially used by cranes for roosting. Although cranes do not occur in all emergent wetlands, the scale of an effective solution clearly exceeds the capability of any single organization or government agency. The use of AQ as a repellent, however, is affordable, effective, easily deployed, and can be implemented by farmers on a scale that solves the problem rather than moves the problem around (Table 1). Typically, the farmer's cost of applying AQ is about 3% the cost of planting or less than 10% of the average amount of damage that occurs to an untreated field, not including the cost of replanting.

Table 1. Acreage of Anthraquinone-treated corn seed to repel cranes in the upper Midwest, 2006-2014.

	2006	2007	2008	2009	2010	2011	2012	2013	2014
WI	37,768	18,038	40,514	44,832	57,586	76,309	111,389	150,132	135,105
MI	1,445	713	12,500	11,940	12,000	6,915	16,830	32,750	27,155
MN	632	12	1,200	3,000	2,000	830	2,676	6,750	6,878
TOTAL	39,845	18,763	54,214	59,772	71,586	84,054	130,895	189,632	169,138

Acknowledgments

Figures 1, 2. Photos by Ted Thousand.

Figures 3, 4. Maps from the International Crane Foundation, unpublished data.

Figure 5. Illustrations by Stephanie G. Wright, based on bird specimens from the Museum of Biodiversity at Ohio State University. Photos accessed November 19, 2014 from http://www.mpgranch.com/staff-blogs/education-and-outreach/dry-land-tracking.aspx.

Figure 6. Photo by Anne Lacy.

Figure 7. Photo by Jason Welter.

Figure 8. Photo by David and JoAnn Schoengold.

Figure 9. Photo by Tim Bender.

Figure 10. Photo by Su Liying.

Figure 11. Photo courtesy of Florida Fish and Wildlife Conservation Commission.

Figure 12. Top photo by Efi Naim and bottom photo by Zev Labinger.

Figure 13. Photo courtesy of the Endangered Wildlife Trust - Wildlife and Energy Program.

Table 1. Arkion Life Sciences, LLC provided treated acreage data.

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Glossary

Fledging: The stage of a bird's life when the wing feathers and muscles are sufficiently developed to enable flight.

Hallux: Posterior-oriented toe.

Philopatric: Returns year after year to use the areas near where it hatched.

Staging area: During migration, a stopping point where birds rest and feed to improve body condition and increase body fat.

Key Words

Birds, Cranes, Consumption of planted seed, *Grus americana, Grus canadensis*, Diverters, Powerline collision, Sandhill cranes, Seed repellents, Territorial cranes, Whooping cranes.

Disclaimer

Wildlife can threaten the health and safety of you and others in the area. Use of damage prevention and control methods also may pose risks to humans, pets, livestock, other non-target animals, and the environment. Be aware of the risks and take steps to reduce or eliminate those risks.

Some methods mentioned in this document may not be legal, permitted, or appropriate in your area. Read and follow all pesticide label recommendations and local requirements. Check with personnel from your state wildlife agency and local officials to determine if methods are acceptable and allowed.

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